THE EUROPEAN WEEK OF
ASTRONOMY AND SPACE SCIENCE

Abstract Book
(Version 2.0)

Lisbon, 6-10 September 2010

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The changing face of Astronomy (Inaugural Lodewijk Woltjer lecture)

Lodewijk Woltjer

The particle accelerator / astrophysics connection

Geraldine Servant

This talk will be an occasion to underline the common interests of the communities investigating the smallest and the biggest scales. The Large Hadron Collider (LHC) will take experiments into a new energy domain beyond the Standard Model of strong and electroweak interactions. As the LHC will unveil the mysteries of the electroweak symmetry breaking, it could also have far-reaching implications for cosmology, such as the nature of the Dark Matter or the origin of the matter-antimatter asymmetry of the Universe. The LHC program has a strong overlap with astrophysics and getting a complete understanding of the matter/energy budget as well as the history of the universe requires to complement LHC results with data from particle astrophysics experiments such as neutrino telescopes, gamma ray telescopes, antimatter searches, cosmic microwave background missions, galaxy surveys or gravity wave interferometers.

Recent developments at ESO

Bruno Leibundgut

The ESO public surveys

Magda Arnaboldi

Observational astronomy is currently investing in major projects like SDDSS, UKIDSS Pan-STARRS, Sky Mapper and LSST which are all survey systems and include telescope, instruments,
The goal of these projects is to target new science in a large variety of fields and supporting broad communities. The ESO public surveys with VISTA and VST are ESO’s responses to these new requests from the astronomical community. I will present the VISTA and VST telescopes, the ESO public surveys and the strategies that ESO has set in place to manage these projects, from the proposal submission, data acquisition and to the circulation of data products to the community.

The Earth as a distant planet

*Enric Pallé*

It is foreseen that in the near future, we will be able to measure the light from extrasolar planets similar to the Earth. When these data become available, a truly inter-disciplinary approach to their analysis will be necessary in order to understand the physical properties of these worlds based on globally-averaged measurements. In this task, observation of the Earth (as the only inhabited planet that we know of) and the rest of the planets of the solar system will be our guide to interpret the observations. Here I will review what information the observations of the Earth seen as a planet would reveal to a distant observer.

The Scientific Programme of ESA & its future: The Cosmic Vision 2015-2025 Long Term Plan

*Jean Clavel*

The current status of the mandatory scientific programme of ESA will be briefly summarised, focussing on astronomy missions. In the second part of the presentation, I will present the Cosmic Vision 2015-2025 long term plan, the future missions which are currently under study or definition and the process by which these missions are being selected.

The ESA Herschel Space Observatory - first year in-flight and early science highlights

*Goran Pilbratt*

The Herschel Space Observatory was successfully launched on 14 May 2009, carried into space by an Ariane 5 ECA launcher together with the second passenger Planck, both spacecraft being injected into transfer orbits towards L2 with exquisite precision. Herschel is the most recent observational mission in the European Space Agency (ESA) science programme. It carries a 3.5 metre diameter Cassegrain passively cooled monolithic silicon carbide telescope. The focal plane units of the science payload complement - two cameras/medium resolution imaging spectrometers, the Photodetector Array Camera and Spectrometer (PACS) and Spectral and Photometric Imaging REnciçoer (SPIRE), and the very high resolution Heterodyne Instrument for the Far-Infrared (HIFI) spectrometer - are housed in a superfluid helium cryostat.

Herschel is the first large aperture space infrared observatory, it builds on previous infrared space missions including the ESA ISO and NASA Spitzer observatories, by offering a much larger telescope...
Plenary Sessions

and pushes towards longer wavelengths. It will perform imaging photometry and spectroscopy in the far infrared and submillimetre part of the spectrum, covering approximately the 55-671 µm range. I will describe Herschel and its science capabilities putting it into perspective. Herschel is designed to observe the 'cool universe'; the key science objectives include star and galaxy formation and evolution, and in particular the physics, dynamics, and chemistry of the interstellar medium and its molecular clouds, the wombs of the stars and planets. Herschel is currently opening a new window to study how the universe has evolved to become the universe we see today, and how our star the sun, our planet the earth, and we ourselves fit in. I will outline the early inflight operations of Herschel and the transition from launch and early operational phases into the routine science phase. I will present the demonstrated science capabilities by providing examples of scientific highlights to date.

Herschel has been designed to offer a minimum of 3 years of routine science observations. Nominally ∼20,000 hours will be available for astronomy, 32% is guaranteed time (GT) and the remainder is open time (OT) offered to the general astronomical community through a standard competitive proposal procedure. The time allocation for both GT and OT Key Programmes was been concluded before the launch, and the first in-flight AO is underway. I will briefly mention future observing opportunities.

The Rosetta close encounters with two main-belt asteroids

Rita Schulz

ESA’s Planetary Cornerstone Mission Rosetta is on its way to rendezvous with comet 67P/Churyumov-Gerasimenko in 2014 after which it will accompany the comet into the inner solar system, while releasing the Lander Philae onto the surface of the comet nucleus. During the long cruise phase to the main target the spacecraft was scheduled to perform close fly-bys of two main-belt asteroids, (21) Lutetia and (2867) Steins. These asteroids were selected after careful evaluation of the scientific significance of all reachable targets constrained by the available fuel budget. Rosetta has now performed both fly-bys successfully. Closest approach occurred on 5 September 2008 for (2867) Steins and on 10 July 2010 for (21) Lutetia. The fly-by strategy was arranged such that it allowed for continuous observations of each asteroid before, during and after closest approach whilst the spacecraft passed through phase angle zero. Most of the scientific instruments on board Rosetta were switched on for investigations of the asteroid and its surrounding environment, obtaining imaging and spectral observations from the UV to sub-mm wavelengths as well as particle and field measurements. Both targets have turned out to be extraordinarily interesting objects for close inspection. This is not just because (21) Lutetia is the largest asteroid, and (2867) Steins is the only E-type asteroid ever visited by a space mission, but rather the results reveal the complex morphology, dynamics, and composition of both. After completion of the detailed analysis of the data obtained by Rosetta these two objects will be among the best-studied asteroids and as such will add significantly to our understanding of the different types of asteroids. This in itself will help to solve the puzzle of how the solar system formed and has evolved.

Charting the Dark Universe

Catherine Heymans

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Dark Matter and Dark Energy constitute over 95% of the energy density of the Universe, and determining their nature constitutes the major challenge for cosmology over the next decade. Weak gravitational lensing is a powerful technique that can map Dark Matter structures from its gravitational effects alone and probe Dark Energy through its effect on the growth of these structures. From an observational prospective, I’ll discuss the challenges and successes of this unique technique showing the first results from the complete Canada-France-Hawaii Telescope Lensing Survey. I’ll present cosmological parameter constraints and our wide-field maps of large-scale Dark Matter structures.

From the ESO NTT to the VLT and the 42m ELT: the development of Active Optics as the basis of all modern telescope optics (Tycho Brahe Prize award lecture)

Raymond Wilson

The Square Kilometre Array: an update

Richard Schilizzi

The Square Kilometre Array (SKA) will be the premier instrument to study the thermal and non-thermal radiation at centimetre and metre wavelengths from the cosmos, in particular from the most abundant element in the universe, neutral hydrogen. Its science impact will be widely felt in astro-particle physics and cosmology, fundamental physics, galactic and extragalactic astronomy, solar system science and astrobiology. The SKA will have a collecting area of up to one million square metres spread over at least 3000 km, providing a sensitivity 40 times higher than the Expanded Very Large Array. Its instantaneous reception pattern on the sky will be several tens of square degrees, many times that of existing instruments, with potentially several large (100 square degree), independent fields-of-view for multiple simultaneous users. The SKA will be an extremely powerful survey telescope with the capability to follow up individual objects with high angular and time resolution. The SKA design involves parabolic dishes with innovative feeds to maximize a combination of spatial and frequency coverage, and, at the lower frequencies, phased arrays that offer new operational capabilities. Much of the required technology is currently being developed in the course of specific design studies and the construction of several SKA Pathfinder instruments around the world. The talk will summarise the science case for the SKA, and provide an update on the design, prototyping, and site development activities.
S1: From Varying Couplings to Fundamental Physics

Astrophysical Probes of Fundamental Physics
C.J.A.P. Martins

The dramatic confrontation between new observations and theories of the early and recent universe makes cosmology one of the most rapidly advancing fields in the physical sciences. The universe is a unique laboratory in which to probe fundamental physics, the rationale being to start from fundamental physics inspired models and explore their consequences in sufficient quantitative detail to be able to identify key astrophysical and cosmological tests of the underlying theory (or developing new tests when appropriate). An unprecedented number of such tests will be possible in the coming years, by exploiting the ever improving observational data. In this spirit I will highlight some open issues in cosmology and particle physics and provide some motivation for this symposium.

Probing Dark Energy with Varying Fundamental Parameters
N.J. Nunes

I plan to present current constraints on the possible coupling between dark energy and electromagnetism. I also plan to forecast, using different methods, to what accuracy such coupling can be determined or constrained with data from future spectrographs (ESPRESSO and CODEX).

Varying Speed of Light and Cosmic Structure
J. Magueijo

I review varying speed of light theories resulting from having different metrics for matter and for gravity. In these theories there are 2 light cones at any point and the speed of light with respect to that of gravity changes. In the minimal theory the action maps into a (anti-)DBI action in the Einstein frame, and scale-invariant fluctuations are produced. I explain how this basic prediction comes about and can be modified in non-minimal theories. The predictive value of the theory is then in its non-Gaussian predictions which have a unique form for each tilt.

Beyond Bekenstein’s Theory
L. Kraiselburd, H. Vucetich

There are several very different motivations for studying the variation of fundamental constants. They may provide a connection between cosmology and particle physics due to the coincidence of
large dimensionless numbers arising from the combination of different physical constants. Bekenstein’s variable charge model is very attractive because it is based on very general assumptions: covariance, gauge invariance, causality and time-reversal invariance of electromagnetism. The very generality of its assumptions guarantee the applicability of the scheme to other gauge interactions such as the strong forces. Besides, it introduces a useful simplifying assumption; namely, that the gravitational sector is unaffected by the scalar field introduced to vary the coupling constant. That is why it is interesting to explore first this simplified model, before a similar exploration of more general theories. However, the model uses an ensemble of classical particles to represent matter and this is not a good model of matter wherever quantum phenomena are important, neither at high energy scales or small distances scales, since fermions have a natural length scale, namely the Compton wavelength of the particle.

Varying Fundamental Constants from Big Bang to Atomic Clocks

V.V. Flambaum

I present a review of works devoted to the variation of the fine structure constant $\alpha$, strong interaction and fundamental masses (Higgs vacuum). There are some hints for the variation in quasar absorption spectra and Big Bang nucleosynthesis data. A very promising method to search for the variation consists in comparison of different atomic clocks. Huge enhancement of the variation effects happens in transitions between very close atomic, nuclear and molecular energy levels. Large enhancement also happens in nuclear, atomic and molecular collisions near resonances. How changing physical constants may occur? Light scalar fields very naturally appear in modern cosmological models, affecting parameters of the Standard Model (e.g. $\alpha$). Cosmological variations of these scalar fields should occur because of drastic changes of matter composition in Universe: the latest such event is rather recent (about 5 billion years ago), from matter to dark energy domination. Massive bodies can also affect physical constants.

Experiments with Optical Clocks Based on Trapped Ions

E. Peik

The comparison of different optical transition frequencies over time can be used in a laboratory search for a possible time dependence of the fine structure constant. Optical clocks with laser-cooled trapped ions offer excellent control of systematic frequency shifts and allow to perform highly precise measurements of frequencies and frequency ratios. We investigate two reference transitions with very low natural linewidths that are promising candidates for precise clocks and also offer high sensitivity to variations of $\alpha$: the electric octupole transition at 467 nm in 171Yb+ and the optical nuclear transition at about 7.6 eV in 229Th3+.

Testing the stability of fundamental constants using LNE-SYRTE clock ensemble

S. Bize

SYRTE is developing an ensemble of high performance atomic clocks and precision oscillators. This unique ensemble comprises three atomic fountain clocks, three optical lattice clocks as well as ultra stable microwave and optical oscillators. This clock ensemble is connected to worldwide remote locations through satellite time and frequency transfer systems. Such an ensemble provides a large number of possibilities for testing fundamental physical laws, relying on the high accuracy and
high stability of these devices. We will report on recent progress in the level of performance and on several fundamental tests using LNE-SYRTE clocks. This includes new and improved comparisons between Rb and Cs fountains. This also includes absolute frequency measurements of several optical frequencies using atomic fountains, including the SYRTE transportable fountain FOM. We will also report on the application of these measurements to test the stability of fundamental constants with time and gravitation potential. Improved tests of Lorentz and position invariance using a cryogenic oscillator will also be described. We will also report on the latest developments of Sr and Hg optical lattice clocks. In the future, improved fundamental tests will be done using the possibilities offered by the PHARAO cold atom space clock. We will give an overview of the status of the PHARAO/ACES project.

White Dwarf Constraints on Varying Constants

E. Garcia-Berro, J. Isern, P. Loren-Aguilar

In this talk we review the several constraints that can be placed on a varying gravitational constant using white dwarfs. In particular, the cooling of white dwarfs and more specifically the white dwarf luminosity function allows to place constraints on the rate of variation of G. We foresee that future space missions, like Gaia and SIM, will provide tight constraints on such a variation. We also discuss the limits that can be obtained using pulsating white dwarfs, of which G117-B15A, the most stable optical clock known so far, is a representative example. Finally, we summarize the limits on a varying G that can be obtained using the Hubble diagram of Type Ia (thermonuclear) supernovae.

Constraining Newton’s Gravitational Constant with CMB Temperature and Polarization Anisotropies

S. Galli, A. Melchiorri, G.F. Smoot, O. Zahn

We present new constraints on cosmic variations of Newton’s gravitational constant by making use of the latest CMB data from WMAP, BOOMERANG, CBI and ACBAR experiments and independent constraints coming from Big Bang Nucleosynthesis. We found that current CMB data provide constraints at the 10% level, that can be improved to 3% by including BBN data. We show that future data expected from the Planck satellite could constrain G at the 1.5% level while an ultimate, cosmic variance limited, CMB experiment could reach a precision of about 0.4%, competitive with current laboratory measurements.

The Variation of G in a Negatively Curved Space-time

J.P. Mimoso, F. Lobo

Scalar-tensor (ST) gravity theories provide an appropriate theoretical framework for the variation of Newton’s fundamental constant, conveyed by the dynamics of a scalar-field non-minimally coupled to the space-time geometry. The experimental scrutiny of scalar-tensor gravity theories has led to a detailed analysis of their post-newtonian features, and is encapsulated into the so-called parametrised post-newtonian formalism (PPN). Of course this approach can only be applied whenever there is a newtonian limit, and the latter is related to the GR solution that is generalized by a given ST solution under consideration. This procedure thus assumes two hypothesis: On the one hand, that there should be a weak field limit of the GR solution; On the other hand that the latter corresponds to the limit case of given ST solution. In the present work we consider a ST solution
with negative spatial curvature. It generalizes a general relativistic solution known as being of a
degenerate class (A) for its unusual properties. In particular, the GR solution does not exhibit the
usual weak field limit in the region where the gravitational field is static. The absence of a weak
field limit for the hyperbolic GR solution means that such limit is also absent for comparison with
the ST solution, and thus one cannot barely apply the PPN formalism. We therefore analyse the
properties of the hyperbolic ST solution, and discuss the question of defining a generalised newto-
nian limit both for the GR solution and for the purpose of contrasting it with the ST solution. This
contributes a basic framework to build up a parametrised pseudo-newtonian formalism adequate
to test ST negatively curved space-times.

String Theory, Dark Energy and Varying Couplings

M. Zagermann

Semi-realistic compactifications of the extra space dimensions predicted by string theory generically
lead to a large number of scalar fields (the moduli fields) in the resulting effective 4D field theory.
I review the difficulties of some recent attempts to find stabilized string theory vacua with positive
cosmological constant at tree level and comment on various issues related to the discussion of
varying fundamental couplings in the context of string compactifications.

New Analysis of a Large Sample of VLT Quasar Spectra for Varying
Fine structure Constant

J. Webb

Previous observations of quasar spectra from the Keck telescope suggested a time variation of the
fine structure constant. We have now completed a new study using a large sample of quasar spectra
from the VLT. When the new VLT data are combined with the previous Keck sample, a consistency
emerges within the data itself, concordant with the earlier Keck result, and in addition revealing a
statistically significant signal for a dipole-type spatial dependence.

The Value of the Fine-structure Constant over Cosmological Times

C. Gutierrez

The optical spectra of objects classified as QSOs in the SDSS catalogues are analyzed with the
aim of determining the value of the fine structure constant in the past and then check for possible
changes in such constant over cosmological timescales. The analysis is done by measuring the
position of the fine structure lines of the [OIII] doublet in QSO nebular emission. A value of
$\Delta \alpha / \alpha = (2.4 \pm 2.5) \times 10^{-5}$ (up to redshift $z=0.8$) was determined. The use of a larger number of
spectra allows a factor 5 improvement on previous constraints based on the same method. On the
whole, we find no evidence of changes in $\alpha$ on such cosmological timescales. The mean variation
compatible with our results is $1/ < t > \Delta \alpha / \alpha = (+0.7 \pm 0.7) \times 10^{-14}$ yr$^{-1}$.

Current State of $\mu$ Measurements Versus Cosmic Time

R.I. Thompson

One of the fundamental constants of the universe is the ratio of the proton to electron mass often
designated as $\mu$. The value of this constant has been measured as a function of cosmic time in
both terrestrial laboratories and in astronomical objects. This talk examines the results of these
measurements with a main focus on the astronomical measurements that produce \( \mu \) values at early times in the universe. All of the astronomical measurements involve molecular spectroscopy since the rotational and vibrational energies of molecules are sensitive to the value of \( \mu \). Radio methods have measured rotational energies in the relatively local universe while optical studies of the electronic-vibrational-rotational transitions in Damped Lyman Alpha clouds have probed the early universe. To date no convincing measurement of a change in the value of \( \mu \) have been made. The talk will discuss the methods, accuracy, and limitations of each measurement.

**Robust Limit on a Varying Proton-to-electron Mass Ratio from a Single H2 System**

*M. Wendt, P. Molaro*

The variation of the dimensionless fundamental physical constant \( \mu \) can be checked through observations of Lyman and Werner lines of molecular hydrogen observed in the spectra of distant QSOs. Only few systems have been used for the purpose providing different results between the different authors. Our intention is to assess the accuracy of the investigation concerning a possible variation of the fundamental physical constant \( \mu = m_p/m_e \) and to provide more robust results. The goal in mind is to resolve the current controversy on variation and devise explanations for the different findings. We achieve this not by another single result but by providing alternative approaches to the problem. Current analyses tend to underestimate the impact of systematic errors. This work presents alternative approaches to handle systematics and introduces few methods required for precision analysis of QSO spectra available in the near future. Furthermore we present first results of recent state-of-the-art UVES observations.

**On the Variation of the Proton-to-electron Mass Ratio**

*W. Ubachs, F. van Weerdenburg, M. Murphy, A. Malec, J. Bagdonaitė, L. Kaper*

The dimensionless proton-electron mass ratio is one of the central targets for an experimental search of a varying coupling constant. On a cosmological time scale the hydrogen molecule, being the most abundant molecular species in the universe, is a good test ground. Although many quasar and damped-Lyman systems have been identified only very few of those bear the signatures of a high quality absorption spectrum of molecular hydrogen. We will report on analysis of a high signal-to-noise ratio VLT-spectrum of J2123, which we compare to a spectrum of the same system observed at Keck. A constraint on a varying mass ratio will be derived. Further we will illustrate the analysis of a lower quality spectrum from the Q2348-011 system.

**Sensitivity of Molecular Microwave Spectra to Varying Fundamental Constants**

*M.G. Kozlov*

Microwave spectra of molecules are increasingly used in astrophysics to study possible variations of the fine-structure constant \( \alpha \) and the electron-to-proton mass ratio \( \mu \). Typically, microwave transitions are at least 100 times more sensitive to variation of fundamental constants, than optical transitions. Moreover, microwave transitions of different nature are sensitive to different combinations of fundamental constants. We will discuss several examples of transitions, which can be used in astrophysical studies of variation of fundamental constants.
Searching for Chameleon-like Scalar Fields
S. Levshakov, P. Molaro, M.G. Kozlov, A.V. Lapinov, C. Henkel, D. Reimers

Chameleon-like scalar field models predict a strong dependence of masses and coupling constants on the ambient matter density. Since baryonic matter densities in terrestrial and interstellar environments differ by approximately 15 orders of magnitude, one can test this prediction experimentally through the measurements of relative frequencies in molecular transitions which are most sensitive to changes in dimensionless physical parameters such as, e.g., the electron-to-proton mass ratio. We present our recent measurements obtained with three radio telescopes: 32-m Medicina, 45-m Nobeyama, and 100-m Effelsberg.

Cosmological Birefringence
S.S. Alighieri

The possibility that the plane of polarization of light traveling large distances through the universe might rotate arises in a number of fundamental physical contexts, such as the Einstein Equivalence Principle violation and the presence of a dark matter or dark energy pseudo-scalar field. We have devised a test of such cosmological birefringence, using the UV polarization of distant radio galaxies and report on a recent update of this test.

Detection of 21cm, H2 and D Absorption at z¿3 Along the Line of Sight of J1337+3152
P- Petitjean, R. Srianand, N. Gupta, C. Ledoux, P. Noterdaeme

We report the detection of 21-cm and molecular hydrogen absorption lines in the same damped Lyman α system (DLA; with log N(HI) = 21.36 ± 0.10) at zabs = 3.17447 towards SDSSJ133724.69+315254.55 (zem ∼ 3.174). We constrain the variation of the combination of fundamental constants x = α² Gp/µ, ∆x/x=-(1.7 ± 1.7)×10⁻⁶. This system is unique as we can at the same time have an independent constraint on α using H2 lines. However, as the H2 column density is low, only Werner band absorption lines are seen and, unfortunately, the range of sensitivity coefficients is too narrow to provide a stringent constraint ∆ µ/µ ≤ 4.0x10⁻⁴.

Probing Fundamental Constant Evolution with Radio Spectroscopy
N. Kanekar

Astrophysical studies of redshifted spectral lines provide a powerful probe of changes in low-energy fundamental constants over a large lookback time. In this talk, I will focus on radio studies of changes in the fundamental constants, using different molecular and atomic spectral transitions that allow us to test for changes in the fine structure constant, the proton-electron mass ratio and the proton gyromagnetic ratio. I will also discuss the likely improvements to such studies with the planned advent of new telescopes over the next decade.

Future Facilities for Probing Fundamental Constants
P. Molaro

I will review the future roles of the VLT and European Extremely Large Telescope (E-ELT) in probing possible variations of fundamental constants.
Posters

[O III] as a probe of variations of the fine-structure constant from z=0 to z=3

*J. Brinchmann, S. Shah, et al*

We use the separation of the [O III]4959,5007 doublet in spectra of galaxies from z=0 to 0.7 from the SDSS to constrain variations in the fine-structure constant over that redshift range in an extension of an earlier study by Bahcall et al (2004). Combined with observations of [O III]4959,5007 in high redshift quasars with the VLT we use this to constrain the variation of $\alpha$ out to z~2.5.

Non-Gaussianity in WMAP Data Due to the Correlation of CMB Lensing Potential with Secondary Anisotropies

*E. Calabrese, J. Smidt, A. Amblard, A. Cooray, A. Melchiorri, P. Serra, A. Heavens, D. Munshi*

We measure the skewness power spectrum of the Cosmic Microwave Background (CMB) anisotropies optimized for a detection of the secondary bispectrum generated by the correlation of the CMB lensing potential with integrated Sachs-Wolfe effect and the Sunyaev-Zeldovich effect. The covariance of our measurements is generated by Monte-Carlo simulations of Gaussian CMB fields with noise properties consistent with Wilkinson Microwave Anisotropy Probe (WMAP) 5-year data. When interpreting multi-frequency measurements we also take into account the confusion resulting from unresolved radio point sources. We analyze Q, V and W-band WMAP 5-year raw and foreground-cleaned maps using the KQ75 mask out to lmax=600. We find no significant evidence for a non-zero non-Gaussian signal from the lensing-secondary correlation in all three bands and we constrain the overall amplitude of the cross power spectrum between CMB lensing potential and the sum of SZ and ISW fluctuations to be 0.42±0.86 and 1.19±0.86 in combined V and W-band raw and foreground-cleaned maps provided by the WMAP team, respectively. The point source amplitude at the bispectrum level measured with this skewness power spectrum is higher than previous measurements of point source non-Gaussianity. We also consider an analysis where we also account for the primordial non-Gaussianity in addition to lensing-secondary bispectrum and point sources. The focus of this paper is on secondary anisotropies. Consequently the estimator is not optimised for primordial non-Gaussianity and the limit we find on local non-Gaussianity from the foreground-cleaned V+W maps is $f_{NL} = -13 \pm 62$, when marginalized over point sources and lensing-ISW/SZ contributions to the total bispectrum.

Dark energy and quantum gravitation, from neutrino oscillations

*M. Laloum*

We argue that the present classical formalism of neutrino oscillations is just approximate, thus still requiring various second-order corrections.

High resolution molecular observations of dense dark cores

*A. Mignano, P. Molaro*

We present the results from the observation of two dense dark cores, L183 and L1512, carried out
at the Medicina radiotelescope. The aim of the work is to probe a positive velocity offset of \(\sim 25\text{m/s} \) between the HC3N (\(J=2-1\)) 18.2 GHz and the NH3 (\(J,K)=(1,1)\) 23.7 GHz in such molecular clouds. The offset in \(V_r\) suggests a relative change of the electron-to-proton mass ratio \(\Delta \mu/\mu = (22 \pm 4_{\text{stat}} \pm 3_{\text{sys}}) \times 10^{-9}\), with \(\mu = m_e/m_p\) possibly connected with the two extremely different environments terrestrial and interstellar (Levshakov et al. 2008, 2009, Molaro et al. 2009).

Spectrograph Calibration with Asteroid’s Sunlight

*P. Molaro, M. Centurion*

Astronomical search for a variation of fundamental constants is dealing with accurate radial velocity measurements and need reliable astronomical standards to calibrate the spectrographs to assess possible systematic. Stellar radial velocity standards offer a reference at the level of few hundreds of m/s and are clearly not adequate. We use solar light reflected by the asteroid Ceres observed with HARPS to measure solar lines’ wavelengths and we show that sunlight reflected by asteroids could be used to improve the uncertainties of solar line positions and therefore to be used as a radial velocity standard. The new measurements are consistent with the atlas obtained on FTS solar spectra but with higher precision by a factor greater than 3. The new atlas provides a new way to check radial velocity accuracy down to about 50 m/s locally and few m/s globally. The asteroid-based technique could provide a new way to track radial velocity shifts and it could also be used to study radial velocity deviations in spectrographs such as those recently detected in HIRES and UVES which are crucial for the search of the fundamental constants’ variability.
S2: Environment and the Formation of Galaxies: 30 years later

Galaxies and their environments – past, present, and future

A. Dressler

My title expresses a double purpose, to talk about how our ideas of galaxy evolution have changed in 30 years, and to discuss how the nature of galaxy interactions with their environment has itself evolved from the early universe to the present epoch. My 1980 study of morphology of cluster galaxies took place in the context of a simple and largely ad-hoc model of structure formation that preceded the paradigm of hierarchical clustering in a CDM universe. In that context a correlation of galaxy type with local density was unexpected and received with some skepticism. Today, in contrast, we have a surplus of ideas that explain all or part of this correlation. From my perspective, the morphology-density relation owes mainly to environmental effects that took place in the first 1-2 billion years — gas-rich major mergers, accretion of gas and satellites, and AGN activity among them. It has become clear during these past three decades, however, that later processes such as ram-pressure stripping, tidal interactions, and gas-poor mergers continue to shape the ways galaxies respond to their environment. Constructing a coherent and complete picture of the most important processes is a worthwhile, achievable goal for this decade.

The Void Galaxy Survey


The void galaxy survey consists of a multiwavelength - optical, infrared, ultraviolet and radio - observational study of void galaxies. The galaxies are located in the deepest troughs of voids that were identified from the SDSS DR7 survey sample. The identification is uniquely based on a pure (tessellation-based) geometric procedure, guaranteeing an objective census of the void galaxy population in the nearby Universe. The aim of the project is to compare the physical intrinsic properties of void galaxies and to assess in how far they differ from the regular field population in terms of morphology, brightness, colour, star formation activity and (HI) gas content and morphology. With these galaxies living in the most pristine regions in the local Universe, the survey will yield essential insights on the first stages of galaxy formation and on environmental influences on the galaxy formation process. In this presentation, we will present the first results of our program. This will involve a discussion of the finished pilot program of 15 galaxies, along with some of the unique constellations we have encountered. Amongst others, special attention
will be devoted to the polar ring galaxy we have found in a tenuous wall between voids and on the elongated group of three void galaxies. Also, we report on the recent finding of a constellation of three void galaxies within the deep interior of a void, one surrounded by stellar streams, embedded within a common highly elongated mantle of neutral hydrogen.

The dependence of galaxy properties on environment at low redshift

S. Weinmann

It has long been known that galaxy properties depend on local galaxy density, indicating that galaxy evolution progresses differently in different environments. Thanks to the advent of large galaxy survey, this dependency can now be quantified in detail. I will report on results from the SDSS combined with cluster and group catalogues, which allow us to parameterize environment in terms of group mass and group-centric radius instead of local density. Comparing galaxies in different environments at fixed stellar mass helps us to understand how exactly environment impacts on star formation rates, colours, metallicities and morphologies. I will explain why new results seem to indicate that galaxy structure, as measured by concentration or bulge-to-total ratio, is in fact independent on environment, and that previous results that indicated the opposite mainly come from comparing galaxies at different stellar masses, and from the use of morphological indicator that depend on star formation rates. Finally, I will argue that all environmental effects seen at galaxy masses greater than around $5 \times 10^9 \, M_\odot$ can be explained by “starvation”, and that more violent mechanisms like ram-pressure stripping of the cold gas in the galaxy are less important.

ACCESS: NIR luminosity function and stellar mass function of galaxies in the Shapley supercluster environment

A. Mercurio, P. Merluzzi, C.P. Haines, G. Busarello, R.J. Smith, J.R. Lucey

I will present the near-infrared luminosity and stellar mass functions of galaxies in the core of the Shapley supercluster at $z=0.048$ based on the K-band observations carried out at the United Kingdom Infra-Red Telescope with the Wide Field Infrared Camera in conjunction with B- and R-band photometry from the Shapley Optical Survey. I will examine environmental effects on galaxy properties, showing both luminosity (LF) and stellar mass functions (SMF) in three regions selected according to the local galaxy density. This analysis is part of a science project ACCESS (http://www.oacn.inaf.it/ACCESS/) aimed to identify and understand which physical mechanisms are responsible of galaxy evolution as function of galaxy mass and environment in the Shapley supercluster. We have found a significant increase in the faint-end slope going from high-density to low-density environments, while a faint-end upturn at MK $>-21$ becomes increasingly apparent in the lower density regions. The SMF of supercluster galaxies is characterized by an excess of massive galaxies that are associated with the brightest cluster galaxies. While the value depends on the environment, increasing by 0.2dex from low- to high-density regions, the slope of the galaxy SMF does not vary with the environment. By comparing our findings with cosmological simulations, we conclude that the environmental dependences of the LF are not primarily due to variations in the merging histories, but to processes which are not treated in the semi-analytical models, such as tidal stripping or harassment. In field regions, the SMF shows a sharp upturn below, close to our mass limit, suggesting that the upturns seen in our K-band LFs, but not in the SMF, are due to this dwarf population. The environmental variations seen in the faint end of the K-band LF
suggest that these dwarf galaxies, which are easier to strip than their more massive counterparts, are affected by tidal/gas stripping upon entering the supercluster environment.

The Symbiotic Relationship Between the Environment and Evolution of Galaxies in Groups

E.M. Wilcots, M. Riabokin

The vast majority of galaxies reside in groups and it is becoming increasingly clear that much of the transformation of galaxies occurs in groups prior to their infall into larger clusters. We report on the results of a radio survey that shows how the evolution of the group environment influences the evolution of the resident galaxies and how feedback resulting from the evolution of individual galaxies influences their larger environment. We also show that the onset and impact of feedback in groups is itself a function of the environment.

Galaxy Groups in the Coma-A1367 Supercluster


Groups of galaxies may be the dominant environment in determining galaxy evolution. The combination of close encounters and major mergers may stimulate star formation and AGN activity, and may be responsible for “pre-processing” of galaxies as they fall into clusters. We combine the HI observations of galaxy groups in the Coma-Abell 1367 Supercluster from a 4 degree wide strip of the ALFALFA survey between +24d and +28d from 11h to 14h, with pointed Hα observations from the WIYN 0.9 m telescope. The presence of HI is a measure of the star formation potential of a galaxy, and its spatial distribution reveals the history of recent and on-going interactions between galaxies and with their local environment, while Hα observations reveal the current star formation activity. The groups we observe, determined from 2MASS, span a range of global environments from highest density sub-clumps falling into the center of the Coma cluster, to groups that make up the filament between the Coma and Abell 1367, to poor groups that exist on the edges of voids. We present the HI mass function and global star formation rates for the galaxy groups in an attempt to understand the role of environment in driving galaxy evolution.

Neutral hydrogen in early-type galaxies: the importance of environment

P. Serra, Atlas3D team

I will present the result of a large observational campaign to observe neutral hydrogen (HI) in the volume limited Atlas3D sample of nearby early-type galaxies. Observations were made with the Westerbork telescope, and are establishing the HI properties of early-type galaxies with an unprecedented combination of depth, angular resolution and statistics. We find that ~50% of all early-type galaxies outside the Virgo cluster contain HI (in striking contrast with the ~0% detection rate known to hold inside Virgo). Of these, about half host regular, rotating HI discs/rings, which can be concentrated inside the stellar body of the galaxy or extended up to tens of stellar effective radii. Regular HI distributions are found mostly in galaxies living in very low-density environments, while early-type galaxies living in intermediate environments (e.g., galaxy groups) are characterised by disturbed HI morphology, indicative of recent and on-going gas stripping/accretion. I will discuss the lessons that neutral hydrogen can teach us about the formation and evolution of these galaxies in different environments.
The optical+NIR (grizYJHK) Fundamental Plane of Early-type Galaxies: Dependence on local and global environment

F. La Barbera, P.A.A. Lopes, R.R. de Carvalho, I.G. de La Rosa, A.A. Berlind

Using a sample of 39,993 Early-Type galaxies (ETGs) for which data is available from SDSS and UKIDSS, we have undertaken a Spheroid’s Panchromatic Investigation in Different Environmental Regions (SPIDER). We focus on the environmental dependence of the optical+NIR Fundamental Plane (FP) relation. The environment is characterized through local (e.g. galaxy density) and global (e.g. parent group mass) observables, using the largest 3D group/cluster catalog generated from SDSS at low redshift ($z < 0.1$). We find a strong variation of the FP offset with local density in all wavebands, with the variation depending on the galaxy parent halo mass. A clear environmental dependence of the FP slopes is also detected: the “tilt” of the FP is larger for groups relative to field ETGs, and the variation of FP slopes with waveband depends on the galaxy parent halo mass. These results provide important clues for the galaxy evolution scenario, as they constrain the variation of stellar population properties, and dynamical-to-stellar mass fraction, as a function of galaxy mass.

Environment and self-regulation in galaxy formation

D. Thomas, C. Maraston, K. Schawinski, M. Sarzi, J. Silk

The environment is known to affect the formation and evolution of galaxies considerably best visible through the well-known morphology-density relationship. In this paper we study the effect of environment on the evolution of early-type galaxies by analysing the stellar population properties of 3,360 galaxies morphologically selected by visual inspection from the SDSS in the redshift range $0.05 < z < 0.06$. We find that the distribution of ages is bimodal with a strong peak at old ages and a secondary peak at young ages around $\sim 2.5$ Gyr containing about 10 per cent of the objects. This is analogue to ‘red sequence’ and ‘blue cloud’ identified in galaxy populations usually containing both early and late type galaxies. The fraction of the young, rejuvenated galaxies increases with both decreasing galaxy mass and decreasing environmental density up to about 45%. The rejuvenated galaxies have lower $\alpha$/Fe ratios than the average and most of them show signs of ongoing star formation through their emission line spectra. All objects that host AGN in their centres without star formation are part of the red sequence population. We confirm and statistically strengthen earlier results that luminosity weighted ages, metallicities, and $\alpha$/Fe element ratios of the red sequence population correlate well with velocity dispersion and galaxy mass. Most interestingly, however, these scaling relations are not sensitive to environmental densities and are only driven by galaxy mass. We infer that early-type galaxy formation has undergone a phase transition a few billion years ago around $z \sim 0.2$. A self-regulated formation phase without environmental dependence has recently been superseded by a rejuvenation phase, in which the environment plays a decisive role possibly through galaxy interactions.

Does environment affect the star formation histories of elliptical galaxies?

I. Ferreras, A. Pasquali, B. Rogers, S. Kaviraj

Elliptical galaxies provide one of the best test beds to study the standard paradigm of galaxy formation via hierarchical build-up. One key observable is the effect of environment on the star formation history of galaxies (SFH), providing a potentially powerful way to constrain the baryonic
physics behind this theory. Using the process of Principal Component Analysis on a 7,000-strong sample of early type galaxies from SDSS, we derive two model independent parameters to investigate their star formation histories. One of these two parameters is found to be mostly sensitive to average stellar age, the other sensitive to small amounts of recent star formation. This result was confirmed using GALEX NUV photometry. We investigate the effect of environment in two ways: I. Dark Matter Halo masses of galaxy groups from the catalogue of Yang et al. II. Close pairs involving only early-type galaxies (i.e. a prototypical dry merger precursor). We find that while environment plays a secondary role to stellar mass it has a measurable effect on the SFH of elliptical galaxies, with close pair interactions a possible cause for the recent star formation seen in these systems.

**Are boxy/disky Ellipticals dependent on environment?**

*B. Haeussler, M. Gray, STAGES collaboration*

Boxy and disky isophotes in elliptical galaxies are an imprint of their formation history, equal mass mergers of spiral galaxies and major mergers of ellipticals forming boxy ellipticals and unequal mass mergers of spiral galaxies forming disky ellipticals. It is therefore interesting to examine the boxyness of early-type galaxies, particularly Ellipticals, as a function of environment in large cluster systems, especially as N/body simulations also predict a higher number of disky versus boxy ellipticals in overdense regions. Using high-resolution HST data from the STAGES survey, centered on the Abell901/902 supercluster and with 1/4 deg$^2$ one of the biggest HST surveys in existence, we investigated this dependence. Taking extreme care of the setup of the codes used (particularly ELLIPSE), we ran the analysis on a sample of 292 Ellipticals inside and outside the cluster at a redshift of $z \sim 0.163$ and 266 S0 galaxies at the same redshift range for testing purposes, one of the biggest samples examined for this effect. Although other groups have found environmental dependencies before, I will show that no such dependence is found in the STAGES survey data. The ratio of boxy to disky galaxies stays constant over the whole range of environment and galaxy density present in the field examined.

**An environmental Butcher-Oemler effect in intermediate redshift X-ray clusters**

*S. Urquhart, J. Willis, H. Hoekstra*

For a sample of 66 X-ray selected galaxy clusters with well determined X-ray temperatures spanning the range $1 < kT(\text{keV}) < 12$, we present uniform CFHT Megacam g and r photometry. These clusters occupy the redshift interval $0.04 < z < 0.41$. We investigate the colour bimodality of the cluster galaxy populations and compute blue fractions using the criteria derived from Butcher and Oemler (1984). We identify a clear environmental dependence of cluster blue fraction in that cool (low mass) clusters display higher blue fractions than hotter (higher mass) clusters. Also computed is the local galaxy density using the fifth nearest neighbour distance as a measure of local environment. In doing this, the effects of the global environment (ram pressure stripping) can be compared with those of the local environment (galaxy-galaxy interactions).

**The line-of-sight velocity modulation of star formation diagnostics in and near galaxy clusters: observations and theory**

*G. Mamon, S. Mahajan, S. Raychaudhury*

Analyzing diagnostics of recent star formation of galaxies around 268 clusters with SDSS data, we
show that the trends of decreasing star formation with increasing projected radius are modulated by the absolute line-of-sight velocity. We then deproject the fraction of recent starburst galaxies (RSBGs) and use cosmological simulations to calibrate models involving virial, infall and backsplash populations to explain the observed velocity modulation of the radial trends. Our analysis provides us a quantitative measure of how star formation is quenched during the first passage through a cluster.

**Galaxy evolution in clusters since z~1**

*A. Aragon-Salamanca*

Galaxy clusters provide some of the most extreme environments in which galaxies evolve. They are therefore excellent laboratories to study the age-old question of “nature” vs. “nurture” in galaxy evolution. In this talk I will review some of the key observational results obtained during the last decade on the evolution of the morphology, structure, dynamics, star-formation history and stellar populations of cluster galaxies since the time when the universe was half its present age.

**The role of galaxy stellar mass in the colour-density relation up to z~1**

*Cucciati, Iovino, Kovac, Scodeggio, Lilly, zCOSMOS Team*

It is well known that galaxy properties correlate with the local environment in which galaxies reside. In contrast, it is still a matter of debate why and when these environmental dependences originate, and whether only one “main” property depends on environment, thus driving all the other environmental dependences via the correlations among properties themselves. Using the first zCOSMOS spectroscopic data (about 10000 galaxies), we analyze density effects on galaxy U-B colour, D4000 Angstrom break and specific star formation rate up to z=1, with local environment ranging from very low densities up to the highest density peaks. We pay attention to the role of both luminosity and stellar mass in selecting galaxy populations for environmental studies, and in particular we focus on the triple colour-mass-density relation, disentangling environmental effects on the two properties.

**From poor fields to rich clusters: the detailed role of the environment on galaxy formation and evolution at z~1**

*D. Sobral, P. Best, I. Smail, J. Geach, M. Cirasuolo, HiZELS collaboration*

At z=0, clusters are primarily populated by red, elliptical and massive galaxies, while star-forming, spiral and lower-mass galaxies are common in low-density environments. Understanding how and when these differences were established is of absolute importance for our understanding of galaxy formation and evolution, but, currently, and despite some progress, results at high-z remain contradictory. By taking advantage of the widest and deepest HI narrow-band survey at z~1 over the COSMOS and UKIDSS UDS fields, we will detail how star-formation activity, morphology, colour, downsizing trends and the HI luminosity function depend on environment over the full range of local densities at z~1 (from poor fields to rich groups and clusters, including a confirmed super-cluster with a striking filamentary structure) and show that previously contradictory results can be completely reconciled by probing such a wide range of environments and, most importantly, by understanding the important inter-relations between environment, stellar mass, merging activity and colour at z~1.
Galaxy properties in different environments at high redshift in the GOODS NICMOS Survey


In this study we investigate the influence of stellar mass and local density on galaxy rest-frame colour and star formation rates at redshifts between $1.5 < z < 3$ based on observational data from a deep HST H-band survey of unprecedented depth, reaching a stellar mass completeness limit of log $M^* = 9.5$ $M_\odot$ at $z=3$. We find that galaxy colour, SFR and specific SFR depends strongly on galaxy stellar mass at all redshifts up to $z \sim 3$. We detect a very weak but significant influence of local galaxy density on rest-frame (U-B) colour over the whole redshift range, which does not seem to be caused by stellar mass trends alone. To summarize, our data suggests that stellar mass is the most important factor in determining the SFRs and colours of galaxies in the early universe up to $z \sim 3$. Local density has a small but significant additional effect, which depends on stellar mass: low-mass galaxies are marginally redder in high relative overdensities, while high-mass galaxies in overdense regions tend to have bluer colours. The red sequence is built up very early and emerges at $z \sim 2.7$, which is when the most massive galaxies start to appear red due to decreasing star formation rates and the subsequent passive evolution of their stellar populations. This process might happen in the most dense local environments, suggesting that some of the star formation happening in the more massive galaxies is triggered by environment-related processes such as galaxy interactions and merging.

Modeling the evolution of galaxies as a function of environment

G. De Lucia

I will give a summary of galaxy evolution processes in hierarchical cosmologies and of their relative importance at different masses, times, and environments. I will discuss processes that are commonly included in modern semi-analytic models of galaxy formation, and I will comment on recent results and open issues.

The origin of the morphology-density relation

D. Wilman, G. de Lucia, J. Mulchaey

The origin of the morphology-density relation is one of the longest standing puzzles in extragalactic astronomy, predating even Dressler’s 1980 quantification of the $z=0$ relation in galaxy clusters. A number of important questions can be asked: * Why do most galaxies with insignificant levels of star formation also contain massive pressure-dominated stellar systems (ellipticals or massive bulges in S0s)? * How do we explain the relative lack of evolution in the fraction of massive ellipticals since $z \sim 1$, and their overabundance in high density regions and halo cores? * Why do most passive galaxies newly formed since $z \sim 0.5$ retain their disks as S0s, and why is the S0 fraction - density relation much flatter than for ellipticals, such that they are commonly found in low mass groups? * Can we explain the ubiquity of hot halo gas in both ellipticals and S0s in all environments in the context of ICM-ISM interactions? We present data supporting the posts behind these questions, and going some way towards answering them: the environmental dependence of morphological types at different redshifts and the morphological dependence of hot halo gas in clusters, groups and field environments. We then present the results from a new recipe for morphological evolution in mergers, inspired by SPH simulations, and applied to a semi-analytical model. This goes some
way to explain the origin of the morphology-density relation and the relative importance of the myriad physical processes usually invoked as potential explanations.

The grouping, merging and tidal stirring of dwarf galaxies in the Local Group

*E. Lokas*

I will present the results of a study of the evolution of a population of subhaloes in a simulated Local Group from the point of view of the effects it may have on the origin of different types of dwarf galaxies. I will focus on the processes of tidal stripping of the satellites, their interaction, merging and grouping. The tidal stripping manifests itself in the transition between the phase of mass accretion and mass loss seen in most subhaloes, which occurs at the moment of infall on to the host halo, and the change of the shape of their mass function with redshift. Although the satellites often form groups, they are loosely bound within them and do not interact with each other. Mergers between prospective subhaloes are significant only during an early stage of evolution but such events could contribute to the formation of more distant early-type Milky Way companions. I will also describe high resolution simulations of individual two-component dwarf galaxies with a disk evolving in the tidal field of the Milky Way and mergers of disky dwarfs. I will demonstrate that both can lead to the formation of dwarf spheroidal galaxies by morphological transformation of their stellar components and the transition from ordered to random motion of the stars.

Ram Pressure Stripping and Gravitational Interactions in Groups and Clusters

*J. Kenney*

I review the observational evidence for ram pressure stripping in nearby group and cluster galaxies, and the roles of ram pressure stripping, tidal interactions and starvation in cluster galaxy evolution. I describe several diagnostic indicators of active ram pressure, and how to distinguish ram pressure stripping from tidal interactions. Both effects play a significant role in transforming the populations of spirals and dwarfs in the densest regions of the universe.

Ram-pressure-stripped galaxies - Which are their survivors?

*G. Hensler, A. Boselli, K. Sternig*

Galaxies that fall into the gravitational potential of galaxy clusters experience the existence of hot tenuous intra-cluster gas. Ram pressure pushes the interstellar medium out of galaxies, easier for the low-mass galaxies and therefore already in the outermost cluster regions. Normal spiral galaxies are observed in the act of gas stripping within the denser intra-cluster medium. Numerical models over the last years are performed with different numerical schemes and match almost equally with the observations of ram-pressure stripping (RPS) galaxies. Since such models almost always consider only constant ram-pressure conditions they finish at the maximum effect and mostly do not follow the further path of stripped galaxies to their apocentric orbit when the ram pressure declines. There, however, the appearance of galaxies with RPS-truncated gaseous disks lacks in the outskirts of clusters. Their radial distribution should clearly differ from that of normal morphologies. Theoretically, two possible outcomes can be imagined: One possibility is that additional dispersal effects, like e.g. Kelvin-Helmholtz instability or heat conduction, withdraw the remaining gas and produce disk-dominated S0s. If gaseous disks survive the RPS they could also re-organize...
their gas distributions by radial pressure effects and can be identified as HI-deficient spirals. We studied both candidates in the Virgo cluster and will present their radial distributions.

**Gravity at work: How high density environments regulate galaxy properties**

*S. Khochfar*

We present results on how the conversion of gravitational potential energy from infalling satellites in high-density environments is able to influence the evolution of galaxies. We focus on the star formation history and formation epoch of galaxies, and show how these can be brought into better agreement with observation once gravitational heating is considered. Gravitational heating has a contribution comparable to that of AGNs, and can provide significant heating at late time in clusters, stopping cooling flows in them. We will show results of a detailed investigation on the magnitude of these effects and the epoch at which they occur.

**Posters**

**Simulations of star counts and galaxies towards VVV survey region**

*E. Amôres, N. Padilla, L. Sodré, D. Minniti, B. Barbuy, VVV collaboration*

Vista Variables In The Via Lactea (VVV) is an ESO variability survey (http://www.vvvsurvey.org) that is performing observations in near infrared bands (J,H,K,Y and Z) towards the galactic bulge and part of the disk. It is observing not only galactic objects but also extragalactic objects (galaxies and QSO’s) despite the large extinction of up to AV < 30 mag in the galactic plane. One of the ways to identify/separate galaxies from stars is based on the analysis of the color-color and color-magnitude diagrams that allow us to identify stellar/galaxy loci in those diagrams. In the present work, we present results of simulations for star and galaxy counts using a Galaxy and Large-Scale Structure Model (respectively) towards VVV survey region. In total there are around 3 billions and 2 millions of simulated stars and galaxies, respectively, up to the survey limiting magnitude. Those simulations were performed using the most recent and realistic extinction models. In the case of the galaxy simulations, these come from the semi-analytic galaxy formation model of Bower et al. (2006) applied to the Millennium simulation (Springel et al., 2006). Our results consist of color-color and color-magnitude diagrams in the space of the colors (JHKYZ) for stars and galaxies. They also include the expected observed distribution of background galaxies, as well as the expected number of stars that will be observed by VVV in any range of magnitude, colors, spectral types and distances for each galactic component (disk, bulge and halo), which is also useful for several VVV projects.

**SDSS/GALEX Mergers and their Environments as Probes of Galaxy Formation and Evolution**

*C. Anthony, S. Kaviraj*

Mergers are fundamental to the standard hierarchical paradigm of galaxy formation. They produce intense star formation episodes, driving the build-up of stellar mass and black holes and alter
the morphological mix of the universe. While they are routinely included in galaxy formation models, the evolution of star formation and AGN activity has not been fully explored from a purely observational perspective. I have used observational evidence using SDSS and GALEX data to test currently accepted models of galaxy evolution by analysing galaxy close pairs drawn from the SDSS (using code which picks out nearby/interacting galaxies using their angular separation and spectroscopic redshift difference). UV and optical photometry is used to estimate the recent star formation in close pair systems as a function of separation, galaxy properties (e.g. morphology and luminosity) and global environment. SDSS spectra is used to probe the properties of AGN in the merging systems and the interplay between star formation and AGN activity is studied using a large homogeneous dataset. The results provide constraints on our current theoretical infrastructure and provide a picture of how merging affects galaxy evolution from an observational perspective using state-of-the-art spectro-photometric data from current large-scale observational surveys.

Simulations of shell galaxies with GADGET-2: the influence of dark matter profiles on the distribution of shells

K. Bartoskova, B. Jungwiert, I. Ebrova, L. Jilkova, M. Krizek

The process of creation of shell galaxies can contribute to probing dark matter distribution in elliptical galaxies. In this poster we present N-body simulations of a minor merger using the code GADGET-2. Self-consistent simulations of a head-on collision reveal merger remnants in the form of a shell galaxy. Because of the self-consistent treatment of the gravity, the effects of dynamical friction and the tidal forces are naturally present. These were not involved in most previous simulations of shell galaxies. Inner shells are also detected, in agreement with observations. However, the shell distribution depends on the chosen mass distribution of the primary massive galaxy. We select various combinations of two-component models (stars and dark matter) for the primary elliptical galaxy, taking into account current constraints on dark matter models. Such a study was never done in great detail before. We discuss the differences in resulting shell structures.

Ram pressure stripping of hot galactic halos in galaxy clusters

V. Baumgartner, D. Breitschwerdt

The intracluster medium (ICM) in galaxy clusters contains heavy elements with about 1/3 of the solar abundance. These heavy elements are the products of stellar nucleosynthesis and are either expelled by galactic winds or lost from the galaxies due to interactions with the intracluster gas. We investigate the stripping of hot, high-metallicity galactic halos, which occurs as galaxies are moving through a cluster, being subject to the ram pressure of the ICM. Our new model for ram pressure stripping differs from earlier models (e.g. Gunn & Gott 1972), since it includes processes inside the galaxies like the transport of gas from the disk into the halo. Taking into account different components of the interstellar medium and their vertical distribution, we get a more realistic and detailed stripping criterion.

Testing the hierarchical scenario with field disk galaxy evolution

A. Boehm

We have constructed a data set of >250 field disk galaxies at redshifts 0.1 < z < 1.0 with Very Large Telescope (VLT) spectroscopy and Hubble Space Telescope imaging. This is one of the largest kinematical samples of distant disks to date. We use spatially resolved rotation curves to
derive maximum rotation velocities $V_{\text{max}}$ and total masses; we also investigate disk sizes, bulge-to-disk ratios, stellar population properties etc. The stellar-to-total-mass ratios are constant over the probed cosmic epoch, which favors a HIERARCHICAL buildup of the dark matter halos the disks reside in. On the other hand, the mean stellar mass-to-light ratios evolve more strongly in the low-mass galaxies than in high-mass galaxies and the mean stellar ages are lower for low-mass galaxies than for high-mass galaxies. This points to an ANTI-HIERARCHICAL evolution of the stellar populations (aka “downsizing”), possibly due to supernova feedback. We will also present the first results from our latest survey of very low- and very high-mass disks at redshift $z \sim 0.5$; these data are among the deepest spectra of distant galaxies ever taken with the VLT. In particular, we aim at a better understanding of the Tully-Fisher Relation and the correlation of $V_{\text{max}}$ with central stellar velocity dispersion.

The transformation of Virgo galaxies under the influence of ram pressure

S. Boissier, A. Boselli

We show that simple models of chemical/photometric evolution of galaxies allow to study the transformation of galaxies under the influence of ram pressure in the Virgo cluster. With the new data of the large surveys of Virgo in progress (NGVS in the optical, GUViCS in the UV), we will be able to develop such approaches to a larger number of galaxies.

The assembly of massive galaxies through mergers in the local universe

P. Brochado, J. Brinchmann, C. Lobo

Within the LCDM cosmology, mergers of galaxies are a key path in the assembly of new galaxies. To understand the processes behind mergers and their role in the build up of the high mass end of the galaxy mass function, we made use of the spectroscopic catalogue of the Sloan Digital Sky Survey Data Release 6 (SDSS DR6). We present the merger sample of close pairs and groups drawn from SDSS DR6 - selecting galaxies with projected separation of $r_p \leq 30$ kpc and velocity offset of $\Delta v \leq 800$ km/s in the redshift range $0.005 < z < 0.2$ - containing 4000 visually classified potential mergers, including the largest dry merger sample known to date. We show that there is an enhancement of star formation activity of a factor of 2 and investigate the decrease on AGN activity for small galaxy separations. We focus in particular on the role of dry mergers in the build-up of the most massive galaxies showing that massive present-day elliptical galaxies have spectra consistent with the merging of two gas-poor progenitors and that $< 15\%$ of the most massive end of the mass function ($\log(M/M_\odot) > 11.0$) has been built up by dry mergers since $z=0.2$.

3D spectroscopy unveils minor merging in massive galaxies

F. Buitrago

Massive (stellar mass $\geq 10^{11} M_\odot$) galaxies at high redshift ($z \geq 1.5$) are not very well understood both observationally and in simulations. Their extremely small sizes (effective radii of 1-2 kpc) make them as dense as globular clusters, whereas in the present day Universe they consist of large galaxies with old and metal-rich stellar populations. In every location they are thought to be the most massive members of their respective environments and thus a key piece to comprehend how galaxies and their surroundings evolve. In order to explore this development, we present near IFU
observations with SINFONI at VLT for ten massive galaxies at z~1.4 solely selected by their high mass. 3D spectroscopy allow us to retrieve velocity dispersions, kinematic maps and dynamical masses for them. We joined this with data coming from GOODS NICMOS Survey, which was performed by our group and is the biggest sample of massive galaxies (80 objects) at high redshift (1.7 < z < 3) to date. As a result, we will show an integral view about the different processes massive galaxies undergo. This includes merging with neighbouring galaxies. Due to the great sensitivity of both sets of images not only major mergers are seen but even the elusive minor events.

NGC 4262: a Virgo galaxy with an extended ultraviolet ring

_D. Bettoni, L. Buson, G. Galletta_

GALEX satellite has recently shown the presence of an extended, outer ring studded with UV-bright HII regions surrounding the otherwise normal lenticular galaxy NGC 4262. Such a structure is coupled with a ring of cold (HI) gas. Having structured UV-bright sources beyond its optical disc, NGC 4262 can be classified as a Type I extended ultraviolet disc (XUV).

The colours, AGN properties, environments and star formation histories of bulge dominated post-mergers in the local universe

_A. Carpineti_

Galaxy merging is a fundamental aspect of the standard hierarchical galaxy formation paradigm. In Darg et al. (2010MNRAS.401.1043) we have created a large, homogeneous set of mergers through direct visual inspection of the entire SDSS using the GalaxyZoo project, a public user interface on the world wide web for the morphological classification of galaxies. At the time of writing, over 200,000 volunteers have submitted over 80 million classifications yielding a robust catalogue of around 3000 mergers which has been presented in Darg et al. We explore a subset of galaxies from this catalogue that are ‘post-mergers’, where the remnant appears to be in the final stages of relaxation. We focus on post-mergers that show evidence for a dominant bulge, making them plausible progenitors of early-type galaxies. For this set of galaxies we explore their GALEX-SDSS UV/optical colours, AGN activity, local environments and star formation histories. 64% of our galaxies are either quiescent or show LINER-like emission, while the rest are either star forming (9%) or have Seyfert AGNs (25%). We find that the plausible mass ratios for the mergers that created these systems are between 1:1 and 1:10, with a median value of around 1:3. The spheroidal postmergers have bluer colours than the general elliptical galaxy population, most likely due to merger-induced star formation. Comparison with stellar models suggests that the star formation activity in most of these systems peaked less than 1 Gyrs ago, suggesting that some of star formation recently discovered in early-type galaxies is merger-driven.

Component Pairs Luminosity Functions in the Millennium Galaxy Catalogue

_K. Casteels, D. Patton_

We present new methods for measuring luminosity functions (LFs) of galaxies in close pairs as a probe for luminosity changes in interacting and merging systems. Using mock catalogues we develop techniques for creating global and component (bulges-ellipticals and disks) pairs LFs. We also explore how imposing fixed magnitude ranges (ΔM) between pairs can be used to obtain
pairs LFs for majors and minor merger pairs. These techniques are then applied to the publicly available GIM2D bulge/disk decomposition Millennium Galaxy Catalogue (Allen et al. 2006) for pairs in the ranges \( r_p < 50 \text{ kpc}, \Delta V < 500 \text{ km/s}, \) and \( -17 > MB > -22. \) We find that the global pairs LF has considerably more power towards the bright end compared to the field LF. We also find that all the pairs components have more power towards the bright end of their pairs LFs compared to their field counter parts. The disk and red bulge-elliptical pairs LFs show less luminosity enhancement compared to the global pairs LF, whereas the blue bulge-elliptical pairs LF shows the greatest increase in power towards the bright end. These results indicate that luminosity dependent clustering is definitely taking place, and there is also evidence for significant luminosity enhancement in the blue bulges and ellipticals, possibly due to increased star formation. When a \( \Delta M \) is introduced between galaxy pairs to isolate major mergers, we find that as \( \Delta M \) decreases, the pairs LFs gain even more power towards the bright end.

Ages of globular cluster systems related to galaxy morphology

Some photometric studies of globular cluster (GC) systems using the optical/ near-infrared colour combination have suggested the presence of a great fraction of intermediate-age (2-8 Gyrs) GCs in apparently normal elliptical galaxies with old stellar populations, such as NGC 4365. Using homogeneously derived K-band LIRIS/WHT and archival g and z ACS/HST photometry, we investigate the age distributions of GC systems in 14 E/S0 galaxies. Without relying on SSP models, we perform a relative comparison between the different GC systems quantifying relative age differences. The age distribution of GCs in NGC 4365 appears to be similar to that of other large ellipticals, like NGC 4486 and NGC 4649. We find a correlation between the morphological type of a galaxy and its mean relative GC system age. Galaxies with simple morphology such as E0s, E1s and E2s seem to have on average genuinely old clusters whereas S0s have younger GC systems. Surprisingly, this appears to be driven by the more metal-poor clusters. I will discuss the implications of this finding to the formation/assembly of GC systems and their host galaxies.

Distinct core and halo stellar populations and the formation history of the bright Coma cluster early-type galaxy NGC 4889
L. Coccato, O. Gerhard, M. Arnaboldi

We measure the stellar kinematics and the stellar population of the brightest cluster galaxy (BCG) NGC 4889, reaching unprecedented regions at \( \sim 60 \) kpc (4 Re) from its center. We construct radial profiles of metallicity, \([\alpha/Fe]\) abundance ratio and age, from the center out to its halo, probing for the first time the stellar population in the outer halo of a BCG. Our data show that the central (R<18 kpc) and outer (R>18 kpc) parts of NGC 4889 have different stellar population contents and gradients, suggesting different formation histories between the galaxy and its halo. Data for the central parts are indicative of a quasi-monolithic scenario, in which stars formed outside-in, after a single rapid burst. Those for the outer regions indicate that the halo formed later, from shredded satellites that accreted the halo during a series of minor mergers. This is consistent with numerical simulations of formation of BCGs, and the dense environment in which these objects are located. The different chemical properties between the central galaxy and its halo may represent the stellar population signature of the size evolution of NGC 4489, in a scenario in which the halo
was accreted on the top of a galaxy of smaller size. This is consistent with the recent findings of the redshift evolution of the sizes of early-type galaxies.

**AGN feedback and quenching of star formation: a multiwavelength approach with the EURO-VO**

*C. Lobo, S. Anton, B. Coelho, I. Marquez, J. Masegosa*

We selected bulgeless red sequence galaxies of the SDSS (DR7) using Sersic indices and colours data, compiled on the New-York University Value Added Galaxy Catalogue (NYU-VAGC, Blanton et al. 2005), we obtained about a hundred objects. Using EURO-VO tools we collected multiwavelength data (images and information on fluxes in different wavebands) available for these objects. We built spectral energy distribution of these objects, and undertook a thorough analysis to ascertain: the frequency of AGN among these galaxies, the degree of star formation and intrinsic extinction. We want to determine: how common are bulgeless galaxies with SMBHs and how red and dead are they?

**Unravelling the origins of S0 galaxies using maximum likelihood analysis of planetary nebulae kinematics**

*A. Cortesi, PNS consortium*

To better understand the origins of S0 galaxies, we present a new method of analyzing their stellar kinematics from discrete tracers such as planetary nebulae. This method involves binning the data in the radial direction so as to extract the most general possible non-parametric kinematic profiles, but using a maximum likelihood fit within each bin in order to make full use of the information in the discrete kinematic tracers. Both disk and spheroid kinematic components are fitted, with a two-dimensional decomposition of imaging data used to attribute to each tracer a probability of membership in the separate components. Likelihood clipping also allows us to identify objects whose properties are not consistent with the adopted model, rendering the technique robust against contaminants and able to identify additional kinematic features. As a first test of the method, we apply it to the S0 system NGC 1023, for which a PN catalogue has already been released and analyzed by Noordermeer et al. (2008). This new analysis demonstrates that the peculiar kinematic properties previously attributed to this galaxy can be fully explained by contamination from spheroid stars. Its stellar kinematics are, in fact, indistinguishable from those of a normal spiral galaxy, indicating that it may have evolved directly from such a system via gas stripping. The method also has sufficient sensitivity to identify a relatively small population of stars that do not fit with the kinematics of the main galaxy, but appear to be a star stream associated with an ongoing minor merger. We are currently applying this analysis technique to observations of a larger sample of S0 galaxies whose PNe kinematics have been observed with PN.S; by obtaining a measure of the stellar kinematics of S0s in a range of field, poor and rich group and environments, we will be able to see if they all have the stripped-spiral properties of NGC 1023, and hence whether there is a single route to S0 formation.

**The VIMOS VLT Deep Survey: a homogeneous galaxy group catalogue up to z∼1**

*Cucciati, Marinoni, Iovino, Bardelli, Adami, VVDS Team*

We present a homogeneous and complete catalogue of optical galaxy groups identified in the
VIMOS-VLT Deep Survey (VVDS). We use mock catalogues extracted from the Millennium simulation to study the potential systematics that might affect the overall n(z) distribution of the identified systems, and also to assess how well galaxy redshifts trace the line-of-sight velocity dispersion of the underlying mass overdensity. We train on these mock catalogues the adopted group-finding technique (the Voronoi-Delaunay Method, VDM), to recover in a robust and unbiased way the redshift and velocity dispersion distributions of groups and maximize the level of completeness and purity of the group catalogue. We identify 144 VVDS groups with at least 3 members within $0.2 \leq z \leq 1.0$. We use the group sample to study the redshift evolution of the fraction of blue galaxies (U-B≤1) within $0.2 \leq z \leq 1.0$ in both groups and in the whole ensemble of galaxies irrespectively of their environment.

An X-ray view on massive elliptical galaxies: Their dark matter content

P. Das, O. Gerhard, E. Churazov, I. Zhuravleva

Massive elliptical galaxies are huge conglomerates of stars, dust, dark matter and hot gas that emits lines and thermal bremsstrahlung radiation. In quiescent galaxies the hot gas is in hydrostatic equilibrium and therefore serves as a powerful probe of the gravitational potential. We have developed a new non-parametric Bayesian approach to obtain the most probable mass distributions and associated confidence ranges, given density and temperature profiles of hot gas in hydrostatic equilibrium. We applied this to Chandra and XMM-Newton observations of a sample of six nearby massive elliptical galaxies, occurring at the centre of dense environments in groups and the Virgo and Fornax clusters of galaxies. We find that at large radii, the mass profiles rise more steeply than isothermal profiles, supporting that the galaxies in the sample are embedded in the more massive group-sized haloes of the surrounding environments. Complementing the total mass information from the X-rays with photometry and stellar population models to infer the dark matter content, we find massive dark matter haloes with dark matter mass fractions of $\sim 35-80\%$ at $2Re$, rising to a maximum of $80-90\%$ at the outermost radii. We also find that the six galaxies follow a Tully-Fisher relation with slope $\sim 4$ showing that systems with more luminous stellar components reside in the deepest potentials. Finally, we find that more massive systems are found in denser environments, supporting that a larger number of systems fall onto the central system compared to in less dense regions.

A volume limited HI imaging survey at $z=0.2$

B. Deshev, M. Verheijen, J. van Gorkom, K. Dwarakanat, B. Poggianti

We present here results from our completed ultra-deep blind HI survey of two galaxy clusters at redshift $z=0.2$, performed with the Westerbork Synthesis Radio Telescope (WSRT). The field of the X-ray bright, massive Butcher-Oemler cluster Abell 963 was observed with a total of 117×12hrs integration time. Additionally, Abell 2192 was observed as an example of a more diffuse cluster, at similar distance, with a total of 73×12hrs integration time. In both fields, sampling a total volume of $7 \times 10^4 \text{ Mpc}^3$, the expected noise levels of 19 and $24 \times 10^{-6} \text{ Jy/beam}$ respectively, at a velocity resolution of 44 km/s, were achieved. This allows for a clear, 21cm view on the large scale structure in which the clusters are embedded, ranging from voids through filaments and groups infalling in the clusters to the centers of the clusters themselves. Additionally the entire primary beam of WSRT is imaged in B and R optical bands with INT (Isaac Newton Telescope). The $\sim 170$
detections with optical counterparts found in the two fields clearly outline the clusters and few groups, out to 5 Mpc away from the cluster centers. No galaxy with HI mass above our detection limit of $10^9 \, M_\odot$ is found in the central 1 Mpc of both clusters. The non-detection of the blue galaxies in the center of A963, responsible for the Butcher-Oemler effect, suggests that although still blue, those galaxies must have already lost most of their gas, probably due to interaction with the cluster environment. The space, velocity and mass distribution of the HI detections is presented here, with the complementary optical colors and morphology. This data base, combined with our deep optical imaging, UV GALEX data and IR Spitzer imaging will uniquely link gas content and star formation for galaxies in a wide range of environments, and shed a light on the gas content of the blue cluster population at intermediate redshift.

Local Galaxy Evolution as a Function of Mass and Environment

I. Drozdovsky

Based on the updated all-sky catalog of $\sim 8600$ Local Supercluster galaxies within 30 Mpc, we are presenting a new comparative study of the galaxy content and the mean characteristics of the nearby Universe (true “redshift-zero”) as a function of mass and environment. Our main goal is to shed light on the process of galaxy formation and evolution for two extreme low-/high-density environments: the isolated versus closely interacting galaxies. This would allow us to disentangle the effects of internal physical processes on the star formation history (SFH) from environment-related mechanisms. The formation and evolution of low-mass galaxies is of particular interest in this respect, since these simplest stellar systems are ubiquitous and less affected by an unknown galaxy assembly history. I would present results from two complementary studies: (i) the recent star formation and mean baryonic properties of the local Universe as a function of environment; (ii) the star formation and chemical enrichment histories of the nearby satellite versus isolated galaxies from their resolved stars (the LCID project). While the first project is focused on the current morphology-density properties of the Local Supercluster, the second “fossil records” study is able to probe entire SFH of the nearby galaxies, including the early-epoch (look-back time $> 8$ Gyr). Given the many recent advances in our understanding of the star formation history (SFH) of the Local Group (LG) and other nearby galaxies, and in the evolution of star formation with redshift, we also present an updated comparison of the comoving space density of the star formation rate as a function of look-back time for the Local and Distant Universe. While the recent episodic star formation activity is observed in dwarf galaxies, most dwarfs of the Local Group and its surroundings are also dominated by the old stellar populations with no apparent evidence for the ’downsizing’ effect in the galaxy evolution. The overall trend of star formation density from the LG supports a fairly flat evolution of the SFR without showing the turnover implied by the Lyman dropout measurements. This suggests factors of $\sim 10$ extinction correction to high-redshift UV-based measures.

Comparing the Redshift Evolution of Emission Line Galaxies behind the Virgo Cluster field


We present the first results from our survey of high-redshift galaxies behind the Virgo Cluster field. Two main objectives of this program are (i) to study the properties and contribution of the
Lyα emission line galaxies (LAE) to the Star Formation Rate Density (SFRD) of the Universe at $z > 3$; (ii) to explore the decline of Cosmic SFRD at $z < 1$ and the downsizing effect. Based on the analysis of deep images obtained in 500nm, Hα & 720nm narrow-band and various broad-band filters, we have identified a sample of $\sim 120$ candidate LAE and a few hundreds low-redshift emission line galaxies, reaching emission lines to a flux limit of $> 2 \times 10^{-18}$ ergs/sec/cm$^2$. Follow-up observations with the VLT/VIMOS and GTC/OSIRIS of one of the survey fields have confirmed our classification and redshifts. We measure star formation rates from the observed Ly-alpha, [OII], [OIII], or Hα line fluxes. In addition to the large area of this survey ($\sim 3$ deg$^2$ in total) and depth, a possibility to carry out both, the low-redshift (the outer Virgo intracluster objects) and high-redshift studies within the same field makes our survey unique. When our survey will be completed, by comparing the Luminosity Functions of $z > 3$ LAEs we will be able to shed light on the redshift evolution of these important tracers of star formation in the early Universe, testing alleged change in their properties between $4 < 5$, and estimate their contribution to the Cosmic SFRD.

New Approaches to Simulating Shell Galaxies Formation in Minor Mergers

I. Ebrova, B. Jungwiert, L. Jilkova, M. Krizek, K. Bartoskova

The mechanism of the formation of faint stellar shells around elliptical galaxies in a radial minor merger is known since the 80s. We simulate this process using time dependent analytical potentials that represent the merging galaxies together with millions of test particles. We developed a method which allows us to compute the dynamical friction acting on the dwarf galaxy during such merger. The method is based on the Chandrasekhar formula, but it takes into account the changes of density and velocity dispersion over the giant elliptical galaxy. In order to do this, we used the axial symmetry of our configuration to simplify the integrals over the impact parameter and velocity distributions so that they can be solved numerically. The combination of the friction and gradual disruption of the dwarf galaxy has never been modeled in much detail, and it has a dramatic impact on the positions and luminosities of the shells. These phenomena need to be considered in the context of probing the history of the merger in a shell galaxy. Furthermore we investigate the effect of the dark matter content on the resulting appearance of the structure taking into account the present state of knowledge of stellar and dark matter distributions in both giant and dwarf ellipticals.

Quadruple-peaked Line-of-sight Velocity Distributions in Shell Galaxies

I. Ebrova, L. Jilkova, B. Jungwiert, K. Bartoskova, M. Krizek, T. Bartakova, I. Stoklasova

As shown by Merrifield & Kuijken (1998) stellar absorption line profiles in shell galaxies can in principle be used to constrain the distribution of dark matter halos. We show, however, that line shapes are more complex than previously thought, a quadruple-peaked line profiles being more natural than the originally proposed double peaked-ones. We present the theoretical analysis of the line profile as well as several sets of numerical simulations of minor mergers and show how to derive halo properties from the positions of all the four velocity peaks.

An optical Study of Fossil Galaxy Groups
Numerical simulations as well as optical and X-ray observations have shown that poor groups of galaxies can evolve to what is called a fossil group. Dynamical friction as the driving process leads to the coalescence of individual galaxies in ordinary poor groups leaving behind nothing more than a central, massive elliptical galaxy supposed to contain the merger history of the whole group. Due to merging timescales for less-massive galaxies and gas cooling timescales of the X-ray intragroup medium exceeding a Hubble time, a surrounding faint-galaxy population and an extended X-ray halo similar to that found in ordinary groups, is expected. However, detailed studies of fossil groups in the optical have only been carried out for a handful of systems. Using both VLT VIMOS and WHT ISIS data we investigate the luminosity function of one fossil aggregate and the stellar population of six fossil group central ellipticals.

Reconciling a significant hierarchical assembly of massive early-type galaxies at $z \lesssim 1$ with mass-downsizing

M.C. Eliche-Moral, M. Prieto, J. Gallego, J. Zamorano

Recent studies derive opposite conclusions on the role of major mergers in the buildup of the present-day massive early-type galaxies (mETGs). In fact, hierarchical models predict that they must have finished their assembly at a quite late cosmic epoch ($z \sim 0.5$), conflicting with the observational phenomenon of galaxy mass-downsizing. In this talk, we present the results of a semi-analytical model that tries to test this question directly, by studying how the present-day mETGs population would have evolved backwards-in-time, under the hypothesis that each observed major merger has given place to an early-type galaxy. We will show that the model can reproduce the observed evolution of the galaxy LFs at $z \lesssim 1$, simultaneously for different rest-frame bands and selection criteria. Accordingly to observations, the model shows that: 1) the increase of the mETGs number density and of the stellar mass at the massive-end of the red sequence observed since $z \sim 1$ to the present can be explained just accounting for the effects of the major mergers strictly-reported by observations; 2) the wet major mergers must have controlled this buildup since $z \sim 1$, although dry and mixed mergers have also contributed significantly to it; 3) the bulk of this assembly takes place during the time-period of $\sim 1.4$ Gyr elapsed at $0.7 < z < 1$, being nearly frozen at $z \lesssim 0.7$; and 4) this frostbite can be explained just accounting for the observational decrease of the major merger fraction since $z \sim 0.7$. The most striking model prediction is that at least $\sim 87\%$ of the mETGs existing at $z \sim 1$ are not the passively-evolved, high-$z$ counterparts of present-day mETGs, but their gas-poor progenitors instead. This implies that $\lesssim 5\%$ of present-day mETGs have been really in place since $z \sim 1$. We will show that, accounting for this fact, the model is capable of deriving a final assembly redshift of mETGs in good agreement with hierarchical models, reproducing observational mass-downsizing trends at the same time.

Early-type galaxies in clusters at different redshifts to constrain their evolution

A. Ferre-Mateu, P. Sanchez-Blazquez, A. Vazdekis, I.G de la Rosa

I will present a new detailed stellar population analysis of early-type galaxies in one dense cluster at $z=0.83$ and two at $z\sim 0.55$. Unlike in previous studies at intermediate redshifts we aim at studying galaxies on an individual basis and fully characterize their stellar populations as a function of galaxy mass and cluster properties with increasing redshift. For this, we are using very high
S/N data obtained with GEMINI. The analysis of stellar population in high redshift early-type galaxies is, somehow, easier at higher redshift as the spectral properties vary much faster with age as for younger ages. Based on medium-quality SDSS spectra, our group has recently found that there exist clear correlations between key abundance ratio chemical clocks and cluster properties at $z \sim 0.1-0.2$, suggesting differences in galaxy cluster assembly timescales. For all three clusters, galaxies have been morphologically classified so we can focus in those that are confirmed early-types. We determine mean luminosity-weighted ages and a number of abundance ratios of species and their relation with the cluster properties.

**Stellar populations and HI complexes in the halo of M33**

*M. Grossi, N. Wang, E. Corbelli, C. Giovanardi, S. Okamoto, N. Arimoto*

The late-type spiral galaxy M33 is the brightest of M31’s satellites. While M31 is known to be a disturbed galaxy, M33 seems not to have undergone any recent or past mergers having a quite undisturbed stellar disc and no prominent bulge. On the other hand, the presence of a population of neutral hydrogen (HI) clouds, recently found in the outskirts of the galaxy with a blind 21-cm survey (ALFALFA), may give evidence for ongoing minor mergers, the recent arrival of external gas, or a past interaction with M31. We present Subaru/Suprime-Cam deep V and I observations of seven fields in the outer disc and halo of M33 in correspondence of the main HI features around this galaxy. We analyse the stellar population by means of I, V-I colour magnitude diagrams reaching down to the red clump. We find an extended distribution of red giant branch stars out to a deprojected radius of 30 kpc in the southeast and 40 kpc in the northwest direction from the center. Young stellar populations with age of around 100 Myr are found out to 20 kpc ($\sim 10$ visual scale lengths), between the main HI complex in the southeast and the galactic disc. We present preliminary results on the star formation history of these regions using the technique of synthetic CMD fitting, and we discuss whether the HI and stellar distributions could be related to a past interaction with M31.

**Nature and nurture in the evolution of faint galaxies: the relationship between stellar population parameters, velocity dispersion, morphology and environment**

*R. Grutzbauch, F. Annibali, A. Bressan, R. Rampazzo, W. W. Zeilinger*

We present a stellar population analysis for a sample of 11 faint early-type galaxies located in poor groups, i.e. low-density environments. The mean ages, metallicities, and $[\alpha/Fe]$ ratios were derived from the Lick indices through comparison with simple stellar populations (SSPs) accounting for variable $[\alpha/Fe]$ ratios. Our galaxies turn out younger, less metal rich, and less enhanced in the $\alpha$-elements than giant ETGs, in agreement with the extrapolation of the stellar population parameters vs velocity dispersion trends seen in giant ETGs. We also observe a strong positive correlation between $[\alpha/Fe]$ and the bulge-to-total light ratio, and between $[\alpha/Fe]$ and the Sersic index $n$: less concentrated, more disky galaxies exhibit lower $[\alpha/Fe]$ ratio, which can be interpreted with longer star formation time-scales or steeper initial mass function. Comparing our sample with Coma dwarfs, we find that environment strongly affects the evolution of faint galaxies: the $[\alpha/Fe]$ ratios increase from low to high densities. By contrast, no strong difference in the $[\alpha/Fe]$ ratios is observed for giant ETGs in the field and in the cluster. This could be explained with that massive ETGs completed their star formation process at early times, before the emergence.
of structures, and do not exhibit today a strong environmental dependence. On the other hand, low mass galaxies, which evolved much slower (according to downsizing) and could eventually feel the effect of environment, bring today the clear sign of “nurture”. This scenario is in agreement with findings based on large redshift surveys, which revealed an increasing environmental effect on galaxy evolution moving from higher to lower redshift, and from higher to lower galaxy stellar masses.

**Compact Radio Cores: blazars and more**

*J. Gupta*

Radio-loud active galactic nuclei are now recognised to play a vital role in the process of galaxy formation, providing feedback which regulates the star-formation process. Logically, it follows that we must understand AGN in order to understand galaxy formation and evolution. However, the details of AGN feedback are unclear, it is still not known what triggers the bursts of AGN activity, how long the bursts of activity last or how the bursts evolve. Blazars are a subset of radio-loud AGN where one of the radio jets is directed towards the observer at a small angle to the line of sight. Therefore in blazars we get the most direct view of the relativistic jets that may ultimately provide the feedback. Blazar samples in the past have been plagued with selection effects which make it impossible to differentiate between intrinsic properties and selection-induced trends. We have defined a new sample of nearby blazar-like objects, minimising the selection effects in order to understand the fundamental properties of these objects. The Survey of Extragalactic Nuclear Spectral Energies (SENSE) sample contains 151 compact radio core objects within $z < 0.2$. Here we present the first results from the SENSE sample with an emphasis on the ways in which we are using multiwavelength observations of this carefully selection sample to probe the physics of blazars and the wider AGN population.

**The effect of TP-AGB stars on the evolution of the rest-frame near-infrared galaxy luminosity function**

*B. Henriques, C. Maraston, P. Monaco, F. Fontanot, N. Menci, G. De Lucia, C. Tonini*

We address the fundamental question of matching the rest-frame K-band luminosity function of galaxies over the Hubble time using semi-analytic models, after modification of the stellar population modeling. We include the Maraston (2005) evolutionary synthesis models, that feature a higher contribution by the Thermally Pulsating - Asymptotic Giant Branch (TP- AGB) stellar phase, into three different semi-analytic models, namely the De Lucia and Blaizot version of the Munich code, MORGANA and the Menci model. We find that the modification of the stellar population emission alone solves the mismatch between models and the observed rest-frame K-band luminosity from the brightest galaxies derived from UKIDSS data at high redshift. For all explored semi-analytic models this holds at the redshifts - between 2 and 3 - where the discrepancy was recently pointed out. The reason for the success is that at these cosmic epochs the model galaxies have the right age to contain a well-developed TP-AGB phase which makes them redder without the need of changing their mass or age. At lower redshifts ($z < 2$) some of the explored models deviate from the data, which is associated to too short merging timescales and inefficient radio-mode AGN feedback.

**HAWK-I cluster survey**

*M. Huertas-Company, C. Lidman, HCS collaboration*
Distant galaxy cluster surveys are a unique probe of the effects of environment in galaxy evolution. Given their distance, observations at near-IR are needed to sample the rest frame optical. However, current studies have been limited by the lack of high-quality and uniform data in the near-IR. We have obtained a uniform set of deep near-IR images with the HAWK-I camera on the VLT of 10 massive galaxy clusters currently in the redshift 0.8<1.4. All the clusters in the survey also have deep ACS images and extensive multi-object spectroscopy. The poster will summarize the status of the survey and present some first results.

The effect of the environment on the Tully-Fisher relation

Y. Jaffe, A. Aragon-Salamanca, H. Kuntschner and S. Bamford

We measure the relation between galaxy luminosity and disk maximum rotation velocity (the Tully-Fisher relation [TFR]) for a sample of 418 emission-line galaxies from the ESO Distant Cluster Survey. Our aim is to distinguish between the possible physical mechanisms that act on galaxies when they fall into clusters and provide observational constraints for theoretical models of galaxy formation. The sample spans a vast range of environments up to z < 1. We compare the TFR residuals of field and cluster galaxies for ’matched’ samples in absolute B-band magnitude and redshift. Interestingly, we find the TFR residual distribution of both populations to behave similarly. This finding favors a scenario in which galaxies do not experience an initial enhancement of their star formation when they join a galaxy cluster, as it has been proposed in previous studies with smaller samples. Moreover, we looked at the morphologies of the galaxies in our sample and found a population of elliptical galaxies that show a clear rotation curve. These could be the progenitors of the similar objects found locally.

The Bright End of the Colour-Magnitude Relation

N. Jimenez, S. Cora

We investigate the origin of the colour-magnitude relation (CMR) followed by early-type cluster galaxies by using a combination of cosmological N-body simulations of cluster of galaxies and a semi-analytic model of galaxy formation (Lagos, Cora & Padilla 2008). Results show good agreement between the general trend of the simulated and observed CMR. However, in many clusters, the most luminous galaxies depart from the linear fit to observed data displaying almost constant colours. With the aim of understanding this behaviour, we analyze the dependence with redshift of the stellar mass contributed to each galaxy by different processes, i.e., quiescent star formation, and starburst during major/minor and wet/dry mergers, and disk instability events. The evolution of the metallicity of the stellar component, contributed by each of these processes, is also investigated. We find that the major contribution of stellar mass at low redshift is due to minor dry and major dry mergers, being the metallicity of the stellar mass accreted during this process quite low. Thus, these events seem to increase the mass of the more luminous galaxies without changing their colours.

The chemical enrichment histories of SDSS galaxies

J. Johansson, D. Thomas, C. Maraston

We derive the full chemical enrichment histories for SDSS galaxies using a large variety of abundance ratios, namely [C/Fe], [N/Fe], [O/Fe], [Mg/Fe], [Ca/Fe] and [Ti/Fe]. The sample consists of nearly 4000 quiescent early-type galaxies. We utilise stellar population models of absorption line indices that are an updated and flux-calibrated version of the models of Thomas et al. (2003) based on
the MILES stellar library. Most importantly, the flux calibration of our new models makes the application of Lick offsets unnecessary. We confirm previous results of increasing age, [Z/H] and [α/Fe] with stellar velocity dispersion and galaxy mass. We derive similar trends for the elements [O/Fe], [Mg/Fe], [C/Fe] and [N/Fe]. On the contrary we find that Ca and Ti scale with Fe, hence there are no such correlations with galaxy mass for either [Ca/Fe] or [Ti/Fe]. This indicates that SNIa contribute more to the enrichment of heavy alpha-elements than previously thought. This puts strong constraints on supernova nucleosynthesis and models of galactic chemical evolution. Interestingly, we find no correlations with environment for any of the element abundance ratios. This is in disagreement with previous studies that found indications for over-abundances of N and C in low density environments and poses tight constrains to the formation histories of massive elliptical galaxies.

Lopsidedness in WHISP galaxies

E. Juette, J. van Eymeren, C. Jog, R. Dettmar, Y. Stein

It has been known for many years that galaxy discs are often asymmetric, both in the stellar and the gaseous component. However, the origin of this effect is not well know to date, and quantitative studies are rare. Here we present the first statistical investigation of a large sample of HI discs using the WHISP survey. We obtained a Fourier-Analysis to study the morphological lopsidedness in 76 galaxies. This allows to trace the degree of asymmetry with radius. We further investigated dependence on, e.g., the galactic type and the environment.

The evolution of early-type galaxies over the last 8 billion year: insights from the rest-frame UV

S. Kaviraj, S. Yi, K. Schawinski, R. Ellis, E. Gawiser, P. van Dokkum, J. Silk, GALEX and MUSYC collaborations

An exciting recent discovery has been the detection of widespread recent star formation (RSF) in nearby early-type galaxies (ETGs), using new survey data in the rest-frame UV. We review the current status of this work, with a particular emphasis on the drivers of this star formation. Data from the GALEX UV survey (z < 0.1), combined with deep optical surveys (e.g. MUSYC, GOODS, COSMOS) that trace the rest-frame UV at high redshift, indicate that ETGs of all luminosities form stars over the lifetime of the Universe, with luminous systems (−23 < M_V < −21) forming up to 10-15% of their stellar mass after z = 1. While small mass fractions of young stars seem to be ubiquitous in the nearby ETG population, the source of this star formation remains a matter of debate. We demonstrate that the RSF at late epochs cannot be driven solely by internal mass loss, suggesting that some or most of the gas fueling the RSF is externally accreted. Visual inspection of HST images of ETGs from the COSMOS survey at z ∼ 0.5 show a remarkable correspondence between the presence of morphological disturbances and UV excess, which suggests that mergers may be the principal driver of this RSF. However, the major merger rate is found to be too low to satisfy the number of ETGs that carry such morphological disturbances, suggesting minor mergers as the primary channel of gas accretion and star formation in the ETG population. We discuss the implications of repeated minor merger activity on the spectral and dynamical evolution of massive galaxies and draw comparisons with the literature which suggest that minor merging, a hitherto poorly explored process, may be a key element of the evolution of galaxies at late epochs.
Metallicities of galaxies in the nearby Lynx-Cancer void
A.Y. Kniazev, A.L. Tepliakova, S.A. Pustilnik, A.N. Burenkov

We present the first results of spectral observations of dwarf galaxies in the Lynx-Cancer void. For more than one third of about 100 galaxies the estimates of the O/H parameter are obtained. The data are mainly from spectral observations with the SAO 6m telescope, and also from SDSS and the literature. The analysis of the obtained data indicates a systematically lower metal content in the galaxies of this void compared with field dwarf galaxies. Additionally, we present more detailed information and discuss the properties of several galaxies with metallicities near the bottom of the known range, namely with $12+\log(O/H)=7.12-7.3$.

Dynamics of the Galaxy: structure, flares and cosmic rays
M. Laloum

Many essential paradoxes in the mechanical balance of the Galaxy are highlighted. Their outstanding relevance demands a coherent and likely explanation. We propose a unique and synthetic interpretation, including a cosmological theory of the origin of the observed cosmic rays, especially at the highest energies known. It involves MATTER-ANTIMATTER ANNIHILATION in the median plane of the Milky Way, as a source of “DARK MATTER”. Accordingly, we discuss the structure and balance of the Galaxy, seen as made of two parallel disks of matter versus antimatter dominance, and opposed by the repulsion of an annihilation gas, settled in the equator disk. The admitted suppression of antimatter in the Universe, just after the “Big-Bang”, is questioned. Accordingly, ULTRA-RELATIVISTIC THERMODYNAMICS of cosmic rays are settled. The rhythmic emissions of “Gamma-Ray Bursts” and other flares are easily explained. Many stringent tests tend to confirm this theory: pointedly, the now classical energy behaviour of the incident flux of energetic cosmic rays is easily derived as a power law, quite with expected exponents of -2.5 and -3, possibly (main dependence, including the first knee). Ultra-high energies, further, are easily attainable, with no necessary restriction of the “GZK” kind, for instance. Beyond 1020 eV, rather, a new break is still thus made feasible. Beyond CP invariance, T reversal is axiomatically discussed, as well as the very nature of time in Special Relativity.

VVDS-Deep survey: from major to minor mergers of bright galaxies up to $z = 1$
C. Lopez-Sanjuan, O. Le Fevre, L. de Ravel, O. Cucciati, VVDS Team

We present the first determination of the minor merger rate from spectroscopically confirmed close pairs. We take advantage of the wide area (0.5 deg$^2$) and deep spectroscopy (IAB < 24) of VVDS-Deep survey to study the major to minor merger fraction of bright galaxies (LB > LB*) in the range $0.2 < z < 0.95$. We find that the minor merger rate (luminosity ratio $1/4 < \mu < 1/10$) increases with cosmic time, becoming higher than the major merger rate ($\mu > 1/4$) at $z = 0.5$. On the other hand, the major + minor merger rate ($\mu > 1/10$) is roughly constant, in agreement with previous morphological studies. When we split our bright galaxies into red and blue by their rest-frame NUV-R color, we find that the merger fraction of red galaxies is higher than the one of blue galaxies, and that it does not evolve in the redshift range under study. Our measured merger rate implies $\sim 1$ merger (0.6 major, 0.4 minor) event per red galaxy since $z = 1$, with a stellar mass increase of 35% and a size evolution by a factor of 1.8. These values are consistent with the evolution of massive red sequence galaxies, and suggest mergers as drivers of these systems’
evolution since $z = 1$. On the other hand, the major merger fraction of blue galaxies decreases dramatically with cosmic time, being minor companions three times more numerous than major at $z = 0.5$. However, minor mergers are not enough to drive a spiral to elliptical transformation, but likely a late to early spiral one.

A multi-wavelength view on Galaxy Formation & Evolution : the SWIRE-SDSS database & the Spitzer/Herschel Local Luminosity Function

L. Marchetti, M. Vaccari, A. Franceschini, SWIRE & HerMES

Infrared wavelengths contain a substantial amount of information about the origin of galaxies and active galactic nuclei and about the evolutionary history of star formation, metal production and gravitational accretion. They present a widely complementary view with respect to more classical galaxy surveys in the optical. In a context of ever deeper surveys at most wavelengths, it is even more difficult and important to reliably measure galaxy infrared properties in the Local Universe: difficult because the very possibility to carry out extremely deep observations leads to most observing time being spent on the deepest pencil-beam surveys rather than shallower wide-area ones, and important because the increasingly detailed knowledge of the high-redshift Universe needs similarly well-defined local benchmarks to trace the formation and evolution of galaxies across cosmic time in great detail. Perhaps more importantly, in the era of multi-wavelength surveys and virtual observatories, shallow wide-area surveys with large data rates are likely to profit the most from the paradigm shift caused in astronomical research by the easy access to a number of otherwise separate databases for science exploitation. Our work capitalizes on the above trends. We present a detailed investigation of statistical properties of infrared galaxies in the low-redshift universe by exploiting two major survey projects, in the infrared and optical respectively. The SWIRE (infrared) and the SDSS (optical) catalogs are matched with early HerMES/Herschel data as well as with ancillary datasets such as the INTWFS, 2MASS and UKIDSS, to derive the galaxy local luminosity function at MIPS (24, 70 and 160 µm) and SPIRE (250, 350 and 500 µm) bands and thus place stronger constraints on models for the formation and evolution of infrared galaxies. A good knowledge of statistical properties of galaxies across such a wide wavelength range and a 50 deg$^2$ area puts us in the best position to study the different processes playing a role in galaxy formation and evolution and thus determine how the environment shapes galaxy properties across cosmic history.

CALIFA Survey: mapping the local universe in 3D

E. Marmol-Queralto, CALIFA COLLABORATION

The Calar Alto Legacy Integral Field Area Survey (CALIFA Survey, PI: S.F. Sanchez) is an international project which main objective is to characterize the gas and stellar content in galaxies at the Local Universe by studying their spatially resolved spectroscopic properties in the optical range. For doing so, CALIFA will observe a diameter selected, statistically well defined, sample of $\sim$600 galaxies up to $z \sim 0.03$ (ie., $\sim$120 Mpc), of any kind, covering the full color-magnitude diagram down to $M_b \sim -18$ mag. The observations will be performed using the wide-field IFU PPAK integrated in the PMAS spectrograph at the 3.5m telescope of the Calar Alto Observatory, using two different configurations, mostly focused in the study of the gas content and stellar population of these galaxies, in one hand, and in the dynamical properties, on the other. In order to achieve
this huge program, the Calar Alto Executive Committee has allocated 210 dark nights in the next 6 semesters (starting in July 2010) to perform the required observations. This international project comprises more than 50 astronomers, of 5 different countries and 8 different institutes across the world (mainly European centers). We present here this ongoing project that will provide the largest and most comprehensive wide-field IFU survey of galaxies carried out to date and will allow to address several fundamental issues in galactic structure and evolution.

**Pure DRGs: witnessing a link between Starburst and AGN activities at redshifts 2-4?**

*H. Messias, J. Afonso, A. Hopkins, B. Mobasher, J. Lotz, D. Farrah*

Extremely and Distant Red Galaxies are known to reside in denser environments when compared with the overall K-selected galaxy population. Among the most massive objects in the early universe, they are thought to be the progenitors of local massive ellipticals. In this talk I will focus on a sub-population of Distant Red Galaxies that appears to be forming through merger accretion. They are mostly found in the range \( z \sim 2 - 4 \), coincident with the peak of activity in the universe, and simultaneously show star-formation and AGN activity. This population may provide important clues for the connection between these two phases through a merger scenario, as already proposed by galaxy evolution models and other observational work.

**Study of the Byurakan-IRAS Galaxy pairs and the galaxy evolution**

*A.M. Mickaelian*

Byurakan-IRAS Galaxies (BIG) are the extragalactic objects resulted from the project of optical identifications of IRAS point sources based on their DSS images and the DFBS (Digitized First Byurakan Survey) low-dispersion spectra. As a result, 1278 galaxies have been revealed at high galactic latitudes, including 42 PSC sources identified with 103 galaxies that make up 30 physical pairs and 12 multiples (interacting systems and mergers). These BIG objects have been observed spectroscopically; the redshifts have been measured and classification for activity types has been carried out (Seyferts, LINERs, SB, HII). Using more accurate FIRST positions, we have defined the real IR sources; they might be either one of the components or all components are responsible for the IR radiation. It is shown that for the cases where more than one component is an IR source, the average IR luminosity is higher; typically IR luminosity \( >10^{12} \ L_\odot \) is coming from the whole system, which means that the interactions induce vast amounts of dust and/or trigger intense starburst processes in these objects. The dependence of the mean distances of components on the IR luminosity and redshift has been studied to follow the evolution of these interacting/merging systems. Some of the systems contain AGN that allows us investigate the interrelationship between starburst and nuclear activity, as well as interactions.

**Towards Understanding Simulations of Galaxy Formation**

*N. Mitchell*

Numerical simulations are now a fundamental tool with which modern astronomers test current theory. However an increasing number of authors have noted significant discrepancies between galaxy properties when run in different hydrodynamic codes (e.g. Frenk 1999, Agertz 2007, Mitchell 2009). As we can now finally begin to run large cosmological simulations with complex gas physics it is necessary to understand the way in which these differences between codes affect the properties
of the ISM. From the efficiency of supernova feedback to the large scale heating of gas during galaxy cluster mergers, I will show that there are notable differences between particle and grid based codes, explain their origin and demonstrate work that has been undertaken at Vienna to improve the way in which we model the properties of the ISM.

The cosmic mass density field reconstruction from the SDSS group catalog

*J.C. Munoz-Cuartas, V. Mueller, J. Forero-Romero*

We present the results of the reconstruction of the cosmic mass density field from the SDSS group catalog of Yang et al. (2007). We used a novel technique proposed in Wang et al. (2010) that allows the use of the mass distribution in and around dark matter structures as computed from cosmological simulations to map the mass distribution as traced by groups of galaxies. This method enables us to extract natural and mass conservative reconstructions of the density field and avoid the use of arbitrary smoothing functions. We present the results of our reconstruction, the statistics of the density field as well as identifications of structural properties as filaments, sheets, and voids. The reconstructed density fields can be further used in the investigation of environmental dependent galaxy properties and covering fractions of the survey volume by these structures.

The evolution of early-type galaxies in different environments: an HI view

*T. Oosterloo*

I will present the results of a deep HI imaging survey of the SAURON sample of early-type galaxies. The HI properties of these galaxies strongly depend on environment. For detection limits of a few times $10^6 \, M_\odot$, HI is detected in more than 50% of the field galaxies, while < 10% of the Virgo objects are detected. In about half of the detections, the HI forms a regularly rotating disc or ring. In many galaxies unsettled tails and clouds are seen. All HI discs have counterparts of ionised gas and inner HI discs are also detected in molecular gas. The cold ISM present in the central regions is dominated by molecular gas ($M_{\text{H}_2}/M_{\text{HI}} \sim 10$). We conclude that accretion of small amounts of HI is very common for field early-type galaxies while cluster galaxies do not accrete HI. The few galaxies with a significant young stellar sub-population all have inner gas discs, but for the remaining galaxies there is no trend between stellar population and HI properties. A number of early-type galaxies are very gas rich, but nevertheless have a purely old stellar population. The stellar populations of field galaxies are typically younger than those in Virgo. This is likely related to differences in accretion history.

Selection of Luminous Galaxies at the Edge of the Universe

*S. Pereira de Matos*

The study of distant galaxies is crucial for the understanding of the very first stages in galactic evolution, however the criteria to select these objects are numerous. A Australia Telescope Compact Array (ATCA) 1.4 GHz survey, together with Advanced Camera for Surveys (ACS), on board of the Hubble Space Telescope (HST) for the identification of the objects, served the purpose of looking for strongly emitting radio-sources potentially at very high $z$. These radio-loud galaxies can be promising distant candidates since they can be detected everywhere in the Universe in the current deep radio surveys. The best radio-galaxy candidates may be weakly or even not detected
at other wavelengths, hence the identified radio sources in the ATCA survey were also studied in the optical using data from the Galaxy Evolution from Morphology and SEDs (GEMS) survey and the Great Observatories Origins Deep Survey (GOODS) as well as in the Spitzer Wide-area Infrared Extragalactic (SWIRE) survey. Among the 94 radio-sources singled out in the ATCA survey, 14 have an infrared (IR) counterpart, but of those only 7 correspond to an IR galaxy likely emitting two jets at radio frequencies; 40 were within the area covered either by GEMS or GOODS and of those 7 had an optical counterpart and only one was identified in the optical. The results here obtained need further study from deep radio surveys, therefore these radio sources will be singled out for future observations with new telescopes and instruments, such as the Atacama Large Millimetre Array (ALMA).

Evolution of star-forming galaxies in the Hercules cluster: new observational clues of the mass-metallicity relation

*V. Petropoulou, J.M. Vilchez, P. Papaderos, J. Iglesias-Páramo*

Spatially resolved spectroscopy has been obtained with the IDS (INT, ORM) and ISIS (WHT, ORM) spectrographs for a sample of 27 star-forming galaxies belonging to the Hercules cluster. The galaxies have been selected from a deep Hα survey carried out by our group. Emission-line spectra were corrected from the underlying stellar population continuum emission using the evolutionary code STARLIGHT. Chemical abundances and physical properties of the ionized gas as well as the mean metallicity and age of the underlying stellar component were derived. The information obtained has provided us with new observable clues to analyze the effect of cluster environment on the chemical evolution of galaxies.

Measuring the halo mass function in loose groups

*D.J. Pisano*

The “missing satellite” problem, the absence of sufficient numbers of low mass galaxies as compared to CDM models of galaxy formation, has been well-established for the Local Group for some time. While recent surveys have discovered more faint dwarf galaxies and mitigated this problem, a deficit remains. However, to date the “missing satellite” problem has not been well quantified beyond the Local Group. We report on results from our Parkes HI survey of six loose groups and our determination of the velocity distribution function, a proxy for the halo mass function, in the group environment. We compare our results with determinations of the VDF in other environments and simulations.

Will the James Webb Space Telescope detect population III galaxies?

*C. Rydberg*

The JWST is the next large space based infrared telescope and is scheduled for launch in 2014. Using a 6.5 meter primary mirror it will probably see the first galaxies. Population III stars are postulated to exist at approximately z=10-30. According to current research population III stars are expected to be extremely massive (around 100 solar masses) and hot (around 100,000 K). I calculate the apparent AB-magnitudes for the most luminous population III stars in various JWST filters at z=10-30. Atmospheres generated by the TLUSTY code are being used. I assess what this means for the luminosity and AB-magnitudes of the first pristine galaxies consisting of population
III stars. The poster shows the estimated apparent AB-magnitudes for the galaxies and stars at different redshifts. Observations of this kind of objects could contribute towards the understanding of galaxy formation in the early universe.

**On galaxy mass-radius relationship**

*D. Bindoni, L. Secco, E. Contini, R. Caimmi*

On the basis of Clausius' virial maximum theory to explain the galaxy Fundamental Plane (FP) (see, e.g., Secco & Bindoni, 2009) a natural explanation follows about the observed relationship between stellar mass and effective radius ($M^*-Re$) for the early type galaxies. The main key of this correlation lies on the deep link which has to exist between cosmology and the existence of Fundamental Plane (FP). Without it neither the tilt of FP, nor the main scaling laws for galaxies might find a reason by conserving virial equilibrium together with galaxy homology. The general strategy consists to use the two-component tensor virial theorem (e.g., Brosche et al., 1983; Caimmi & Secco, 1992) to describe the virial configuration of the baryonic component embedded in a DM halo at the end of relaxation phase. In a $\Lambda$CDM flat cosmology, starting from variance at equivalence epoch, we derive a theoretical relationship, $M^*-Re$, which fits fairly well that extracted from the data of galaxy sample used by Tortora et al. (2009).

**Chemical abundances in the polar disk of NGC4650A: implications for cold accretion scenario**

*M. Spavone, E. Iodice, M. Arnaboldi, O. Gerhard, R. Saglia, G. Longo*

The aim of the present study is to test whether the cold accretion of gas through a “cosmic filament” (Maccio’ et al. 2006) is a possible formation scenario for the polar disk galaxy NGC 4650A. If polar disks form from cold accretion of gas, the abundances of the HII regions may be similar to those of very late-type spiral galaxies, regardless of the presence of a bright central stellar spheroid, with total luminosity of few $10^9 L_\odot$. We use deep long slit spectra obtained with the FORS2 spectrograph at the VLT in the optical and near-infrared wavelength ranges for the brightest HII regions in the disk polar disk of NGC 4650A. The strongest emission lines ([OII] H$\beta$, [OIII], H$\alpha$) were used to derived oxygen abundances, metallicities and the global star formation rates for the disk. The deep spectra available allowed us to measure the Oxygen abundances ($12 + \log (O/H)$) using the “Empirical method” based on intensities of the strongest emission lines, and the “Direct method”, based on the determination of the electron temperature from the detection of weak auroral lines, as the [OIII] at 4363 Angstrom. The Oxygen abundance measured for the polar disk is then compared with those measured for different galaxy types of similar total luminosities, and then compared against the predictions of different polar ring formation scenarios. The average metallicity values for the polar disk in NGC 4650A is $Z=0.2 Z_\odot$, and it is lower than the values measured for ordinary spirals of similar luminosity. Moreover the gradient of the metallicity is flat along the polar disk major axis, which implies none or negligible metal enrichment from the stars in the older central spheroid. The low metallicity value in the polar disk NGC 4650A and the flat metallicity gradient are both consistent with a later infall of metal-poor gas, as expected in the cold accretion processes.

**Eleven billion years of massive galaxies evolution**

*I. Trujillo*
Massive galaxies, presently the main population at the center of the galaxy clusters, were born with different structural properties to what we see today. Eleven billion years ago these galaxies were extremely compact, with sizes around 5 times smaller than what we find today. In this contribution, I will summarize the results obtained by my group in relation to the changes this population has suffered in terms of sizes, velocity dispersions, stellar mass densities profiles and star formation rates. I will discuss the potential evolutionary scenarios these massive compact high-z galaxies have followed and what it is the most likely end for these objects.

**Spitzer Extragalactic Representative Volume Survey (SERVS) Early Science**

*M. Vaccari, M. Lacy, D. Farrah, SERVS Consortium*

We present the Spitzer Extragalactic Representative Volume Survey (SERVS), an 18 deg$^2$ medium-deep survey at 3.6 and 4.5 $\mu$m with the post-cryogenic Spitzer Space Telescope to $\sim 2$ $\mu$Jy (AB = 23.1) depth. SERVS is designed to enable the study of galaxy evolution as a function of environment from $z \sim 1$ to the present day, and is the first extragalactic survey both large enough and deep enough to put rare objects such as luminous quasars and galaxy clusters at $z \geq 1$ into their cosmological context. SERVS is designed to overlap with several key surveys at optical, near- through far-infrared, submillimeter and radio wavelengths to provide a coherent picture of the formation of massive galaxies. In this talk, we discuss the SERVS data, ancillary data from other surveys in the SERVS fields, outline the main science topics that SERVS will address and present SERVS Early Science results ranging from the IRAC ultra-deep observations of radio sources to the detection of $z \sim 1$ cluster candidates through Voronoi tessellation and Optical/NIR/MIR color selection and the determination of their composite stellar mass function, from the number counts and angular clustering of SERVS sources to IRAC stacking studies aimed at characterizing the environments in which high-redshift QSOs reside.

**Environments of strongly star-forming galaxies**

*P. Vaisanen, A. Tekola*

Not very much is known about the environments of (ultra) luminous infrared galaxies, (U)LIRGs, in the local universe, other than that they are usually interacting or merging systems, and probably avoid the densest clusters. We have correlated the IRAS catalogs with 2MASS and 6dF catalogs to investigate the large scale environments within 2 Mpc of strong IR galaxies, and to find correlations between mass, luminosity, star-formation rate (SFR) and environmental density in these systems. We find that the density around the IR galaxies stays constant with luminosity up to log(LIR/L$_{\odot}$) = 11 and then increases with IR luminosity at higher LIR. In this sense (U)LIRGs behave more like galaxies at redshift $> 1$, and not like the local galaxy population where SFR decreases with density. We also show how at constant mass the environment directly correlates with SFR, and how the ULIRGs appear to have different relations between environment, mass, and SFR than LIRGs and starbursts. (U)LIRGs also have a higher SF efficiency than non-LIRG IR galaxies. Finally, we show that (U)LIRGs live inside halos with masses in a very characteristic range.

**The environment of early galaxy formation from sub-mm surveys**

*E. van Kampen*

This talk focuses on the early formation of the galaxies in overdense environments (proto-clusters),
as observed in various on-going and planned sub-mm surveys. An initial comparison to models will be shown as well.

An X-ray view of radio polarized ridges in perturbed spiral galaxies
M. Wezgowiec, et al.
Observations of group and cluster galaxies reveal a large variety of interactions between galaxies and with the surrounding medium. The most common evidence for such interactions are asymmetries and distortions of the galactic magnetic field seen in the radio polarized emission. In particular, regions of strong gas compression are often seen as radio polarized ridges. However, using the radio data only it is difficult to conclude whether the ram pressure stripping or tidal interactions are responsible for the perturbations. We present X-ray observations of two perturbed Virgo Cluster galaxies, NGC 4254 and NGC4569, and NGC2276 from NGC2300 galaxy group. We argue that the examination of the hot gas distribution and its spectral analysis, including regions where radio polarized ridges are seen, can help in determination of the nature of disturbances. Higher hot gas temperatures in the position of a polarized ridge would suggest ram pressure effects, what we see in NGC 4569, while in case of tidal effects no rise in the temperature would be seen, as in the southern radio polarized ridge in NGC 4254. NGC2276 seems to incorporate both types of effects.
S3: Dwarf Galaxies: Keys to Galaxy Formation and Evolution

Outstanding Questions in Dwarf Galaxy Research
E. Skillman

Resolved observations of nearby galaxies help us to understand the evolution of dwarf galaxies. The star formation histories recovered from their fossil records place strong constraints on how dwarf galaxies have evolved. What is the nature of the first episode of star formation in dwarf galaxies? Are dwarf galaxies able to accrete a significant amount of gas at later times, or is the bulk of the gas in place once the dwarf galaxy establishes its gravitational identity? What processes are responsible for the conversion from gas-rich to gas-poor dwarf galaxies? In the current epoch, we have a wealth of observations which allow us to study the character of the interstellar medium and the process of star formation. How does the interstellar medium change as a function of metallicity? Are there different modes of star formation for different physical conditions (metallicity, mass surface density)? Spatially resolved, recent star formation histories allow us to ask fundamental questions such as: What conditions are required for star formation? What is the impact of the star formation on the structure of the ISM? Does star formation heat the ISM and consequently suppress future star formation, or does it compress the ISM and lead to more star formation? Does understanding star formation at z=0 help us to understand star formation at higher redshifts?

Constraints on the effects of reionization in the star formation history of dwarf galaxies: conclusions from the LCID project.
C. Gallart, for the LCID collaboration

I will present the final results of the ACS (Local Cosmology from Isolated dwarfs, LCID) project, which has used over 100 orbits of HST time to obtain color-magnitude diagrams reaching the oldest main sequence turnoffs (V~28) in six isolated Local Group dwarf galaxies (two dIrr, IC1613 and Leo A, two transition dIrr/dSph, LGS3 and Phoenix, and the only two isolated dSph in the Local Group, Cetus and Tucana). Isolated dwarf galaxies are important probes of the conditions of the early Universe, since their early star formation history and subsequent evolution are predicted to have been influenced by global phenomena such as cosmic reionization. I will discuss the detailed star formation and chemical enrichment histories, and stellar population gradients that we have derived for the LCID galaxies through comparison with synthetic color-magnitude diagrams, with particular emphasis on the similarities and differences of the six galaxies in the sample in relation with their morphological type. Finally, whether the characteristic features of their star formation
histories can be interpreted as signatures of both global (such as cosmic reionization) and local (such as SNe feedback) phenomena will be discussed.

**Measuring Star Formation Rates In Dwarf Galaxies**

*J. Lee*

I will share recent results on the measurement of star formation rates (SFRs) which involve the (mis-)behavior of dwarf galaxies relative to expectations based on our more developed understanding of normal star-forming spiral galaxies. Using a complete, statistical sample of star-forming galaxies within the Local Volume, we have evaluated the consistency between SFRs inferred from Hα nebular emission and the far ultraviolet non-ionizing continuum. Our analysis probes activities ranging from those that are characteristic of the Milky Way to ultra-low SFRs of $0.0001\ M_\odot/\text{yr}$. We establish that there is a systematic decline of the integrated Hα-to-FUV flux ratio as galaxies less active than the Small Magellanic Cloud are probed. Thus, if standard linear SFR conversion recipes are applied in this regime, the UV yields a higher SFR than Hα by factors of two to more than ten. It has been argued that such a systematic may be evidence for a non-universal stellar initial mass function. I discuss this and other possible causes of this observed discrepancy, which presents a challenge to the study of star formation in low density environments.

**Star-Forming Dwarf Galaxies**

*N. Bergvall*

Detailed, multifrequency observations of local gas-rich dwarf galaxies provide us with a wealth of information, helping us to better understand star formation, chemical enrichment and dust formation. Short-lived global starbursts, often triggered by mergers, display formation of massive stars and numerous star clusters and give insight to the effects of SN winds and an intense radiation field, modifying the balance between different gas phases. From a cosmological perspective, studies of local gas-rich dwarfs also play an important role. In the hierarchical scenario of galaxy formation, their high redshift counterparts constitute the fundamental building blocks of more massive systems. They may also provide the bulk of the Lyman continuum photons needed to reionize the universe. In the future, Lyman α emission from star forming dwarfs at high redshifts will serve as beacons, tracing the evolution of the baryonic structures. Locally, searches for gas rich, optically dark galaxies will help to constrain the low mass end of the predicted cosmic mass spectrum. Simulations and observations of the complex interplay between star formation induced gas outflows, stripping and gas accretion will shed light on the baryon deficiency problem in low mass galaxies and the relationships between gas-rich and gas-poor systems. In my talk I will briefly discuss these issues with focus on the star formation and starburst properties as related to the environment and the structural properties of the galaxies.

**Properties of Hα emitting dwarf galaxies in nearby clusters**

*J. Iglesias-Páramo*

I will show the main results of the Hα emitting dwarf galaxies detected in our sample of nearby clusters of galaxies. I will discuss on the intensity and morphology of their Hα emission, and their relative position with respect to the center of the clusters.
Morphological mutations of dwarf galaxies

G. Hensler

As an extension of the massive Hubble-type galaxies, since their sufficiently broad archiving also dwarf galaxies (DGs) have been tried to be classified according to their morphology. Detailed and more comprehensive studies of DGs have however spotted a much larger variety and complexity of their substructures to exist and much stronger environmental effects to act continuously on their evolution. In contrast to the predictions from CDM cosmology, it is highly questioned if the baryonic portion of dwarf galactic has formed at first within the dark matter subhalos and if DGs have hierarchically fed the major galaxies. At least, it is clear, that they have not at all reached their morphological destinations, but undergo morphological transitions. On the one hand, their low gravitational potential allows strong influences of internal as well as external perturbations on their evolution, as there are e.g. gas expulsion by galactic winds and accretion of intergalactic gas. Since galaxies, in general, change their environment, DGs can e.g. pass through galaxy cluster conditions and change their morphology. Another aspect newly emerged from observations and highly attractive is the subsequent DG formation associated with tidal arm condensations in galaxy merging. And finally a set of satellite galaxies that develops in the neighbourhood of massive ones is affected by mutual tidal interactions, partly accreted by the major halo and should therefore reveal characteristic properties.

Transformation of a Virgo Dwarf Irregular Galaxy by Ram Pressure Stripping


We present optical and UV imaging and optical spectroscopy of the Virgo Cluster dwarf irregular galaxy IC3418, which may be a “smoking gun” example of the transformation of a dwarf irregular into a dwarf elliptical by ICM ram pressure stripping. GALEX UV and WIYN optical images show a spectacular 1-sided, 17 kpc length tail of UV-bright knots, head-tail, and linear stellar features. Much of the UV light in the tail arises from linear, parallel streams of young stars. The only H-alpha emission arises from a few HII regions in the outer half of the tail, the brightest of which are at the heads of head-tail UV sources, whose tails point back toward the galaxy. The head-tail (“fireballs”) and linear stellar features in the stripped tail are likely formed from dense gas clumps which continue to accelerate outwards through ram pressure, leaving behind streams of newly formed stars which are not affected by ram pressure. Neither H-alpha nor HI emission are detected in the main body of the galaxy, despite structure in optical images resembling star forming regions and spiral arms. Keck optical spectra of the main body indicate star formation stopped ~50-100 Myr ago in the central ~1kpc, and 200-300 Myr ago at r = 2 – 4 kpc, precisely the type of outside-in quenching expected from a ram pressure stripping event. In IC3418, we propose that we are witnessing a critical stage in the transformation of a dI into a dE, the removal of the entire ISM by ICM ram pressure stripping.

Dwarf Elliptical Galaxies - United and Divided

H. Jerjen

Though of humble appearance and easily overlooked because of their modest size and star density, dwarf elliptical galaxies are the most common type of galaxies known, yet the formation of these
systems remains an open question. Great effort has been made using deep ground and space-based imaging and spectroscopy to detail the properties of Local Group dwarf spheroidals and the dE populations in nearby groups and clusters. Only there the star formation history, remnant gas and dark matter contents can be studied with highest resolution that is impossible to accomplish at high redshifts. We often find long-lasting star formation episodes with low star formation efficiencies and distinct subpopulations. There is evidence for environmentally-driven evolution, stochastic enrichment, and recent searches are beginning to uncover ultra-faint, dark matter dominated dwarfs in the Milky Way halo hosting some of the most metal-poor stars. A diversity like we have not seen before.

A SAURON study of dEs in the Virgo Cluster: stellar populations and kinematics

A. Rys, J. Falcon-Barroso, M. Koleva

Dwarf elliptical galaxies are the most common galaxy type in nearby galaxy clusters, yet they remain relatively poorly studied objects and many of their basic properties have yet to be quantified. Traditional long-slit observations are likely to miss more complicated kinematic features, but with the SAURON integral field unit on the William Herschel Telescope (La Palma) we are able to study both kinematics and stellar populations in two dimensions, obtaining an unprecedented view of the mass distribution and star formation histories. In this contribution we will present the results of a SAURON study of five bright nucleated dwarf ellipticals (dEs) in the Virgo Cluster, drawn from the Lisker et al. (2007) list of all Virgo dEs. The resulting stellar velocity maps show that we have two rotating galaxies in our sample, with two more likely being triaxial objects due to their visible flattening and no observed rotation. The obtained velocity dispersion maps are compared with the results available in the literature for long-slit data. Our SSP-equivalent star formation history tests performed with the ULySS tool (Koleva et al. 2009) reveal an age and metallicity gradient in one of the observed galaxies. We will discuss the results of further simulations performed with ULySS using the multiple-burst mode. Mapping the changes in Z/age in two dimensions allows us to exploit the full potential of our dataset and establish the order in which different (sub)components have formed. We will also show line strength maps of the main spectral features and will present the analysis of line strengths (Hβ, Fe5015 and Mg)b at each position using new stellar population models based on the MILES stellar library (Vazdekis et al. 2010) to obtain ages and metallicities and investigate abundance ratios to set the timescales for the formation of different substructures. Finally, we will compare our results with those coming from the SAURON survey for early-type (giant) galaxies. This will give us a clue about how the properties of these galaxies fit into the larger context of galaxy formation and evolution.

Stellar archeology: a cosmological view of dwarf galaxies

S. Salvadori

Extremely metal poor stars ([Fe/H]<-3) represent the living fossils of the first stellar generations. Stellar surveys of dwarf spheroidal galaxies (dSphs) have recently shown that stars with [Fe/H] < -3 are extremely rare in classical dSphs, while they represent the ~25% of the total stellar mass in ultra-faint dwarfs (L < 10^5 L⊙). Despite this difference high-resolution spectroscopic studies have revealed that the abundance patterns of [Fe/H]<-3 stars are consistent between these two classes of galaxies. When did ultra-faint and classical dSphs form? What is the origin of
extremely metal-poor stars? We investigate the nature of the Milky Way (MW) dSph satellites in a general cosmological context, simultaneously accounting for various MW properties, including the Metallicity Distribution Function (MDF) of Galactic halo stars. By reproducing the observed Fe-Luminosity relation and the mean MDF of dSphs, we found that ultra-faint dwarfs are left-overs of H2-cooling minihaloes formed at \( z > 8.5 \) and thus the progenitors of classical dSphs in which \([\text{Fe/H}] < -3\) stars formed.

The ISM of Dwarf Galaxies

U. Klein

I will review the current knowledge about the structure and physical properties of the ISM in dwarf irregular, i.e. star-forming galaxies. There is a large number of gas-rich dwarf galaxies in the local universe, some of them forming stars at high rates, while others exhibit a low level of star formation. A few dwarf galaxies possess extremely extended HI disks, exceeding the sizes of stellar disks by a large factor. Their kinematics provides an excellent tool to study the distribution of baryonic and non-baryonic matter in this species. Most of our knowledge about the neutral ISM in dwarf galaxies rests upon the HI line. Much less is known about the molecular phase in them, traceable via the CO molecule. Its detectability is tightly coupled to their metallicities. The hot ISM of dwarf galaxies is connected with the star-formation rate. Dwarf galaxies with violent star formation tend to possess X-ray emitting coronae. They are likely to produce outflows, which may serve to eject metals into the ICM/IGM. Strongly star-forming dwarf galaxies also exhibit synchrotron radiation, resulting from relativistic electrons moving in the interstellar magnetic field. The containment of these particles is low in dwarf galaxies, making them a possible source for the magnetisation of the ICM/IGM in the early universe.

Tidal Dwarf Galaxies: from simulations to observations and vice versa

P.-A. Duc

After having reviewed the formation, evolution and survival of Tidal Dwarf Galaxies in galaxy mergers, as predicted by numerical simulations and (sometimes) observed by observations, I will present what these objects may tell about star/cluster formation and cosmology.

3D Spectroscopic Observations of Dwarf Galaxies

P. Weilbacher, L.-M. Cairós, N. Caon N., P. Papaderos

I will review selected observations of dwarf galaxies made with the technique of integral field or 3D spectroscopy. I will discuss advantages and drawbacks of this type of observations and show scientific results published in the last years before turning to preliminary findings and future possibilities.

LITTLE THINGS: an HI survey of Nearby Dwarf Irregulars

E. Brinks

On behalf of the LITTLE THINGS team (PI: Deidre Hunter), I will report on the current status of this VLA Large Program, a project involving over 300 hours of HI spectral line observations of a sample of \( \sim 40 \) dwarf irregular galaxies.
Cold Gas Content Of Dwarf Galaxy Simulations

K. Pilkington, B. Gibson, C. Brook, G. Stinson, F. Calura

We present an analysis of the neutral hydrogen (HI) properties of a fully cosmological hydrodynamical dwarf galaxy simulation. As reported recently by Governato et al (2010), these simulations are the first of their kind to result in the successful reproduction of a (dwarf) spiral galaxy, without any associated stellar bulge. In a blind experiment, we have now set out to compare in detail the HI distribution and kinematics of these simulated bulgeless disks with that observed in a sample of nearby dwarf galaxies. We wish to answer the question... Are the gas properties of the first successfully simulated bulgeless dwarfs consistent with observations? To do so, we have extracted from the simulations, radial and vertical gas density profiles, spatially-resolved maps of scale heights (e.g. flaring, warping) and velocity dispersion (e.g. velocity ellipsoid, turbulence), and the power spectrum of structure within the cold interstellar medium. Our highest resolution dwarf shows several unique and challenging characteristics (relative to the THINGS observations of comparable dwarfs) which we are in the midst quantifying, including (i) a high-density cold gas core within the inner 1∼kpc (10 times the density at one HI disk scale length), (ii) significant, and continual, disk flaring from the inner to the outer HI disk (factor of 10 increase in scale height per dex increase in scale length), (iii) a significantly (kinematically) colder HI disk (factor of 5 lower lines-of-sight velocity dispersions, relative to HoII, NGC 4214, and IC 2574, for example), and (iv) a somewhat flatter ISM power spectrum than that seen in the SMC (i.e. the simulated dwarf appears to possess more “power” on smaller spatial scales than the SMC does). We will discuss the ramifications of our preliminary analyses in terms of the defining roles played by energy feedback and star formation thresholds in such cosmological hydrodynamical simulations.

Predicting the frequency of young and of tiny galaxies

G. Mamon, D. Tweed, T. Thuan

Using a very simple model of galaxy formation on top of high mass-resolution halo merger trees, we analyze the distribution of stellar ages for different z=0 galaxy masses and predict the frequency of galaxies with mostly young stellar populations at z=0 as a function of galaxy mass. We also study how the very low-mass end of the galaxy mass function varies with the physics of reionization and discuss the nature of the smallest galaxies.

The Dwarf galaxy - Ultra Compact Dwarf connection

D. Forbes

Using an age-metallicity analysis, I will report recent results concerning the number of accreted dwarf galaxies and their globular cluster systems to the mass build-up of the Milky Way. This analysis suggests 6-8 accreted dwarf galaxies with 27-47 associated globular clusters. Turning to external systems, I will explore the connection between dwarf galaxies and ultra compact dwarf objects. In particular, highlighting the ‘missing link’ region between the lowest mass dwarf galaxies and the highest mass ultra compact dwarfs. A census of dwarf galaxy populations is certainly incomplete without accounting for such objects. The exact nature of these transition objects also have a bearing on the question of dark matter and on the differences between small galaxies and star clusters (e.g. what is a galaxy?).

The formation of ultra-compact dwarf galaxies and nucleated dwarf
Ultra-compact dwarf galaxies (UCDs) have similar properties as massive globular clusters or the nuclei of nucleated galaxies. Recent observations suggesting a high dark matter content and a steep spatial distribution within groups and clusters provide new clues as to their origins. We perform high-resolution N-body/smoothed particle hydrodynamics simulations designed to elucidate two possible formation mechanisms for these systems: the merging of globular clusters in the centre of a dark matter halo, or the massively stripped remnant of a nucleated galaxy. Both models produce density profiles as well as the half-light radii that can fit the observational constraints. However, we show that the first scenario results to UCDs that are underluminous and contain no dark matter. This is because the sinking process ejects most of the dark matter particles from the halo centre. Stripped nuclei give a more promising explanation, especially if the nuclei form via the sinking of gas, funnelled down inner galactic bars, since this process enhances the central dark matter content. Even when the entire disc is tidally stripped away, the nucleus stays intact and can remain dark matter dominated even after severe stripping. Total galaxy disruption beyond the nuclei only occurs on certain orbits and depends on the amount of dissipation during nuclei formation. By comparing the total disruption of cold dark matter subhaloes in a cluster potential, we demonstrate that this model also leads to the observed spatial distribution of UCDs which can be tested in more detail with larger data sets.

Feedback in Dwarf Galaxies
E.M. Wilcots

The impact of massive stars on their environment is the most important internal driver of the evolution of dwarf galaxies. Strong stellar winds and supernovae explosions inject mechanical energy and cosmic rays into the host galaxy which can reorganized multiple phases of the interstellar medium and drive large scale outflows. Here we will present the results of multi-wavelength observations of a sample of nearby star-forming dwarf galaxies with the aim of quantifying the impact of stellar feedback on the interstellar medium and overall evolution of these galaxies. We look at the underlying population of massive stars, the kinematics and distribution of neutral and ionized gas, as well as at the influence of magnetic fields.

Lyα emission and Super-Star Clusters in dwarf galaxies
Göran Östlin

I will discuss results from HST imaging programs of, preferentially metal-poor and low-mass, starburst galaxies on the subjects of massive stellar cluster content, and on the escape, or not, of Lyman alpha photons from such systems.

The formation of massive stellar clusters appears unavoidable in galaxies with high star formation rate density. Luminous blue compact galaxies, with considerable star formation rates, low metallicity and moderate dust content are ideal locations in which to study the formation of young massive clusters. I will present results from our ongoing HST study of such galaxies, and show that they are unusually efficient in forming massive clusters.

Reprocessing roughly one third of the ionising photon budget, the Lyman alpha line is an important tracer of massive star formation and one of only few useful spectral probes of galaxies at high redshifts. Due to its resonant nature and the abundance of neutral hydrogen in the universe,
radiative transport effects are important, and predicting the line strength for a given galaxy is non trivial. I will discuss results from the HST on Ly$\alpha$ imaging of local starburst and present evidence for the importance of resonant scattering. I will also discuss what can be learned from combined Ly$\alpha$ and H$\alpha$ studies in the unique cosmic window at redshifts slightly larger than two.

Unveiling the nature of the “green pea” galaxies

*R. Amorin, E. Perez-Montero, J.M. Vilchez*

The green pea galaxies are very compact, low-mass starburst galaxies at redshifts 0.1-0.3, recently discovered by the Galaxy Zoo project. In this presentation we will show new results on their chemical abundances and evolution (Amorin et al. 2010). Our study reveal that these extremely star-forming galaxies are genuine metal-poor systems, with mean oxygen abundances $\sim$20% solar. Moreover, at a given metallicity, the green peas display systematically large N/O ratios compared to normal galaxies. While their N/O ratios follow the relation with stellar mass of local star-forming galaxies in the SDSS, we find that the mass-metallicity relation of the “green peas” is offset more than a factor of two to lower metallicities. Recent massive and rapid inflow of gas, possibly coupled with selective outflows driven by supernova winds, are proposed here to explain our findings and the known galaxy properties, i.e, unusually high specific SFRs, extreme compactness and disturbed morphologies.

Positive star formation feedback in super stellar clusters and in dwarf galaxies

*G. Tenorio-Tagle*

I shall review recent observations of super stellar clusters that clearly indicate mass accumulation and the eventual formation of further stellar generations. I shall then compare the properties of these clusters with the ones causing the ionization in dwarf galaxies and conclude that such clusters by causing further star formation in situ, inhibit the exit of their processed material and thus the contamination of their host galaxy.

Physical properties of 6dF dwarf galaxies

*J.M. Gomes, P. Papaderos*

The power of spectral synthesis as a mean to estimate physical properties of galaxies has been well established. Spectral synthesis is basically the decomposition of an observed spectrum in terms of a superposition of a base of simple stellar populations of various ages and metallicities, producing as output the star-formation and chemical histories of a galaxy and its extinction. We have entered in a new era with the availability of large and high-quality data bases of observed galactic spectra. The combination of a wide set of synthetic and observed stellar libraries with mean while much refined population synthesis codes permits us to significantly improve our understanding of the formation and evolution of galaxies. The STARLIGHT (Cid Fernandes et al. 2005), provides one of the most powerful tools presently available. We have applied this code to approximately 3000 dwarf galaxy spectra from the Six-Degree-Field Survey (6dF) of nearby galaxies. The advantage of using this survey instead of Sloan Digital Sky Survey is that the fiber aperture is twice as large, much reducing the aperture effect encountered in SDSS. We are going to summarize the main results from this study, in particular discuss the mean stellar age and metallicity and the star formation history of late-type dwarf galaxies from 6dF.
Dwarf galaxies as a cosmological test
A.V. Tikhonov

Here I will present new results on LCDM-overabundance in terms of observational (Local Volume = LV) and model (high resolution wmap5/3 simulations) cumulative Circular Velocity Functions = VFs (with corrections of DM halo peak circular velocity for adiabatic compression). LCDM demonstrate evident divergence from observations which starts from rotational (circular) velocities $V_c \sim 80$ km/s and steeply increases toward smaller $V_c$ ($V_{rot}$). Factor of 4 LCDM overabundance obtained with voids statistics on volume-limited (VL) Local Supercluster sample ($D < 25$ Mpc, $MB < -15$, $abs(b)>15$) points in the direction of our previous results - factor of 10 LCDM overabundance on ($MB < -12$) LV galaxy sample (8Mpc) obtained by a comparison of the observed spectrum of mini-voids in the LV with the spectrum of mini-voids determined from the simulations. These two overabundance factors are nearly exact numerical points on real and model VFs divergence if we use LVs Tully-Fisher dependence to correspond $V_{rot}$ with $MB$. Different things coincide. Theory predicts much more dwarf objects than we do see dwarf galaxies in the field. The problem is that not only such quite isolated dwarf galaxies as CamelopardalisB, CGCG269-049 or DDO125 (being quite old, having rotation amplitudes of about 10-15 km/s, exhibiting quite regular rotation, producing stars etc.) missed (they do exist but in much less amount then we may reasonably expect from any CDM model predictions) but also we do not see in our very local neighbourhood substantial number of “Magellanic Clouds”-like galaxies to fit LCDM prediction. This seems to be nearly impossible from the observational point of view. I will present our new sample of H$\alpha$ observations of about 20 nearby isolated dwarf galaxies - their dynamics, velocity dispersions and preliminary mass-modeling. This new data argue in favor of the claimed results of this talk. Nonbarionic solution with the warm dark matter (mass of the particle $m_x \sim 1$ keV) gives numerically right answer (WDM VF curve nicely reproduces the observational one) but it is suffered by some potential problems. Still we consider possible solutions for the field LCDM-overabundance problem such as significant missing VLSB dwarf galaxy (dSphs or Malin1-like galaxies) population, the one with reionization physics, CDM particles decay, etc.

Posters

Formation and evolution of gas-rich dwarf galaxies
Y. Ascasibar, M. Gavilan, M. Molla, A. Diaz

We propose that the formation and evolution of dwarf irregular (dIrr) and blue compact dwarf (BCD) galaxies can be understood in terms of a simple model where star formation is fueled by continuous infall of primordial gas. The model predictions (elemental abundances, stellar and gas masses, and photometric colors) are compared with a set of observations obtained from the literature. Our results suggest that isolated gas-rich dwarf galaxies may share a common origin, with less massive objects being less efficient in converting their gas into stars.

The Fine-Scale Structure of the neutral ISM in nearby Galaxies
We present an analysis of the properties of HI holes detected in 12 spiral and 8 dwarf galaxies that are part of "The HI Nearby Galaxy Survey" (THINGS). We detected more than 1000 holes in total in the sampled galaxies. Where they can be measured, their sizes range from about 100 pc (our resolution limit) to about 2 kpc, their expansion velocities range from 4 to 36 km/s, and their ages are estimated to range between 3 and 150 Myr. The holes are found throughout the disks of the galaxies, out to the edge of the HI disk; 23% of the holes fall outside R25. We find that shear limits the age of holes in spirals (shear is less important in dwarf galaxies) which explains why HI holes in dwarfs are rounder, on average than in spirals. Shear, which is particularly strong in the inner part of spiral galaxies, also explains why we find that holes outside R25 are larger and older. We derive the scale height of the HI disk as a function of galactocentric radius and find that the disk flares up in all galaxies with dwarf galaxies having on average a thicker disk. We proceed to derive the surface and volume porosity (Q2D and Q3D) and find that this correlates with the type of the host galaxy: dwarf galaxies tend to be more porous. The size distribution of the holes in our sample follows a power law with a slope of $a = -2.9$. Assuming that the holes are the result of massive star formation, we derive values for the supernova rate (SNR) and star formation rate (SFR) which scales with the SFR derived based on other tracers. If we extrapolate the observed number of holes to include those that fall below our resolution limit, down to holes created by a single supernova, we find that our results are compatible with the hypothesis that HI holes result from star formation. We present the first results from a comparison of the HI holes with Spitzer 8um and 24um, Galex NUV maps, and the CO(2-1) data provided by the SINGS, NGS and HERACLES surveys respectively.

Spatial distribution of stellar components in the Magellanic Clouds

M. Belcheva, E. Livanou, M. Kontizas, E. Kontizas, G. Nikolov

Gaia, an ESA mission planned for launch in 2012, will create the largest and most precise three dimensional chart of our Galaxy by providing unprecedented positional and radial velocity measurements for about one billion stars in our Galaxy and throughout the Local Group. It is expected to resolve nearby galaxies in stars, improving greatly our knowledge of them. Our main goal is to obtain the spatial distribution of different stellar components in these galaxies and work towards producing a model of the Magellanic Clouds to be used, among others, in simulations by CU2 (a part of the Gaia Data Processing and Analysis Consortium) during the Gaia mission preparation. In this study the Magellanic Clouds are the main targets. Using ground based data from infra-red and optical surveys such as 2MASS and the Magellanic Clouds Photometric Survey we investigate the spatial distribution of various stellar populations in these galaxies using isodensity maps and radial density profiles.

Stellar populations in nearby dwarfs: the cases of Carina dwarf spheroidal and of IC10 dwarf irregular

G. Bono, et al.

Dwarf galaxies have been the crossroad of significant theoretical and observational efforts, but we still lack firm constraints concerning their formation and evolution. They are also fundamental laboratories to investigate the impact of the environment on star formation and on chemical evolution
in stellar systems that are 3-4 order of magnitudes smaller than giant galaxies and to constrain the evolutionary properties of metal-poor, intermediate-mass stars. We present some recent results concerning the dwarf spheroidal Carina and the dwarf irregular IC10. In particular, we focus our attention on the evolutionary properties of their stellar populations using accurate and deep color-magnitude diagrams together with homogeneous sets of isochrones and helium burning evolutionary models.

**Wolf-Rayet galaxies in the local Universe - constraints on stellar models and low metallicity GRBs**

*J. Brinchmann*

Wolf-Rayet galaxies are a class of objects that show signs of Wolf-Rayet stars in spectra of a significant part of a galaxy. Here we discuss a survey for Wolf-Rayet galaxies in the SDSS Data Release 7, an update on our previous study, extending the number of Wolf-Rayet galaxies to ∼650, the largest sample of its kind. Using this sample we show how it puts constraints on stellar models and we use it to ask whether there are enough Wolf-Rayet stars in the local Universe with low metallicities to explain the rate of H-deficient supernovae in metal poor dwarf galaxies. We show a reasonable consistency and argue that our statistics also is consistent with the hypothesis that explosions of Wolf-Rayet stars at low metallicity are the sources of long-duration Gamma-ray bursts.

**The star-forming dwarf galaxy population in the Local Universe and beyond: the first 3D spectroscopic study of a large sample of Blue Compact Dwarf galaxies**

*L.-M. Cairós, N. Caon, P. Papaderos, P. Weilbacher, M. Roth*

In spite of the great effort that has been done during the last two decades on the investigations on Blue Compact Dwarf (BCD) Galaxies, we are still far from understanding fundamental issues as the mechanism responsible for the ignition of the actual starburst, the evolutionary status of these galaxies or their star forming histories. Integral Field Spectroscopy is the ideal observational technique to explore such issues: each single exposure contains both spatial and spectral information in a large area of the galaxy, so just in one shot we collect information for all the star forming regions as well as for the low surface brightness stellar component of the galaxies. Besides, the kinematical information also allow us to investigate what mechanisms ignite the star-formation in BCDs. In this talk I will present results on the first comprehensive analysis of a large sample of BCDs by means of Integral Field Spectroscopy. This dataset allow us to gain insights into the most crucial unanswered questions in BCDs research. Besides, this analysis will form an essential reference to understand and interpret high-z star-forming galaxies.

**Origin and evolution state of Fehrenbach & Duflot star**

*N.A. Drake, C.B. Pereira*

We discuss the origin and evolution state of Feh-Duf star (Fehrenbach & Duflot 1981) based on determination of detailed chemical pattern and calculations of Galactic space-velocity components of this star. The extreme retrograde motion ($V_{GRF} = -260 \sim \text{km s}^{-1}$) as well as the low oxygen-to-iron ratio, [O/Fe] = +0.10 dex, as compared to halo stars of the same metallicity ([Fe/H] = -1.93), may be a sign that Feh-Duf star was accreted by the Milky Way from a dwarf satellite galaxy.
Comparing the Local and Cosmic Star Formation Histories: Local Cosmology from Isolated Dwarf Galaxies

I. Drozdovsky, LCID team

Given the many recent advances in our understanding of the star formation history (SFH) of the Local Group (LG) and other nearby galaxies, and in the evolution of star formation with redshift, we present an updated comparison of the comoving space density of the star formation rate as a function of look-back time for the Local and Distant Universe. The Local SFH is derived from analysis of resolved stellar populations (fossil records) in individual nearby galaxies, based on our own estimations – the 'Local Cosmology from the Isolated Dwarfs' (LCID) project– as well as available in the literature. The early epoch (look back time >8 Gyr) of the star formation is of particular interest, and the isolated nearby dwarf galaxies are a key factor factor in order to disentangle the internal physical processes from environment-related mechanisms). While the recent episodic star formation activity is observed in dwarf galaxies, most dwarfs of the Local Group and its surroundings are also dominated by the old stellar populations with no apparent evidence for the downsizing effect in the galaxy evolution. The overall trend of star formation density from the LG supports a fairly flat evolution of the SFR without showing the turnover implied by the Lyman dropout measurements. This suggests factors of ∼10 extinction correction to high-redshift UV-based measures.

Dust properties of star-forming dwarf galaxies in the Herschel Virgo Cluster Survey

M. Grossi, HeViCS consortium

We present the dust properties of a small sample of star-forming dwarf galaxies in the Virgo cluster drawn from the Science Demonstration data set of the Herschel Virgo Cluster survey (HeViCS). These galaxies have low metallicities (7.8 < 12 + log(O/H) < 8.3) and star-formation rates less or around 10^{-1} M⊙/yr. We measure the spectral energy distribution (SED) from 100 to 500 µm and derive dust temperatures and dust masses. The SEDs are fitted by a cool component of temperature T ∼ 20 K, implying dust masses of 10^5 M⊙ and dust-to-gas ratios D between 10^{-3} and 10^{-2}. However, a single-temperature grey body fit of the SEDs tends to underestimate the 500 µm fluxes, and we discuss possible explanations to this excess emission.

Tidal Disruption of Satellite Galaxies in a Semi-Analytic Model of Galaxy Formation

B. Henriques, P. Thomas

We introduce tidal stripping of stellar material from satellite galaxies during mergers into the Delucia & Blaizot 2007 semi-analytic model. To test the significance of the new physical process we apply a Monte Carlo Markov Chain parameter estimation technique. The differences in parameter correlations, and in the allowed regions in likelihood space, reveal the impact of the new physics on the basic ingredients of the model, such as the star-formation laws, feedback recipes and the black hole growth model. With satellite disruption in place, we get a model likelihood four times higher than in the original model. Compared to the best-fit model without disruption, the new model removes the excess of dwarf galaxies in the original recipe with a more modest supernova heating. The new model is now consistent with the three observational data sets used to constrain it (LF, galaxy colours and BH-bulge mass relation), while significantly improving the agreement.
with observations for the distribution of metals in stars. Moreover, the model now has predictions for the intra-cluster light, a very significant component of large groups and clusters, that agree with observational estimates.

**Near-Infrared Properties of Irregular Dwarf Galaxies in Nearby Galaxy Groups**

*V. Ivanov, Saviane, Held, et al.*

We have obtained deep NIR imaging of Irregular Dwarf Galaxies in Cen A, M81 and Sculptor groups. We report here the integral properties of these galaxies: luminosities, colors, and structural parameters. Their contribution to the overall group mass, luminosity, and star formation rate is discussed.

**WR-Galaxies in SDSS DR7**

*Y.I. Izotov, K. Agiienko*

We analyse spectra of blue compact dwarf galaxies from Sloan Digital Sky Survey Data Release 7 with fluxes in H$\beta$ $\lambda$4861 over 100 counts. Nearly all galaxies in our sample show broad WR emission in the blue region of the spectrum (the blue bump) consisting of an unresolved blend of NIII $\lambda$4640, CIV $\lambda$4686 emission lines. Broad CIV $\lambda$5808 emission (the red bump) is also detected in few galaxies. We derive the numbers of early WC (WCE) and late WN (WNL) stars from the luminosities of the red and blue bumps, and the number of O stars from the luminosity of the H$\beta$ emission line and compare relative number of WR stars $N$(WR)/$N$(O+WR) with evolutionary synthesis models.

**Warp or lag? The hydrogen gas in the edge-on dwarf galaxy UGC 1281**

*P. Kamphuis, R.F. Peletier, P.C. van der Kruit, G.H. Heald*

The properties of gas in the halos of galaxies constrain global models of the interstellar medium. Kinematical information is of particular interest since it is a clue to the origin of the gas. Until now mostly massive galaxies have been investigated for their halo properties. Here we report on deep HI and H$\alpha$ observations of the edge-on dwarf galaxy UGC 1281 in order to determine the existence of extra planar gas and the kinematics of this galaxy. This is the first time a dwarf galaxy is investigated for its halo characteristics. We have obtained H$\alpha$ integral field spectroscopy using PPAK at Calar Alto and deep HI observations with the WSRT of this edge-on dwarf galaxy. These observations are compared to 3D models in order to determine the distribution of HI in the galaxy. We find that UGC 1281 has H$\alpha$ emission up to 25$''$ (655 pc) in projection above the plane and in general a low H-alpha flux. Compared to other dwarf galaxies UGC 1281 is a normal dwarf galaxy with a slowly rising rotation curve that flattens off at 60 km/s and a central depression in its HI distribution. Its HI extends 70$''$ (1.8 kpc) from the plane. This extra-planar gas can be explained by either a line of sight warp or a vertical gradient of 9.6 $\pm$ 3.8 km/s/kpc in the rotational velocities of the extra-planar gas. If the latter option is correct, the relation between electron scale heights and vertical gradients brakes down in galaxies with low star formation rates.

**A large, homogeneous dataset of tidal dwarf galaxies from the SDSS**
**S3: Dwarf Galaxies: Keys to Galaxy Formation and Evolution**

*S. Kaviraj, Galaxy Zoo collaboration*

We present a sample of tidal dwarf (TD) galaxies, drawn from the SDSS, through the Galaxy Zoo 1 (GZ1) project. GZ1 has used 250,000 members of the general public to morphologically classify 1 million galaxies through direct visual inspection of their SDSS images. As part of this process 3000 mergers have been identified (see Darg et al. 2010, MNRAS, 401, 1043). We use this large, homogeneous catalogue of merging galaxies to construct a sample of over 3000 TDs, extracted by visually identifying tidal objects that are clearly associated with the mergers. We present the basic characteristics of the local TD population, such as masses, diameters, optical colours and star formation rates. We explore the sites of TD formation (e.g. tip of tidal tails, tidal bridges) and explore variations in the characteristics of the TDs as a function of the properties of the parent merger system, e.g. the masses, morphologies, colours (as a proxy for gas fractions) and AGN activity of the merging galaxies. We use this unprecedentedly large and homogeneous sample of objects to exhaustively explore the properties of local TDs, speculate on their contribution to the dwarf galaxy population and their role in the evolution of local galaxies. Finally, the TD sample presented here makes it ideal for comparisons to detailed numerical simulations that aim to elucidate the nature of TDs in the local Universe.

**Planetary Nebulae and HII regions as probes of the evolution of the nearest galaxies**

*A. Kniazev*

The nearest galaxies are an excellent laboratory for studies of stellar populations and evolution. Their stellar populations can be characterized using color-magnitude diagrams of resolved stars. However, the star formation histories are model-dependent and should be compared with further observational data that can be obtained for these galaxies. In particular, individual HII regions and planetary nebulae (PNe) are available for spectroscopy in these galaxies with present-day large telescopes. They can be used as independent tracers of the kinematics, metallicity and evolution of different stellar populations. I will present some of our latest results from our studies of HII regions and/or PNe in some nearest galaxies.

**IFU spectroscopy of HII galaxies**

*P. Lagos*

The aim of this contribution is to show how integral field unit spectroscopy, obtained using 8-m class telescopes, can be used to study the spatial variations of oxygen and nitrogen abundances in a sample of compact HII galaxies. We also investigated the spatial distribution of the HeII 4686 emission line and its relationship with the properties of the interstellar medium.

**The tidal stirring model and its application to the Sagittarius dwarf**

*E. Lokas*

I will present the results of high resolution simulations of two-component dwarf galaxies orbiting the Milky Way, where the stellar component of the dwarf is initially a disk. The effects of tidal interaction of the dwarf with the Milky Way manifest themselves by the strong mass loss, the morphological transformation from the disk to the spheroid and the transition from the streaming to random motion of the stars. I will discuss the dependence of these effects on the orbit of the...
dwarf and its initial properties. The tidal stirring scenario will be applied to model in detail the shape and kinematics of the Sagittarius dwarf. I will demonstrate that the present shape of Sagittarius main body puts strong constraints on its past history and can be used to estimate the number of pericenters it has passed. I will show that Sagittarius is likely still a bound object and its kinematics can be used to reliably estimate the mass. The mass and velocity anisotropy of the dwarf will be estimated using new kinematic data.

Dust in early-type dwarf galaxies

I. De Looze, HeViCS consortium

We present far-infrared observations of the Virgo Cluster taken as part of the HeViCS (Herschel Virgo Cluster Survey) key program. The Science Demonstration Phase data of the central 16 square degree region led to the first detection of cluster early-type dwarf galaxies at far-infrared wavelengths, indicating the presence of a significant amount ($10^4 - 10^5 \, M_{\odot}$) of interstellar dust (De Looze et al. 2010). The detected dwarfs show signatures of discs or substructure in deep optical images, indicating that early-type dwarfs are not a homogeneous population of passively evolving objects. Recent observations of the Virgo cluster with Herschel enlarge the total covered area by a factor of 4. This wide working field allows to compare the far-infrared detection rate with the position in the cluster, exploring which environmental effects come into play in the evolution of early-type dwarf galaxies. In addition to this, the lack of dust emission in some HI-rich objects offers insights in the required conditions for ram-pressure stripping and galaxy harassment.

LPVs as indicators for distance and SFH in NGC 147 and NGC 185

D. Lorenz, T. Lebzelter, W. Nowotny, F. Kerschbaum, J. Telting, H. Olofsson, H.E. Schwarz

We examined the pulsational behaviour of AGB variables of the two Local Group members NGC 147 and NGC 185. A photometric monitoring in the I-band has been done with the Nordic Optical Telescope at La Palma over $\sim$2.5 yrs resulting in $\sim$35 datapoints for the period analysis. We found at least 360 long period variables (LPVs) in NGC 185 and 153 LPVs in NGC 147 and these findings are just preliminary. Additional K-band magnitudes could be derived for 279 (NGC 185) and 153 (NGC 147) LPVs, respectively. For a large fraction of these stars we also have indications for the chemistries (C- or O-rich) from narrow band photometry (Nowotny et al. 2003). The resulting K-logP diagrams for both objects show a well populated sequence of fundamental mode pulsators (sequence C). In NGC 185 we furthermore see a number of LPVs pulsating in an overtone mode (sequence C'). Interestingly, such stars are missing in NGC 147. We speculate that this lack of shorter periods in NGC 147 could originate from a difference in the star formation history (SFH) of the two galaxies, with NGC 147 containing a smaller amount of intermediate-age C and M stars. Assuming universality for period luminosity relations of LPVs we also present new distance estimates of NGC 147 and NGC 185 according to the best fit for sequence C stars in the K-logP diagram.

Dwarf galaxies in nearby galaxy groups

J. Ludwig, E.K. Grebel, J.S. Gallagher

The nearby universe is populated mostly by galaxy groups, whose dominant galaxies are surrounded by numerous dwarf galaxies. We have observed nearby galaxy groups in a distance range of 8 to 25
Mpc with a variety of different morphologies, densities, and richness in order to investigate their dwarf galaxy populations and the resulting environmental effects on the host galaxies. We report about our first results on deep wide-field imaging data of a sample of twelve galaxy groups with a spiral or a S0 as dominant galaxy. One important selection criterion was density. Thus the sample ranges from nearly isolated galaxies to very dense environments. For all of them we were able to detect a considerable number of dwarf companions. Furthermore the host galaxies often show signs of tidal interactions with their dwarf companions.

A detailed 2D spectroscopic study of the central region of NGC5253

A. Monreal-Ibero, J. M. Vilchez, J., Walsh, C. Muñoz-Tuñón

Starburst are considered one of the main contributors to the chemical enrichment of the Interstellar Medium. However, the mechanisms that govern the interaction between the recent/ongoing star formation and the surrounding gas are not yet fully understood. Because of their a priori simplicity, the subgroup of HII galaxies constitute the ideal environment to study these mechanisms. Here, we present a detailed study of the central region of a nearby HII galaxy, NGC 5253, using optical Integral Field Spectroscopy with FLAMES at the VLT. In particular, the extinction and electronic density structure will be shown. Also, we will explore the mechanisms causing the ionization in this area. Finally, we will localize the zones showing nitrogen pollution as well as Wolf-Rayet and nebular HeI features.

A chemical evolution of Draco dwarf galaxy: monolithic or merger scenario?

T. Nykytyuk

A chemical evolution of the Local Group dwarf galaxy Draco is considered. The stellar metallicity distribution function of Draco was calculated in the framework of both the monolithic and the merger scenario. The observed metallicity distribution is not reproduced quite well by monolithic collapse for this galaxy. The use of a merger of several fragments allows to obtain a better resemblance between modelled and observed stellar metallicity distributions.

Stellar populations of Virgo cluster early-type dwarf galaxies with and without discs: a dichotomy in age?

S. Paudel, T. Lisker

The study of early-type dwarf galaxies (dEs) in a cluster environment is a powerful tool to investigate the galaxy evolution, chemical enrichment and environmental effects on these objects. Here, we present the stellar population parameters obtained for the early-type dwarfs in the Virgo cluster, based on absorption line strengths (Lick indices). Our results show that the stellar population properties of dEs not only depend on their luminosity, i.e. brighter dEs are younger and more metal-rich, but also on the morphological subclasses of dEs, i.e. whether they host disk structure or not. We find that dEs with disk structure have younger and more metal-enriched stellar populations than dEs without disk. We then compare the dEs with early-type galaxies at higher and lower luminosities: normal early types (Es) and dwarf spheroidals (dSph). We find that dEs follow a steeper relation between the metallicity and luminosity than both Es and dSphs. We discuss our findings in the light of galaxy formation mechanisms in different environments.
The role of dwarf galaxies in the indirect search for dark matter
L. Pieri

The density content of the Universe counts 23% of non-baryonic matter, whose nature and distribution is unknown. Among the detection techniques, the indirect searches of dark matter annihilation products is undertaking an exciting experimental epoch. Signals of indirect detection of gamma-rays from dark matter annihilation in dwarf galaxies are favored by the clean astrophysical environment and by the astronomical measurements of dark matter profiles. In this poster we will briefly review the issue of indirect detection of gamma-rays from dark matter annihilation in the dwarfs galaxies and we will show the importance of dwarf galaxies in constraining particle physics models and hopefully lead to a dark matter detection.

Extremely metal-poor Blue Compact Dwarf Galaxies: photometric structure and evolutionary status
P. Papaderos, Y.I. Izotov, N.G. Guseva, K.J. Fricke

Extremely metal-poor (12+log(O/H)<7.6) Blue Compact Dwarf (BCD) galaxies (hereafter XBCDs) are important nearby laboratories of extragalactic astronomy and observational cosmology since they allow us to study collective star formation and the buildup of dwarf galaxies under chemical conditions approaching those in the early Universe. I will present results from an ongoing, systematic study of the structural properties, morphology and evolutionary status of these rare objects. Optical surface photometry reveals a stellar host galaxy in all XBCDs studied thus far, implying that these systems are unlikely to be forming their first generation of stars. With regard to the structural properties of their host galaxy, XBCDs are almost indistinguishable from the main sequence of old, higher-metallicity BCDs. However, in contrast to the majority (>90%) of BCDs that are characterised by red elliptical host galaxies, XBCDs reveal moderately blue and irregular hosts. This is consistent with a young evolutionary status and, in the framework of standard star formation histories, implies that several of these key objects formed most of their stellar mass in the past ~1-3 Gyr. A remarkably large fraction of XBCDs shows cometary morphology.

Stellar population of early-type dwarf galaxy and their nuclei.
S. Paudel, T. Lisker

We present a comprehensive spectroscopic analysis of the stellar population properties (age, metallicity and alpha-element abundance) of representative samples of early type dwarf (dE) galaxies and ultra-compact dwarf (UCD) galaxies of the Virgo cluster. Our study includes a careful separation of the central nucleus and the underlying dE galaxy, enabling us not only to compare their stellar populations with each other, but also to compare nuclei to UCDs, as their proposed descendants. Our measured ages for most dE nuclei are lower than the respective underlying galactic halo, with 3.5 Gyr difference on average. In addition to that, we also find the dE nuclei to be more metal-enriched as compared to their host galaxy. Their alpha-element abundances are consistent with the solar value for both nuclei and galaxies.

Dwarf galaxies in the nearby Lynx-Cancer void: photometry, colours and ages
S.A. Pustilnik, A.Y. Kniazev, Y.A. Lyamina, A.L. Tepliakova
The results of photometric analysis of SDSS u,g,r,i images of a large number of galaxies populating the nearby Lynx-Cancer void are presented. The colour indexes u-g, g-r, r-i for the peripheral, oldest, regions exhibit a large range. A comparison with model colours, derived with the PEGASE package, indicates that the ages of the majority of galaxies are of the order of 10 Gyr. However, for a small group of galaxies, the sufficiently blue peripheral colours indicate ages in the range of 1-3 Gyr. These galaxies are discussed in more detail.

The $[\alpha/\text{Fe}]$ ratios in dwarf galaxies: evidence for a non-universal stellar initial mass function?

Simone Recchi

It is well established that the $[\alpha/\text{Fe}]$ ratios in the cores of elliptical galaxies increase with galaxy mass. This relation holds also for early-type dwarf galaxies, although it seems to steepen at low masses. The $[\alpha/\text{Fe}]$ vs. mass relation can be explained assuming that smaller galaxies form over longer timescales (downsizing), allowing a larger amount of Fe (mostly produced by long-living Type Ia Supernovae) to be released and incorporated into newly forming stars. Another way to obtain the same result is by using a flatter initial mass function (IMF) in large galaxies, increasing in this way the number of Type II Supernovae and therefore the production rate of $\alpha$-elements. The integrated galactic initial mass function (IGIMF) theory predicts that the higher the star formation rate, the flatter the IMF. We have checked, by means of semi-analytical calculations, that the IGIMF theory, combined with the downsizing effect (i.e. the shorter duration of the star formation in larger galaxies), well reproduces the observed $[\alpha/\text{Fe}]$ vs. mass relation. In particular, we show a steepening of this relation in dwarf galaxies, in accordance with the available observations.

Looking for clues to the formation of tidal dwarf galaxies: CO mapping of the strongly interacting triplet NGC 7212

S. Temporin, R. Paladino, S. Ciroi, V. Cracco

We present CO(1-0) observations of the strongly interacting triplet of galaxies NGC 7212 (z=0.026). Optical images of the triplet, whose brightest galaxy hosts a Seyfert 2 nucleus, show an intricate structure of tidal tails and loops with some localized blue concentrations that mark sites of enhanced star formation and might indicate the ongoing formation of tidal dwarf galaxies. As a part of a multiwavelength observational effort focussed on this nearby interacting system, we present here the study of the distribution of the molecular gas in the $\sim 3' \times 3'$ region of the sky occupied by the triplet and its tidal features. We use these observations to put constraints on the formation of tidal dwarf galaxies out of the interaction debris of this system.

Flat metallicity profiles in rotating dwarf galaxies

J. Schroyen, S. De Rijcke, S. Valeke

Dwarf irregulars (dIrr) and flat, rotating dwarf ellipticals (dE) generally possess flat metallicity profiles while round dEs show strong metallicity gradients [Koleva et al (2009)]. Unlike dEs, dIrrs also exhibit ongoing star formation [Dolphin (2005)], in most cases compatible with a continuous star formation history (SFH). We show results based on a large suite of Nbody-SPH simulations of flat dwarf galaxies, both rotating and non-rotating, to investigate possible causes for these observations and the relevant physical mechanisms behind it. Specifically, we want to see if it is possible to reproduce these characteristics in isolated dwarf galaxy models, so that the observations
can be explained by purely internal processes without the need for any external interactions. These simulations show that using rotation to flatten a dwarf galaxy is particularly efficient in turning a so-called “breathing” SFH [Valcke et al (2008)] into a more continuous SFH with superposed smaller oscillations, and in producing flat metallicity profiles. Non-rotating dEs in a flattened dark-matter halo are not able to reproduce these characteristics. Thus, it appears that flattening by rotation is key to reproducing the observed characteristics of flat dwarf galaxies. Rotation causes a “centrifugal barrier” which slows down the infall of gas, so that the low-level star formation is not centrally concentrated but occurs galaxy-wide, and in this way also prevents large-scale oscillations in the SFR. This mechanism of smearing out the star formation in time and space proves to be the principal reason for the flat metallicity profiles of dIrrs and flat dEs, instead of the often referred to “fountain mechanism” [De Young & Heckman (1994); Barazza & Binggeli (2002)]. We therefore propose a “centrifugal barrier mechanism” which is able to explain the observations.

Photometric properties of dwarf galaxies in nearby groups of galaxies
J. Vennik, U. Hopp

We have selected new dwarf galaxy candidates in a sample of fairly isolated nearby groups of galaxies, based on photometric and morphological criteria, and determined their true group membership by means of the spectral observations with the Hobby-Eberly Telescope (HET). The main aim of our project is to investigate the impact of the group environment on the evolution of its dwarf members by means of measuring and comparing their photometric, structural and star-forming properties, conditioned by the local environment. For this purpose, we have combined our own CCD imaging data and spectral observations, with archival data from the SDSS database. We trace photometric scaling relations, such as colour - magnitude, surface brightness - magnitude relations and colour gradients of dwarfs in five groups and compare them to scaling relations of late-type dwarfs of the Local Volume and of the Virgo cluster. We found no reliable shift in the exponential model scale parameters between the late-type dwarfs in groups and those in the Virgo cluster, as found earlier, e.g. in Barazza et al. (2001). Stellar populations of late-type dwarfs in different groups have possibly different mean ages and/or metallicities.

The first dwarf galaxies
E. Zackrisson

The first galaxies were likely dwarf galaxies forming in $\sim 10^8\ M_\odot$ dark matter halos at redshifts $z>10$. The stellar content of these objects may be very different from that of dwarf galaxies observed in the local Universe, possibly featuring both high-mass population III stars and so-called dark stars, i.e. stars fueled by dark matter annihilations rather than hydrogen fusion. Here, we present the first spectral synthesis model suitable for the first galaxies, including both population I, II and III stars, dark stars, nebular emission and dust. We also discuss the prospects of detecting these galaxies with the upcoming James Webb Space Telescope, scheduled for launch in 2014.

The red halos of galaxies
E. Zackrisson

Deep optical/near-IR surface photometry of galaxies outside the Local Group have revealed faint and very red halos around objects as diverse as cluster ellipticals, spirals and star-forming dwarf
galaxies. The colours of these structures are much too extreme to be reconciled with the resolved stellar populations studied in the halos of the Milky Way or M31, and alternative scenarios like dust reddening, high metallicities or nebular emission are also disfavoured. Here, we present a number of possible explanations for this phenomenon and discuss their impact on our understanding of galaxy formation and cosmology.
S4: From Macro to Micro Stellar Transits

From eclipsing binaries to planetary transits
A. Giménez

The analysis of the light curves of eclipsing binaries has proven to be a powerful tool in the determination of accurate stellar dimensions across the HR diagram. When the first extrasolar transiting planet was discovered some ten years ago it was immediately understood that a key observational source of information for their characterization had been open. In this presentation, some of the lessons learnt in the study of eclipsing binaries that are useful for the understanding of exoplanets are discussed. This includes the mathematical characterization of transits, the equations for the computation of the Rossiter effect in the radial velocity curves, and several analytical expressions allowing a precise estimation of the elements previous to a full analysis of the observed light curves.

Limb-darkening effects in planetary transits
A. Claret, A. Giménez

The importance of a good treatment of limb-darkening effects in the analysis of light curves is well known but it is shown to be even more relevant in the case of exoplanetary transits than in eclipsing binary stars. The numerical methods used to compute limb-darkening coefficients are nevertheless still a matter of discussion. To improve the situation, we have revised our earlier calculations and compare the new coefficients with previous theoretical values, as well as with empirical measurements from nine eclipsing binaries. Such a comparison reveals that the theoretical atmosphere models are unable to give a satisfactory fit to the observations. This unexpected result is further supported by a recent investigation of transiting extrasolar planets as it is the case of the prototypical HD 209458.

Observations and modelling of Earth’s transmission spectrum through lunar eclipses: a window to transiting exoplanet characterization.
E. Pallé, A. García-Muñoz

Recently we were able to retrieve the Earth’s transmission spectrum trough lunar eclipse observations. This spectrum showed that the depth of most molecular species was stronger than models
had anticipated. The presence of other atmospheric signatures, such as atmospheric dimers and Earth ionospheric absorption were also present in the spectrum. Since 2008 we have been developing a radiative transfer code able to reproduce the Earth’s transmission spectra at different depths in to the penumbra and umbra, and taking into account transmission, refraction, multiple scattering and diffuse light. Here we show the excellent fits of our simulations to the eclipse data at visible and near-infrared wavelength ranges. We will also discuss the results of new eclipse observations at different wavelength ranges and resolutions.

The CoRoT mission

R. Alonso

Launched in December 2006, the 27-cm aperture CoRoT (Convection, Rotation and Transits) mission has pioneered the search for exoplanets from space. Led by the French space agency CNES, with participation of several European countries and Brazil, it surveys up to 12000 stars per observing run, which last from 30 days to 150 days. The talk will summarize the main achievements of CoRoT, which include the discovery of the first transiting objects with masses in the brown dwarf regime (CoRoT-3b, CoRoT-15b), of the first transiting Super-Earth planet (CoRoT-7b), and of the temperate transiting Jupiter CoRoT-9b. After having observed more than 100000 stars, the transit detection capabilities and main limitations of CoRoT (whose extended mission period has been approved until March 2013) will be discussed.

Magnetic activity of CoRoT-6 and CoRoT-7


We model the photospheric activity of CoRoT-6a and CoRoT-7a, two stars hosting planets, and use the maps of the active regions to study stellar differential rotation, and spot evolution. We find convincing evidence for star-planet interaction in the CoRoT 6 system. We show that information derived from light curve modeling can be used for a better understanding of the impact of magnetic activity on stellar RV variations, specifically to quantitatively assess the probability a given signal detected in the RV curve is due to stellar activity.

Detailed Error Analysis of CoRoT-7 Stellar and Planetary Parameters

H. Parviainen, H. Deeg, J.A. Belmonte

With a mass of 5 Earth masses and radius of 1.6 Earth radii, CoRoT-7b is one of the smallest transiting planets found to date. Due to its small size, the transit signal is very shallow, which makes the estimation of the planetary parameters from the light curve challenging. In my study I assess the reliability of the CoRoT light curve derived planetary parameters. I consider the effects caused by different binning scenarios, poorly constrained stellar limb darkening, and possible transit timing variations. CoRoT-7b orbits a bright (V=11.7) active G9V star on a short period of 0.85 days. The light curve observed by the CoRoT satellite spans over 153 individual transits with DF/F = 3.4×10^{-4} and time resolution of 32 seconds. Despite the shallow transit, combining all the transits with the high time resolution yields an high signal to noise ratio enough to allow for a reasonable analysis of the transit shape. Nevertheless, the analysis is complicated by several
factors. Foremost, the stellar limb darkening parameters are degenerate with the impact parameter. Both affect the transit shape curvature during the ingress and egress. Secondly, the possibility for transit time variations can have its effect on the transit shape as well. We obtain the transit shape by folding the light curve over the orbit period, which is assumed constant. If the period varies because of the gravitational pull due to other planets in the system, the folded transit shape is blurred. Finally, the transit shape is also affected by finite integration time and the binning. Binning smooths the shape of the ingress and egress, and smears the transition from the partial to full transit. While, in the case of CoRoT-7b, we expect the effects due to binning be minor compared to other factors, the characterisation of these effects is important in order to gain an extensive understanding of the error sources.

Micro and Macro Transits in the Publicly Released Kepler Data
N.M. Batalla, W.J. Borucki, D.G. Koch, The Kepler Team
In June, 2010, NASA’s Kepler mission released photometric light curves taken at a 30-minute cadence over two epochs: 1) 9.7 days at the end of the commissioning period in May 2009 (52,664 stars brighter than m=13.6 in the Kepler bandpass) and 2) 33.5 days between commissioning and the first quarterly roll of the spacecraft in June 2009 (~156,000 stars brighter than m=16). Over three hundred transiting exoplanet candidates were identified in the released data as well as over 1,800 eclipsing binary stars. Herein, we describe the vetting and characterization procedures used to produce the exoplanet and eclipsing binary catalogues that were released to the public. We discuss the statistical properties of the populations and highlight particularly interesting and/or rare types of systems. Finally, we summarize the work leading up to the next data release which will occur in February 2011.

Searching for exoplanets from time-series observations
C. del Burgo
We apply a time-series analysis to public space- and ground-based observations in order to detect extrasolar planets. The methodology used is based on various techniques of signal processing. We mimic the data by means of a sinusoidal function. The Lomb-Scargle periodogram provides the spectrum of fundamental frequencies. Then, it is introduced a certain number of harmonic frequencies. A least squares fitting is applied to determine the amplitudes and phases of the function. The impact of cosmic rays, instrumental noise, scintillation noise and stray-light, among others effects, is studied.

The WFCAM Transit Survey: a search for rocky planets around cool stars
J.L. Birkby, S. Hodgkin, D. Pinfield, WTS and RoPACS consortium
The theory of core accretion makes two intriguing, observable predictions: i) that the formation of rocky/icy planets is common around M-dwarfs, and ii) that hot-Jupiters are extremely difficult to produce around low-mass stars. Furthermore, due to their small physical size and lower bolometric luminosity, M-dwarfs are up to 300× more sensitive to planetary transits in their habitable zones than solar-type stars. We present here the WFCAM Transit Survey (WTS); an ambitious, near-infrared photometric monitoring campaign of ~6000 M-dwarfs across four 1.5 sq deg fields situated >5 degrees above and below the galactic plane. We utilise a unique opportunity provided by the
highly efficient queue-scheduled operational mode of the UKIRT to observe our fields, with at least one visible at any time, when atmospheric conditions and RA coverage are unsuitable for other ongoing UKIRT programs. By probing the peak of the M-dwarf spectral energy distribution (13<17), we obtain a statistically significant sample of low-mass stars, which allows us to place meaningful constraints on the occurrence and formation of planets around M-dwarfs. The WTS has achieved one thousand epochs after 2 years in one of our target fields and will continue until April 2012. Our light curves have a per datapoint photometric precision of ∼3-4 mmag for the brightest objects, with RMS scatter < 1% for J< 16, sufficient to detect Earth-like transits around M-dwarfs. I report here on the goals of our survey, our most recent results and the properties of our M-dwarf target sample. I also discuss our processing methods and how we combat the challenges encountered when observing occultations of faint red stars and the spectroscopic follow-up required to confirm them. (http://www.ast.cam.ac.uk/~sth/wts/index.html)

PLATO: a Cosmic Vision project to detect and characterize planetary systems

I. Pagano, M. Fridlund, C. Catala, PLATO Consortium

PLATO (PLAnetary Transits and Oscillations of stars) is one of the three medium (M) class missions selected by ESA, in the framework of its Cosmic Vision 2015-2025 program, to enter a definition study phase. The main scientific goals of PLATO are the i) discovery and study of extra-solar planetary systems, (including those hosting Earth-like planets in their habitable zone) by means of planetary transits detection from space and radial velocity follow-up from ground, and ii) the characterization of the hosting stars through seismic analysis, in order to determine with high accuracy planetary masses and ages. We present the PLATO science objectives, the design of the PLATO Payload, and its performances.

Polarization effects in the transiting planetary system HD 189733

N.M. Kostogryz, T.M. Yakobchuk, A.P. Vidmachenko, O.V. Morozhenko

We present the results of the calculations of polarization effects in the transiting planetary system HD 189733 using the method proposed by Carciofi & Magalhães (2005) [1]. It suggests that the stellar radiation coming from different parts of the disk is polarized to various extent with maximum observed on the limb. Obviously, the total radiation from a single star is unpolarized due to the spherical symmetry, while the transiting planet breaks this symmetry of the stellar disk and the additional polarization effects appear in the system. There are 80 transiting planetary systems discovered to date. HD 189733 is one of the most studied such systems with a short-period (2.2d) Jupiter-like planet transiting the disc of the star. The distance from the host star to hot-Jupiter is only 0.031 AU, and the radii ratio is near Rplanet/Rstar = 0.15. Accounting for this together with other parameters, we consider HD 189733 as one the most useful objects to study polarization effects in the future observations. The linear polarization in the planetary system HD 189733 was found from 3D Monte-Carlo modeling using the non-linear stellar limb darkening law from Claret (2000) [2]. In our calculations we adopted the linearly polarized solar limb spectrum from Bueno & Shchukina (2009)[3]. Our preliminary results show that polarization degree in the systems like HD 189733 can be up to 0.07%.
Posters

$\epsilon$ Indi Ba, Bb: dynamical masses and spectroscopic study of the nearest brown dwarf binary system to Earth

C. V. Cardoso, M. J. McCaughrean, R. R. King, W. Brandner, R. Koehler, Q. Konopacky

Binary brown dwarf systems provide crucial benchmarks for testing the low-mass end of evolutionary models as both components will have the same age and chemical composition. $\epsilon$ Indi Ba, Bb, (T1 and T6), are the closest known brown dwarfs to Earth (3.6224 pc). Moreover, with a K4.5 star companion, $\epsilon$ Indi A, allows the break of the substellar mass-age degeneracy. Our observations using the ESO VLT include relative and absolute astrometric monitoring and high angular resolution optical, near-infrared, and thermal-infrared imaging and medium-resolution spectroscopy. Using our spectroscopic observations and VRIzJHKLM' broad-band photometry of the individual components we derived luminosities of $\log L = -4.699 \pm 0.017$ and $-5.232 \pm 0.020$, effective temperatures of 1300 - 1340 K and 880 - 940 K and surface gravities of $\log g = 5.25$ and 5.50 for $\epsilon$ Indi Ba and Bb respectively. The relative orbital motion of the brown dwarfs has been monitored since June 2004 with the VLT NACO near-IR adaptive optics system determining a total dynamical system mass of $121 \pm 1 \, M_{\text{Jup}}$, significantly in excess of previous estimates. Combining our system mass determination and derived luminosity, evolutionary models predict an age of 3.7 - 4.3 Gyr, also significantly higher than previous estimates. We have also been monitoring the absolute astrometric motion of the system since August 2005 against a network of field stars using the VLT FORS2 optical imager and we will present the individual masses of $\epsilon$ Indi Ba, Bb, which assuming they are coeval will be able to test the mass-luminosity relation for intermediate age brown dwarfs without the usual ambiguity due to age. This system will allow us to test the predictions of evolutionary and atmospheric models with a precision never obtained before, and give a tightly constrained benchmark that the next generation of models must be able to reproduce.

Galaxy tidal effects on proto-comet orbits of Oort’s Cloud

A. De Biase, L. Secco, S. Casotto, M. Masi

To test the dynamical effects due to the Galaxy on the proto-comets of Oort’s Cloud, we take into account a test particle which initially moves around the Sun in keplerian orbit. Then the gravitational potentials of the most relevant, dynamical components of the Galaxy: bulge, disk, and dark matter halo, are switched on. To describe their tidal effects on the comet orbits we consider three system of reference in which to write down the perturbed motion equations: i) the inertial one with the origin into the Galaxy centre; ii) the pseudo-inertial one with the Sun at the origin having the galactic components as perturbation terms of the Sun-comet system; iii) the system which has the Sun as origin and is co-rotating with it according to the Hill’s approximation inside the framework of the restricted three-body problem. The main result over an integration time of 1 Gyr is a mean reduction (of about 50%) of the initial perihelion value, $q(0)$, for a test-comet which lies on the galactic equatorial plane and is characterized by: $q(0)= 2000 \, \text{AU}$, aphelion $Q(0)= 140 \, 000 \, \text{AU}$, and galactic longitude, $l=270$, at Sun’s distance (8Kpc) from the galactic centre. The effect increases to reach a mean reduction of 65% as the comet cloud would be placed closer to the galactic centre (4Kpc). In both cases the time span the comet spends to these reduced values ranges between 80-90% of the integration time with a strong perturbation effect on the orbit in
the last case. How to obtain an amplification of the perihelion reduction to the region of the inner planets is also discussed to allow us in the future to study the role of comet cloud dynamics in defining the boundaries of the Galactic Habitable Zone and to generalize it to extrasolar systems.

Rotation of small particles under the radiation force

E. M. Pittich, N. A. Solovaya

The poster presents an investigation of the rotational motion of small particles up to a few centimeters in diameter under the influence of stellar electromagnetic radiation. The rotation of particles is described by the Euler angles extracted from the general rotation transformation matrix, namely the nutation angle $\theta$, the precession angle $\psi$, and the proper rotation angle $\phi$. For our model solution of the rotation of small particles we used a gravitational and radiation model of the solar system, in which the paramagnetic particle orbits the Sun under its gravitational force and the effect of the solar electromagnetic radiation, i.e., the Poynting-Robertson drag and a torque affecting the spin of the particle. Under electromagnetic radiation the rotation of paramagnetic particles with nontrivial shape, nonspherical with asymmetric momentum, accelerates. At the critical rotational speed the particle splits. This process of accelerated rotation and subsequent splitting of the particle continues to the lower limit of the particle size, equaling to the wavelength of the electromagnetic radiation.

Search for Variable Stars in the Near-Infrared with the WFCAM Transit Survey

H. Stoev, L.M. Sarro, A. Moya

The poster presents data on stellar variability in the near-infrared as a result of data mining in the WFCAM Transit Survey as part of the Rocky Planets around Cool Stars (RoPACS) project. RoPACS project is aimed at discovering and studying extrasolar planets around M-type stars utilising the J-filter band to ensure that such cool stars are detectable out to the greatest distance. A pipeline is developed which scans for variability more than 40000 stars with recorded measurements at 900 epochs. It makes use of Fourier transform methods and least-square algorithms and as a result, the intrinsic variability parameters of the stars are provided. Examples of classical variable stars are displayed and partial results from an extensive classification of variable stars in the field are presented.

Interpreting Long-term Observed Period Variations in Close Bina-

N. Nanouris, A. Kalimeris, E. Antonopoulou, H. Rovithis-Livaniou

O-C diagrams analysis offers an opportunity to view the very late orbital evolution history (about 100 yrs) of nearly synchronized close binaries. The orbital period function $P(E)$ becomes known in this way and hence it can be related with the most important physical mechanisms that modulate the orbital period of such binary systems through $dJ/dt-dP/dt$ (angular momentum-orbital period) relations. Preliminary analytic parametric solutions of such a generalized (non-conservative) $dJ/dt-dP/dt$ equation involving mass loss, magnetic braking and tidal evolution are presented here for some detached and semi-detached synchronized pairs (mainly members of the RS CVn group) whose orbital period variations are known by O-C diagram analysis. New mass loss/exchange rates are estimated by considering the presence of magnetic braking process, a mechanism that seems to
be detectable in current O-C diagrams and able to affect their modulation in a crucial way.

**The influence of the dynamical friction on the evolution of triple stellar systems**

*N.A. Solovaya, E.M. Pittich*

Influence of the dynamical friction on the evolution of a triple hierarchical stellar system have been studied. Hierarchical stellar systems are stable in contrary to stellar systems with comparable distances between all three components. We considered a motion in the frame of the general three-body problem using differential equations of the motion with the Hamiltonian without short-periodic terms. Studied isolated triple stellar systems where we took into an account perturbations of the third order, we obtained the solution of differential equations, in which the mean motions of both components have the secular accelerations. Under the influence of perturbations of a distant component the mean motion in the near pair is slowed and vice versa. The mean motion of distant star is constantly increasing. These changes are small, but on the cosmological time interval the hierarchical systems will convert into the stellar systems, in which all components have comparable distances between each other. There systems become unstable. In a general case if we take into an account a dynamical friction, than the angular momentum of this system and its summary energy might be either loss or gain. The angle of a mutual inclination between these orbits is changing. This change may influence dynamical evolution of this stellar system.

**Spectroscopic follow-up for the WTS/RoPACS candidates**

*P. Cruz, D. Barrado*

This work is dedicated to spectroscopically classify planet host candidates from the WFCAM Transit Survey (WTS). The RoPACS network utilizes WTS to discover and study planets around cool stars at infrared wavelengths via the transit method. Follow-up has been performed for some of the candidates to find their spectral types and to exclude false positives. Those candidates which survive the low-resolution spectral classification undergo a more detailed follow-up with medium-resolution spectroscopy in order to detect changes in their radial velocities. Partial results from observations taken with the 3.5-meter telescope at the Calar Alto Observatory are presented here.

**The WFCAM Transit Survey**

*B. Sipocz, G. Kovacs*

The WFCAM Transit Survey (WTS) has been obtaining data on the United Kingdom Infrared Telescope since 2007. The WTS targets thousands M dwarf stars over several square degrees of sky, and aims to find low mass eclipsing binaries and planets transiting M dwarfs with periods up to a few days. The poster overviews the follow-up strategy: photometrical follow-up studies are important to verify transit candidates and to obtain high cadence, high signal to noise light curves in the optical band; low and high resolution spectroscopy is also essential to distinguish planetary and eclipsing binary star systems and to measure planet properties. A small selection of our most promising candidates are presented as well.
S5: Star Clusters in the Era of Large Surveys

Optical digital galactic plane surveys and cluster science

*J. E. Drew, EGAPS consortium (inv)*

The IPHAS survey of the northern Galactic Plane (|b| < 5), in r/i/Hα, is essentially complete and undergoing uniform calibration; UVEX the partner U/g/r survey is ongoing; VPHAS+ covering the Galactic plane in all 5 bands is likely to start in the next year or so after commissioning of the VST (now being assembled). In this talk attention will be drawn to how the catalogues emerging from these surveys can aid star cluster searches and characterisation, mainly by exploiting the narrowband Hα data as an intrinsic colour discriminant rather than as a traditional emission line indicator.

Census of Milky Way Star Clusters from Infrared Surveys

*V. Ivanov*

I will review the existing searches of Milky Way clusters, and report some follow up results from a new near infrared search. I will also present a semi-empirical estimate of the expected number of supermassive Milky Way clusters.

SDSS-III/APOGEE: Detailed Abundances of Galactic Star Clusters

*P. M. Frinchaboy, G. Zasowski, K. Jackson, J. Johnson, S. Majewski, M. Shetrone, A. Rocha, SDSS-III collaboration*

The Sloan Digital Sky Survey III/Apache Point Observatory Galactic Evolution Experiment (SDSS-III/APOGEE) is a large-scale spectroscopic survey of Galactic stars and star clusters. The SDSS-III/APOGEE survey is designed to produce high-S/N, R = 27,500-31,000 spectra that cover a wavelength range of 1.51 to 1.68 microns. By utilizing APOGEE’s excellent kinematics (error ≤ 0.5 km/s) and abundances (errors ≤ 0.1 dex), we will be able to study star cluster kinematics and chemical properties in detail. Over the course of the 3-year survey beginning in 2011, APOGEE will target 25-30 key open and globular clusters. In addition, the large area coverage of the SDSS focal plane will also allow us to target stars in 150-250 additional star clusters during the main survey observations. In this talk I will discuss the strength of APOGEE for both open and globular star cluster studies and the methods of identifying probable clusters members utilizing 2MASS and
Towards uniformity in the photometric calibration of near infrared surveys

*S. Hodgkin*

I will describe some of the recent wide field infrared imaging surveys of young open clusters and star forming regions using VISTA and WFCAM. I will pay particular attention to the challenges involved in processing images containing bright nebulous backgrounds, and the detection of sources therein and the precise determination of their photometry. I will discuss how the surveys are photometrically and astrometrically calibrated from 2MASS and investigate issues arising, including the effects of interstellar reddening. Finally I will show how precisely one can measure time series photometry via careful analysis.

Properties of Star Clusters Found and Investigated by Data from Large Surveys

*E.V. Glushkova, S.E. Koposov, I. Zolotukhin, R.K.S. Yadav*

An automated method capable of searching for star clusters in large surveys has been applied to J, H, Ks data from 2MASS catalog. Totally, we found and verified 168 new clusters; for 142 of them, we evaluated ages, distances and color excesses using photometric data from 2MASS and UKIDSS surveys. Most of new clusters are older than 100 Myr and have distances within the range 1-4 kpc. 26 newly discovered objects are embedded clusters. An independent check against UBV photometric data obtained at a 104-cm Sampurnanad telescope demonstrated a very good agreement of our results with observational data. Some known, but doubted or poorly studied clusters were also investigated by 2MASS catalog. Initial data from IPHAS survey were analyzed and used for further studies of the open cluster system.

Large-scale optical surveys of open clusters

*E. Moraux*

Nearby open clusters are often very extended on the sky with a diameter of several degrees. Large-scale surveys are therefore a key tool to study their population. The last ten years have seen the advent of very large optical cameras with a field of view as large as a square degree, allowing us to obtain a complete census of the stellar population in clusters down to the substellar limit. The high efficiency of the cameras combined to their large FOV enable the survey of several hundreds to thousands cluster members in a limited amount of time, allowing in addition the study of their proper motion and variability.

In this presentation I will present the results we obtained from two different large-scale optical surveys. The first one was aimed at determining the low mass part of the IMF in open clusters down to 30 Jupiter masses and to study its possible dependence on local conditions as well as its evolution. The results show that dynamical evolution start to affect the mass function at low masses after one relaxation time but that the mass functions of non-evolved clusters are remarkably similar, suggesting little impact of specific conditions of the parent molecular cloud (density, metallicity, turbulence) on the IMF.

The second survey I will present is the Monitor project, an unprecedented large scale, high cadence,
photometric monitoring survey of young open clusters and star forming regions. The main aim is to search for transiting planets and brown dwarf eclipsing binaries but the survey is also ideally suited to search for stellar rotation periods and constrain models of angular momentum evolution. I will summarize here all the results we obtained.

**Probing the low-mass end of the IMF in star-forming regions**

*C. Alves de Oliveira, E. Moraux, J. Bouvier, A. Burguess, H. Bouy*

One of the most attempted goals of star formation theories is to determine the dominant process by which brown dwarfs form and the implications of the environment on its outcome. Current theories must be able to reproduce not only the observed shape of the IMF, but predict observable properties of clusters such as multiplicity, mass segregation, frequency and sizes of discs, accretion, etc. The new observational frontier is therefore the detection and characterization of very low mass objects in star forming regions, to confront model predictions from numerical simulations of the collapse of molecular clouds to the observed properties of YSOs. This is the main driver behind a WIRCam large program that has been conducted at CFHT to detect BD with masses between 1 and 30 MJup in a sample of 6 young clusters. Candidate BDs with masses down to the planetary regime are identified using the deep near-IR imaging survey and existing archival data from previous surveys (Spitzer, Subaru, UKIRT). I will present the main results obtained so far for the Rho Ophiuchus molecular cloud and IC 348, where a spectroscopic follow-up of many of these candidates is being conducted using several facilities (TNG, GTC, NTT, VLT, Gemini) to ascertain their spectral types and masses, and ultimately, to construct the low-mass end of the IMF for those star forming regions. Near-IR photometric variability is also being used in both clusters as a youth indicator. Finally, I will discuss the current challenges in achieving the maximum return from these surveys, which require extensive use of 8m-class telescopes for follow-up observations, and large collaborations to quickly incorporate the results from new surveys (e.g. Herschel).

**Dynamics in the embedded phase: accretion, collisions, contraction**

*N. Moeckel*

Numerical studies of the early evolution of star clusters have traditionally been based on full hydrodynamic treatments (hampered by the large computational burden) or a purely gravitational N-body approach (limited by not considering the cluster’s natal gas). I will discuss recent work that pushes the N-body techniques toward a more realistic gas treatment. In particular I will focus on the behavior of forming clusters as they accrete gas, leading to compact configurations that are robust to gas expulsion, and in extreme cases to the collisional growth of very massive stars.

**Examining the properties and dynamics of young protoclusters: striving to unravel the initial conditions and triggers of star formation**

*A. Duarte Cabral, G. Fuller, N. Peretto, C. Dobbs, J. Hatchell*

The formation of stars in molecular clouds begins with the fragmentation and collapse of clumps and cores, either through simple self gravitational collapse or triggered by an external event. The star formation activity within a given cloud is specific to that cloud, where the imprints of the initial conditions are often still seen in the properties of the gas and dust of young protoclusters. We present our work in the Serpens Main Cluster, a young protocluster whose gas emission provides
Do All Stars in the Solar Neighbourhood Form in Dense Clusters?

E. Bressert, N. Bastian, R. Gutermuth, et al.

We present a global study of young stellar object (YSO) surface densities ($\Sigma$) in star forming regions based on a comprehensive collection of Spitzer Space Telescope surveys, which encompasses nearly all star formation in the solar neighbourhood. We show that the distribution of YSO surface densities is a smooth distribution, being adequately described by a lognormal function from a few to $10^3$ YSOs per pc$^2$, with a peak at $\sim 22$ stars pc$^{-2}$ and a dispersion of $\sigma_{\log_{10}\Sigma} \sim 0.85$. We do not find evidence for multiple discrete modes of star-formation (e.g. clustered and distributed). Comparing the observed surface density distribution to previously reported surface density threshold definitions of clusters, we find that the fraction of stars in clusters is crucially dependent on the adopted definitions, ranging from 40 to 90%. However, we find that only a low fraction ($< 20\%$) of stars are formed in dense environments where their formation/evolution (along with their circumstellar disks and/or planets) may be affected by the close proximity of their low-mass neighbours.

New measures for measuring structure in star clusters

S. Goodwin

With the advent of large surveys and significant datasets of cluster membership it is becoming important to have good, quantitative methods with which to analyse structure and compare different clusters. I will discuss some ideas about how this could be done.

Age Zero - the impact of formation on cluster chronology

G. Wuchterl

Present stellar evolutionary tracks use simplified concepts of star, brown dwarf and planet formation. Previously these simplifications seemed justified but radiation fluid dynamical calculations show important corrections to ages below ZAMS-arrival and that a revision of the onset of nuclear reactions and the ZAMS-stellar structure are necessary.

Calculations that account for plausible physics show that young stars are not fully convective once they reach their final mass and show corrections of $-500$ K in Teff and a factor two in luminosity for the solar case. I describe how these unexpected results are derived and discuss the consequences for pre-main sequence evolution, cluster-isochrones and -isopleths, and main sequence arrival.

The new approach allows an unambiguous and physically motivated definition of stellar zero age by starting from observable cloud conditions rather than to count from an arbitrary selected and physically unlikely initial condition. Thus a physically solid foundation for the chronology of clusters of all ages is proposed.

Uncertainties in the Age Scale for Young Open Clusters and Mov-
Young open clusters provide the template data for calibrating nearly all methods of age-dating young field stars. Despite the potential for open cluster ages to be quite precise - and despite a large amount of observational effort - the age scale for young open clusters is still controversial, with correction factors of a factor of two or more proposed. I will discuss some of the causes for this uncertainty, and touch on the role of future large surveys in helping to resolve the issue.

**Ages and age spreads in young clusters**

*R. Jeffries*

I will compare and contrast the various techniques that are used for determining the ages of young clusters and assess which of these might be most useful in large photometric or spectroscopic surveys. I will discuss possible ways to tie down the absolute and relative age scales. I will then look at the vexed question of age spreads in young clusters; reviewing the evidence for an age dispersion and discussing further observational steps towards confirming or denying its reality.

**The relevance of X-ray surveys for the study of the properties of young open clusters**

*G. Micela*

Pre-main sequence solar-type stars are at least three order of magnitude more luminous in X-rays than mid-age stars such as the Sun, making X-ray surveys a very powerful tool to detect young stars. Specifically X-ray observations of star forming regions or young open clusters are very effective to identify cluster members among the older field stars present in the region. This capability is very useful in particular to select stars that have already dissipated their disks (weak line type stars), that cannot be identified with more traditional means such as infrared surveys. As a consequence X-ray surveys are crucial to obtain complete samples needed for the study of global properties of the clusters, such as Initial Mass Functions and disk frequency. In this talk I will present some examples of such studies with special emphasis on the role of X-ray observations.

**Chandra observations of the massive young cluster Cygnus OB2**

*N.J. Wright*

Cygnus OB2 is one of the most massive known star clusters in our Galaxy, and also one of the closest at a distance of only \(\sim 1.5\) kpc. Its proximity offers the unique opportunity to probe the structure, dynamics, and low-mass stellar component of a young star cluster that is often impossible in other, more distant clusters. Its role as an important benchmark for studies of stellar clusters has been highlighted by recent Chandra, Spitzer and Herschel surveys of the region.

I will present results from Chandra observations of the center of Cygnus OB2 that have allowed us to efficiently identify \(\sim 1500\) members of the cluster, largely complete in our field of view down to 1 solar mass. These observations are complemented by optical and near-IR photometry from a number of recent deep surveys of the Galactic Plane that were used to identify and separate foreground stars and estimate masses and extinctions for cluster members based on fitted isochrones. This has provided a number of insights into the star formation history of the region, the stellar mass function, and the circumstellar disk fraction that all suggest that a significant fraction of the cluster...
is older than the commonly accepted age of 2 Myrs. This has implications for the timescales of star formation and its propagation throughout massive clusters.

I will also discuss the Chandra Cygnus OB2 Legacy Survey, a recently completed 1 square degree survey of the entire cluster that will facilitate large-scale studies of the stellar populations and disk properties in the harsh environments prevalent in young clusters. It will also provide the first opportunity to study the large scale star formation process in detail, including a planned radial velocity follow-up survey that will probe the dynamical evolution and disruption of a young stellar cluster for the first time.

Young massive stellar clusters in the Milky Way: Quartet, GLIMPSE9 and Cl1813-178 clusters.


The recent 2MASS and Spitzer/GLIMPSE surveys have revealed over a thousand candidate stellar clusters, which are hidden behind copious amounts of dust and gas in the Galactic plane. By combining multi-wavelength information (near-, mid-infrared, radio and X data), it is possible to characterize new candidate clusters, and to identify young massive clusters. Only a dozen massive (> $10^4 \, M_\odot$) stellar clusters are currently known in the Milky Way. We will present a multi-wavelength analysis of newly discovered massive clusters, and unveil their massive stellar content (Quartet, GLIMPSE9 and Cl1813-178 clusters). The clusters GLIMPSE9 and Cl1813-178 are also likely associated with supernovae remnants, therefore enabling us to estimate the masses of the supernovae progenitors.

Possible scenarios for the formation of multiple populations in Globular Clusters

P. Ventura

In the last decades the traditional paradigm that globular clusters are made up of a single stellar population has been seriously challenged by many photometric and spectroscopic evidences, that outlined the presence of more than an individual component. In this contribution I will briefly present the aforementioned evidences, and discuss a possible scenario for the formation and evolution of globular clusters, with the formation of more stellar generations.

Chemical properties of the open cluster population

S. Randich

In the last decade the number of open clusters with accurate metallicity and elemental abundance determination from high resolution spectroscopy has significantly increased. I will review the status of available data, provide an overview of the chemical properties of the open cluster population, and discuss the distribution of iron and other elements as a function of cluster age and position in the Galactic disk.

Stellar Tidal Streams in the Milky Way: evidence for merger events in the Galactic disk?

D. Martínez-Delgado
In the last decade, the study of the formation and evolution of the Milky Way (MW) has been revolutionized by the first generation of wide-field, digital imaging surveys. The resulting extensive photometric databases have revealed for the first time the existence of spectacular stellar tidal streams (e.g., that from the Sagittarius dwarf galaxy) as well as large stellar substructures in the halo, interpreted as the fossils of the hierarchical formation of our Galaxy. The discovery of a stellar ring-like structure in Monoceros or a giant over-density in Canis Major, located close to the Galactic plane outside the MW disk, can also indicate that mergers might play a relevant role in the formation and star cluster content of the outer regions of spiral disks like that of the MW. Theoretical results also provide clear evidence that the destruction of satellite galaxies plays a relevant role not only in the formation of MW-like spiral galaxies generally but also for their disks as well as their halos, suggesting that the stellar mass assembly of the MW disk, and disks in general, likely continues actively to the present epoch.

In this talk I discuss the evidence of the accretion of satellite galaxies on low-inclination orbits as an important formation mechanism of galactic disks (including the possible external origin of some star clusters), and the controversy on the interpretation of the data using different theoretical models. The external origin of these stellar over-densities in the outer regions of our Galaxy (e.g., the Monoceros, Triangulum/Andromeda tidal streams or Canis Major) is still a matter of debate, mainly due to the severe extinction hindering the exploration of low-latitude areas. Clearly, additional observational data (e.g., detailed chemical abundances, kinematic) obtained along these structures are needed to distinguish between different theoretical scenarios.

**Time resolved surveys of stellar clusters**

*L. Eyer*

There are many ways to conduct a large scale survey, because several parameters are competing with each other, such as depth (effective magnitude range), width (observed surface of the sky), precision, repetition of observations of a same field. In this presentation, the focus will be on the time domain research for star clusters, it will be shown how the temporal dimension is bringing irreplaceable knowledge on one hand about stellar formation and evolution, and on the other hand about our Galaxy. Some specific surveys will be mentioned in particular the Gaia mission.

**Developments of the open cluster database WEBDA**

*M. Netopil, E. Paunzen, C. Stütz*

The database WEBDA offers a significant amount of data concerning open clusters. It is intended to provide a reliable picture of the available data and knowledge on open clusters and to offer a wide access to the existing observations for professional as well as amateur astronomers. WEBDA offers astrometric data in the form of coordinates, rectangular positions, proper motions, photometric data in the major systems in which star clusters have been observed, spectroscopic data, like spectral classification, radial velocities, and rotational velocities. It also contains miscellaneous types of supplementary data like membership probabilities, orbital elements of spectroscopic binaries, and periods of variability for different kinds of variable stars.

We will present the future WEBDA interface and new tools, which are needed that the increasing amount of data due to wide field imagers and deeper investigations is still clearly arranged. Furthermore, we will discuss the capability of WEBDA in the era of large sky surveys.
Bayesian inference of stellar parameters and interstellar extinction using parallaxes and multiband photometry

C. A. L. Bailer-Jones

Astrometric surveys provide the opportunity to measure the absolute magnitudes of large numbers of stars, but only if the line-of-sight extinction is known. Unfortunately, extinction is highly degenerate with stellar effective temperature when estimated from broad band optical/infrared data. To address this problem, I introduce a Bayesian method for estimating both the intrinsic parameters of a star and its line-of-sight extinction, without relying on an extinction map. The method uses both the photometry and parallaxes in a self-consistent manner to provide a non-parametric posterior probability distribution over the parameters. It furthermore makes explicit use of domain knowledge by employing the Hertzsprung–Russell Diagram (HRD) to constrain solutions and ensure that they respect stellar physics. I demonstrate this method by using it to estimate effective temperature and extinction from BVJHK data for a set of artificially reddened Hipparcos stars, for which accurate effective temperatures have been estimated from high resolution spectroscopy. Using just the four colours we see the expected strong degeneracy (positive correlation) between the temperature and extinction. Introducing the parallax data and the HRD reduces this degeneracy and improves both the precision (reduces the error bars) and the accuracy of the parameter estimates, the latter by about 35%. I then apply the method to estimate these parameters and absolute magnitudes for 46 000 F,G,K Hipparcos stars which have a reliable cross match with 2MASS. The method can easily be extended to incorporate the estimation of other parameters, in particular metallicity and surface gravity, and will be used in the analysis of the $10^9$ stars from the Gaia Galactic survey.

AstrOmatic software in the era of large stellar photometric surveys

E. Bertin

AstrOmatic software packages have been developed through the years for processing and analysing large quantities of astronomical imaging data in a consistent and fully automated way. I will discuss the performance of the latest generation of AstrOmatic software from the angle of wide-field stellar studies, and present ongoing development efforts to overcome some limitations of the current algorithms.

Cluster parameter determinations for large datasets

T. Naylor

Large photometric surveys present a major challenge, and a significant opportunity. The challenge is to determine parameters such as age from fitting isochrones to colour-magnitude diagrams for a large number of clusters. For this we will have to develop reliable automated procedures. If we can achieve this, we have the opportunity to obtain objective parameters for a large sample of clusters, taken in identical photometric systems. This will overcome the primary limitation of current datasets, that the uncertainties in the parameters can be dominated by systematic effects. I will review the current methods available for fitting colour-magnitude diagrams, and methods of removing background contamination, in addition to discussing which tools we currently lack.

Open Clusters Science in the Virtual Observatory era

I. Zolotukhin
We present http://ocl.sai.msu.ru, modern web application with integrated rich set of third-party analysis tools aimed at facilitating astrophysical research with the Open Cluster Catalog of the Sternberg Astronomical Institute (presented as a separate talk at this conference). Discovered using Virtual Observatory technologies, almost 200 new open clusters are presented in a way that allows further exploitation of the multiple VO-compatible datasets through the single web-site serving as an entry point. As more datasets become available (e.g. UCAC3 with proper motions), new research perspectives arise with this set of open clusters making it possible to do quick-look science online, which have successfully been demonstrated during several VO-Science tutorials. If populated with a more comprehensive set of open clusters, this tool may become a new WEBDA prototype in the VO era.

Posters

Search for new young clusters towards the star forming regions
J. Borissova, VVV collaboration

One of the main goals of the “Vista Variables in the Via Lactea”, ESO Large survey (Minniti et al. 2010) is to search for new star clusters of different ages. In order to trace the early stages of star clusters formation we carrying out a survey of infrared star clusters and stellar groups in the directions of known massive star formation regions associated with methanol maser emission and hot molecular cores. Using Longmore et al. (2009) and Churchwell et al. (2006, 2007) lists of star forming regions up to the moment we have identified by visual inspection 35 small star cluster candidates. Almost all of them seem to be indeed very young, because most of the mass is still concentrated in the gas.

New Milky Way star cluster candidates from DSS and 2MASS
M. Kronberger, P. Reegen, B. Alessi, D. Patchick, D. Riddle, M. Steine, P. Teutsch

We present 23 open cluster candidates that are not included in the latest version of the catalogue of Dias et al. 2002 and have been overlooked by recent automated galactic cluster surveys. All candidates were found during an ongoing visual inspection of First and Second Generation Digitized Sky Survey (DSS) and Two Micron All Sky Survey (2MASS) images. Using 2MASS and UKIDSS photometry, 11 of the presented candidates have physical parameters determined by isochrone fitting of their [J,J-H] and [J,J-K] colour-magnitude diagrams (CMDs). In order to decontaminate the cluster CMDs from the stellar fore- and background of the Milky Way, the spatial stellar densities in the cluster CMDs are compared with those in CMDs of equivalent neighbouring Milky Way fields, and a statistical approach is applied that determines the significance of the density differences between the two diagrams. The studied clusters have ages ranging from a few Myr to > 1 Gyr, are only moderately reddened (E(B-V) < 1.5) and have typical distances between 1 kpc and 3 kpc.

Study of the young Milky Way star clusters: Mercer35, 83, 69, 53, 28 and 70
R. Kurtev, VVV collaboration

We started a long-term project to search the inner Milky Way for hidden star clusters and to study them in detail. The “Vista Variables in the Via Lactea” (VVV) ESO Large survey (Minniti et al. 2010) is ideal for doing this. Our analysis is based on VVV JHK imaging and SOAR low resolution (R 1200) cross-dispersed spectroscopy of the brightest cluster members in the JHK atmospheric windows of the IR clusters: Mercer35, 83, 69, 53, 28 and 70. Using variety of techniques we found some physical parameters of the clusters: the distance, reddening, age, mass and IMF. Some of them are a factor of two to three less massive than some of the youngest super-massive star clusters like Arches, Quintuplet and the Central cluster and are their smaller analogs.

Observations of the IMF in clusters
J. Ascenso, J.F. Alves

The Initial Mass Function (IMF) is a seemingly a universal outcome of the star formation process. Over the last five decades it has been measured in young clusters and associations, in old globulars and in the field, in the Milky Way and in neighboring galaxies, covering regions spanning a wide range of physical conditions. The result is always similar: a Salpeter-like mass distribution for the higher masses and a subsequent flattening for lower masses. As we analyse more distant and dense clusters, however, our ability to measure the IMF properly becomes severely hampered by crowding. I will show how to deal with this potentially severe bias while presenting the results of the analysis of synthetic clusters.

The substellar mass function of the Sigma Orionis cluster
V.J.S. Béjar

We will review current searches for brown dwarfs and isolated planetary mass objects (IPMOs) in the young Sigma Orionis cluster (Age = 3Myr, d = 352pc). We will summarize main characteristics of the substellar population of the cluster like their spatial distribution and disk fraction, and will compare with the low-mass stars. We will review recent investigations to determine the substellar mass function, with special interest in the search and characterization of the T-type objects of the cluster, which according to theoretical evolutionary models corresponds to masses of a few Jupiter mass. We will study the implications of these findings and compare with the predictions of recent formation models.

A deep photometric survey of the double cluster h and Chi Persei
C. V. Cardoso, J. Bouvier, E. Moraux

We performed a deep multi-band photometric survey of the central regions of the young (∼ 14 Myr) and very rich double cluster, h and Chi Persei, extending the membership down to the boundary region between stellar and sub-stellar domain (0.07 M_☉). We used data from CFHT (WIRCAM and MEGACAM) in I, Y, J, H and Ks bands. To select the candidate members we produced CMDs that we compared with the isochrones, and previous known members from photometric, spectroscopical, X-Ray, proper motion, disk and Hα emission studies. We select several thousand candidate members in h and Chi Persei respectively, down to late M dwarfs in a field of view of 20 by 20 arcmin for each cluster. We will present the deepest Mass Function for this double cluster
and compare it with well studied regions like the Pleiades.

**Dynamical evolution of star clusters**

*M. Gieles*

There are several internal and external factors that play a role in the evolution of star clusters. Here we focus on two dominant effects, namely close encounters between stars, or relaxation and mass-loss of the member stars through stellar winds and supernovae explosions. Since the former operates on the relaxation time-scale of the cluster and the latter on the stellar evolution time-scale of the stars it is often assumed that the combined effect is complicated. In this contribution we show that the interplay between stellar evolution and 2-body relaxation is in fact quite simple. The result is an overall expansion of clusters, which is more important for low mass clusters, such that after some time the radii of clusters depend very little on their masses, even if all clusters have the same (surface) density initially. Several predictions are made for the relation between mass, radius, age and galactocentric position that can be compared to empirical cluster samples.

**Star-Disk Interaction in T Tauri Stars: Analysis of the MgII Lines**

*F. López-Martínez, A.I. Gómez-de-Castro*

The MgII is a fundamental tracer of T Tauri stars (TTSs) atmosphere and outflows. The MgII doublet is the strongest feature in the 2800 Å range in the spectra of T Tauri stars. The rest wavelengths of the doublet are \( \lambda 2795.523 \text{ Å} / 2802.698 \text{ Å} \). In the International Ultraviolet Explorer (IUE) and Hubble Space Telescope (HST) data archives there are 73 observations of the MgII lines in TTSs that provide an excellent sample to study the circumstellar environment of TTSs. The profiles display a narrow central absorption produced by the circumstellar medium over imposed on a very broad emission. Evidence of inclination dependent high velocity flows is found in the blue wing of the profile. Accretion flows are occasionally detected in the red wing. Analysis of the properties of the outflows, atmospheres and the accretion process based on this tracer are presented in this contribution.

**YSO clusters on galactic infrared loops**

*G. Marton, L.V. Tóth, S. Zahorecz*

Clustering and other medium scale inhomogeneities have been found in the distribution of YSO candidates based on the data of the all AKARI (Murakami, H. et al., 2007) infrared sky survey. We have identified Class 0 / I / II candidates based on the mid-IR and FIR flux densities of point sources in the AKARI FIS (Yamamura, I. et al., 2010) and AKARI IRC (Isihara, D. et al., 2010) catalogues. The galactic distribution of the YSO candidates have been analysed, and compared to the distribution of ISM. We have found YSO number density fluctuations relative to the CO line intensity (Dame et al., 2001) indicating that ISM column density is not the only reason for star formation activity. The spatial distribution of the AKARI YSO candidates has also been compared to that of the Galactic Infrared Loops (Kiss et al., 2004 and Könyves et al., 2007). Far-infrared loops have been identified in the Galaxy as “surfaces” of high and low density ISM (Toth and Kiss, 2007), and have been introduced as location for star formation by Kiss, Toth et al. (2006). We will show that some of the loops are extremely active with embedded clusters, while others do not form stars at all.
Indication of mass segregation in LMC star clusters
G. Nikolov, M. Kontizas, A. Dapergolas, M. Belcheva, V. Golev, I. Bellas-Velidis

In this contribution we present our investigation on mass segregation in selected LMC star clusters. We expect that mass segregation is producing stratification of the stars due to either initial conditions of cluster star formation or due to the dynamical evolution of the stellar system. We have selected old and young star clusters in WFPC2 from the HST archive. As a diagnostic of mass segregation we use: 1) Colour-magnitude diagrams at various distance from each cluster centre; 2) Radial-density profiles at various magnitude ranges; and 3) comparison with dynamical models which provide core-radius - a measure of a cluster’s compactness. The dependence of the core radius on magnitude provides an indication whether or not mass segregation is present in the cluster.

Spitzer’s view of NGC2264’s circumstellar disk population
P. S. Teixeira, C. J. Lada, M. Marengo, E. A. Lada

Circumstellar disks are a natural by-product of star-formation and they are the birthing sites of planetary systems. The characterization of these disks and their evolution is therefore crucial to understand and identify the initial conditions for planet formation. I will present our results on the characterization of the disk population in the young cluster NGC2264. The disked sources were identified by their excess emission at wavelengths between 3.6 and 24 microns, and classified according to their spectral energy distribution shapes. Our results have led us to hypothesize that there may be two distinct evolutionary paths for disks: a homologous one where the disk emission decreases uniformly in near- and mid-infrared wavelengths and throughout which most sources pass, and a radially differential one where the emission from the inner region of the disk decreases more rapidly than from the outer region. Whether a disk evolves in a homologously or radially depleted fashion may be indicative of the nature of planet formation in the disk.

Star clusters in the SMC: Search for mass segregation
G. Vassilopoulos, G. Nikolov, M. Kontizas, A. Dapergolas, E. Kontizas, V. Golev

The mass distribution in star clusters can be a phenomenon due to the dynamical evolution, that is expected to result in central concentration of massive stars either at the late dynamical stages of a stellar system or at the early stages due to the primordial distribution of stars in the protocluster cloud. The mass segregation is studied in three star clusters of the SMC, NGC152, NGC176 and NGC339 from archive data of HST WFPC2 camera. The selected clusters are found to have ages $1.2 \times 10^9$, $1.3 \times 10^8$ and $5.6 \times 10^9$ yr respectively. These are intermediate to old age clusters and they are compared with similar studies of very young clusters in the LMC.

An empirical view on the formation of stellar clusters
J.F. Alves

An important fraction of the stars in the Universe are formed in massive clusters. Still, we do not know how massive star clusters form nor why the clustered mode is favored. In this contribution I will present an empirical view on the problem that contrasts sharply with the popular and rather successful “turbulent box” view given by recent numerical simulations. I will argue that dense cores
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are still the relevant units when it comes to the formation of clusters, and that a critical role is played by the OB stars in the cluster: OB stars are the seeds of clusters, synchronizing the collapse of an ensemble of mostly stable cores in massive molecular cloud clumps. It’s not that massive stars are found in clusters, it’s clusters that are found around massive stars. I will discuss the potential successes of this new view as well as the problems it faces.

Rotational evolution and lithium depletion in young stellar clusters

J. Bouvier

I will present models of the rotational evolution of solar-type stars from 1 Myr to the age of the Sun. The models are compared to the distribution of rotational periods derived for stars in young stellar clusters. I will review the predictions of the models regarding core-envelope decoupling in stellar interiors and discuss the implications for main sequence lithium depletion in solar-type stars.

Are the metal-rich globular clusters younger than the metal-poor ones?

A. Di Cecco, G. Bono, R. Becucci, S. Degl’Innocenti, P.B. Stetson, G. Iannicola, R. Buonanno, A. Calamida, M. Monelli

We present deep and accurate photometry of the Galactic globular cluster (GGC) M71 ([Fe/H]=-0.73, Harris 1996). Our data set includes 40 multi-band (g',r',i',z' Sloan bands) images collected with MegaCam@CFHT (FoV: 1° × 1°, scale: 0.187”/pxl) mosaic camera. Simultaneous photometry was performed using several programs: DAOPHOT/ALLSTAR, and ALLFRAME (Stetson 1987, 1994). We also plan to reduce a detailed set of NIR (J,K) images collected with WIRCam available at CFHT (FoV=20’ × 20’, scale: 0.3”/pxl). We selected this system, since it belongs to the metal-rich tail of GGCs. Current empirical evidence indicate that metal-rich GC might be systematically younger than the bulk of GCs (possible occurrence of an age metallicity relation among GCs), but we still lack firm constraints.

To provide an accurate estimate of the age of M71 we plan to apply the same method recently suggested by Bono et al. (2010) and based on a well defined knee located in the lower main sequence. We plan to compute detailed sets of cluster isochrones accounting for both alpha and CNO enhancement. This feature can be easily detected when moving from the I to the K-band. The key advantage of this approach is that it is independent of the distance modulus and minimally affected by the uncertainties on the reddening corrections. We plan to provide age estimates with an accuracy better than 1.5 Gyr (Di Cecco et al. 2010).

UV bright globular clusters in M87: more evidence for super-He-rich stellar populations?

S. Kaviraj, S. Yi, S. Sohn, R. O’Connell, S. Jin Yoon, Y. Wook Lee

We study the ultraviolet (UV) and optical properties of 38 massive globular clusters (GCs) in the Virgo elliptical, M87, imaged using the STIS and WFPC2 instruments onboard the Hubble Space Telescope. The majority of these GCs appear extremely bright in the far-UV (FUV), roughly a magnitude brighter than their Galactic counterparts with similar metallicities. The observed FUV flux is several times larger than predictions of canonical old stellar population models. These
canonical models, which assume a fiducial helium enrichment parameter, \( \frac{dy}{dz} = 2 \), are able to reproduce the observed FUV fluxes only if ages 3, 5 Gyr larger than the age of the Universe are invoked, although the same models fit the UV photometry of Galactic and M31 GCs for realistic old ages. A similar discrepancy (around 3 Gyrs) is found between the mass-weighted and UV-luminosity-weighted ages of the massive Galactic GC Omega Cen, whose colour-magnitude diagram (including peculiar features on its well-populated horizontal branch) can be accurately reproduced by invoking a small super-He-rich (\( \frac{dY}{dZ} = 90 \)) stellar component. By comparison to Omega Cen, we propose that the majority of M87 GCs in our sample contain strong signatures of similarly minor super-He-rich subcomponents. This hypothesis is supported by simulations which suggest that, based on the UV detection limit of this survey, the number of GCs detected is several times that predicted by canonical models. We show that the same phenomenon that causes the extended horizontal branch of Omega Cen explains the UV brightness of our sample. If this is indeed due to the extreme helium, this study would be the first to find its signatures in extragalactic objects.

Chromospheric activity and Lithium abundance in NGC3572, NGC3766, and NGC2516

A. E. Messina, A. C. Lanzafame, I. Busà

Rotation, magnetic activity and age are strictly connected in late-types stars. The level of magnetic activity depend on stellar rotation, which evolve with age and is in turn strongly influenced by magnetic fields. Lithium abundance also depends on age, but the connection with rotation and magnetic activity is still debated. Our knowledge on the evolution between ages corresponding to the inner disk dissipation (around 10 Myr) and when the wind-braking dominates the rotational evolution (after about 700 Myr for a 1 solar mass star) is still rather poor. Open clusters represent ideal targets for investigating the connection between rotation, activity, lithium depletion and age.

From our analysis based on FLAMES@VLT data, we measured the chromospheric activity and the Li-depletion in three open clusters of different ages, namely NGC3572 (8Myr), NGC3766 (15Myr), and NGC2516 (100Myr), supplementing existing data and providing new information on this still poorly explored age range.

Stellar populations in the super star clusters NGC3603 and 30 Doradus

F. Paresce, G. de Marchi, M. Sirianni, M. Andersen, G. Beccari, L. Spezzi, N. Panagia

Early Release Science observations of the super star clusters NGC3603 and 30 Doradus in the UV, optical and near IR with WFC3 show for the first time clear evidence of multiple stellar populations in both clusters with an age spread of 1 to 20-30 Myrs. The spatial distributions of the cluster stars indicate that the older population is more widely and uniformly distributed over the cluster field than the much clumpier younger population. A reasonable separation of the main components of these populations can now be made by the use of their Halpha excess, a good indicator of their PMS status, allowing a better understanding of the stellar mass function and its evolution in time.

Chemical properties of the Hipparcos red clump

E. Puget, G. Tautvaisiene
Hipparcos data have allowed the identification of a large number of clump stars in the solar neighborhood. We discuss our present knowledge about their distributions of metallicities, CNO abundances, carbon isotope ratios and membership of the first ascent giants and helium-core-burning stars. The clump stars have accumulated all chemical composition changes, which have happened during their evolution along the giant branch and during the helium flash, thus are very trustful sources of information about stellar evolution. We discuss the observational data in the light of theoretical models of stellar evolution.

A Subaru view on RSGC1

B. Rochau
The Galactic Red Supergiant Clusters extend the rather small sample of Milky Way starburst clusters towards more evolved young clusters. They were recently detected based on the 2MASS survey, but the properties of their low- and intermediate-mass population remain unaddressed. We will present first results of our deep JHKs Subaru/MOIRCS observations of the youngest of the Red Supergiant Clusters, RSGC1, which map a deep sample of cluster members, even below the pre-main/main sequence transition. They allow to refine cluster properties such as age, distance, cluster mass and, even more, to test pre- and post-main sequence stellar evolutionary models in the range of 10 Myr. This highlights the potential of large surveys followed-up by deep observations.

CNO elements as tracers of stellar evolution in red clump stars of open clusters

G. Tautvaisiene, S. Mikolaitis
Galactic open clusters are known as excellent tracers of stellar and Galactic chemical evolution. The carbon, nitrogen and oxygen abundances, C/N and especially carbon isotope ratios are key tools for stellar evolution studies. In this presentation we overview available up to date analyses of CNO elements in red clump stars of open clusters along with our recent results obtained for the open clusters NGC 6134 and IC 4651. The clump stars have accumulated all chemical composition changes, which have happened during their evolution along the giant branch and during the helium flash, thus are very trustful sources of information. The observational data we discuss in the light of theoretical models of stellar evolution.

Super star clusters with adaptive optics in starburst galaxies

P. Vaisanen, Z. Randriamanakoto
We report on initial results of an on-going survey using near-IR adaptive optics imaging of a few dozen strongly star-forming (SF) galaxies, ranging from starbursts to luminous IR galaxies (LIRGs). The targets are at various stages of merging, interaction, or isolation, and lie at distances between 40 to 150 Mpc. We detect many super star cluster (SSC) candidates in the galaxies, from dozens to hundreds per target. We present the first NIR luminosity functions (LF) of SSCs, their spatial distribution, and find the LF slopes to be shallower than typically seen in the optical in nearby interacting galaxies. We discuss how the observations will be used to constrain SF history and triggering in the galaxies, as well as study the universality of mass functions and SSC formation and disruption models.
Spiral structure and stellar populations in the solar neighbourhood

We present a new image of the spiral structure of the Galaxy, using as spiral arm tracer sources of CS molecular emission associated with star-formation regions. A spiral arm which passes close to the Sun, at a smaller galactic radius, presents a strong break in angle, which is confirmed with other tracers, like Cepheids and Open Clusters. The break in angle of this arm is consistent with stellar orbits at the 4:1 resonance (4 epicycle rotations in one galactic revolution), with a maximum elongation close to the Sun. From the details of the spiral structure of our Galaxy, one can see that there is in the solar neighbourhood a mixture of stars belonging to distinct groups of orbits, and therefore, were born at different galactic radii, have different metallicities and occupy different regions in the U-V plane of galactic velocities. The analysis of the connexion between the spiral structure and the stellar populations helps us to understand recent fine details of the metallicity gradients in the Galaxy, including the azimuthal gradient. This work was greatly beneficited by the results of proper motion and parallax surveys like Hipparcos/Tycho2, and by the radio molecular survey made by Leonardo Bronfmann in Chile. The discovery of new and more distant Cepheids in the galactic plane, with their follow-up in the near infrared to determine their average magnitude during a period, will be made possible by the VISTA survey and will be of great importance for the galactic work.

Populations of Variable Stars in Open Clusters
R.I. Anderson, N. Mowlavi, L. Eyer

We present our work in progress that explores links between characteristics of variable stars in open clusters and the general population properties. Currently, our study is based mainly on two literature sources, the WebDA open cluster data base and the Catalog of Optically Visible Open Clusters and Candidates (Dias et al. 2002-2010). The (inhomogeneous) sample of clusters considered here is constrained by the availability of measured cluster ages and metallicities, as well as information on red giant or other variable star content. We show the kind of information retrieved for our sample of up to 110 clusters and some correlations that can be seen more or less directly. Our preliminary results include tentative signs of chemical enrichment in the galaxy and an increase in the number of red giants with age as expected from stellar evolution. We do not see a correlation between the number of delta Scuti stars in a cluster (from WebDA) with metallicity and turn-off mass or age. Special attention is given to shortcomings or errors in the two main sources. A detailed investigation of a more complete sample of clusters and especially variable stars, as well as an exhaustive review of the literature available are intended for the near future.

The metallicity gradient in the Galactic disk revealed by Cepheids and open clusters
P. Cruz, J.R.D. Lépine

We collected results from individual observations of metallicities of Cepheids and open clusters from the literature, in order to investigate the metallicity gradient in the Galactic disk. We re-computed the distances of the Cepheids based on the period-luminosity and period-intrinsic color relations, and the distances of open clusters with more precise ways of computing the effect of interstellar
extinction. The data obtained were analyzed using the short distance scale of the galactocentric distance of the Sun, R0 = 7.5 kpc. We concentrated our study on the Galactic distributions of [Fe/H] and [O/H]. We discuss the existence of a sudden step down in metallicity (a decrease as we go outwards) at a galactic radius of about 8.6 kpc, followed by a relatively flat region, and we report the existence of an azimuthal gradient. The same break in the metallicity gradient was previously presented by other authors, with a smaller sample of open clusters, and it has been also detected in samples of Cepheids and other objects as well. We also discuss two different hypotheses for this feature, which both are based on the connection between the spiral structure and star-formation rate of the Galaxy.

**Dynamical evolution of rotating globular clusters with embedded black holes**

*J. Fiestas, R. Spurzem*

Dynamical evolution of globular clusters with embedded black holes is investigated. The interaction between the black hole and stellar component in rotating clusters is followed by using of Nbody and 2D+1 Fokker-Planck numerical techniques. The models can reproduce the Bahcall-Wolf solution \( f \propto E^{1/4} (n \propto r^{-7/4}) \) inside the zone of influence of the black hole in a relaxation time scale. We explore system dissolution due to mass-loss in the presence of an external galactic tidal field.

**Tracing the structure of the Perseus Arm with IPHAS**

*R. Raddi, J.E. Drew, S.E. Sale, D. Steeghs*

Research aiming to describe the morphology of the Milky Way disc has to confront both difficulties in obtaining distances and the high interstellar extinction found in the Galactic plane. In several studies, the Perseus Arm appears to be a clear feature of the Milky Way and its distance is estimated to be between 2 and 3 kpc from the Sun. Spiral structures are traced by luminous O and B stars, or more precisely by clusters and associations of them. In this context, we present a study regarding a section of the Perseus Arm, between Galactic longitudes 120° – 140° and Galactic latitudes -1° – +4°, including active star forming regions (e.g. W3/W4/W5). Our approach to the problem is dual: i) Young stellar objects (YSO) are being identified and spectral typed, by analysing optical spectra of bright emission line candidate stars, selected from a wider sample described by Witham et al. (2008). Their distances are obtained from the reddening vs. distance relationship along the line of sight, computed from IPHAS photometry (Sale et al., 2009). ii) We compare A stars (typically ~ 10-100 Myrs old) with F star densities, to analyse evidence of young structures defined in space in a new way.

**Chemical composition of a kinematically identified stellar group in the Milky Way**

*E. Stonkute, G. Tautvaisiene, B. Nordstrom, R. Zenoviene*

The formation and evolution of the Milky Way is quite complex and still not fully understood. From correlations between orbital parameters: apocentre, pericentre and z-angular momentum, Helmi et al. (2006) identified three new coherent groups of stars and suggested that those might correspond to remains of disrupted satellites. Stars in each group cluster around regions of roughly constant eccentricity, metallicity [Fe/H] and age. From high resolution spectra obtained with the FIES spectrograph at the Nordic Optical Telescope, La Palma, we measured abundances of...
oxygen, alpha-elements and other heavier chemical elements in one of the groups. We here report on elemental abundances for 16 stars in that group. Those stars have a metallicity around -0.7 dex and a single isochrone age of about 12 Gyr. We also find that their chemical composition is homogeneous and distinct from Galactic disk dwarfs. This provides further evidence of their extragalactic origin.

A kinematic study of open clusters: implications for their origin

D. Vande Putte, T.P. Garnier, I. Ferreras, R.P. Mignani, M. Cropper

The Galactic population of open clusters provides a wealth of information on star formation in the Galaxy. The open cluster catalogue by Dias et al. (2002, we use version 2.10) is a rich source of data, including kinematic information. This large sample made it possible to carry out a systematic analysis of 481 open cluster orbits, using parameters based on orbit eccentricity and separation from the Galactic plane. These two parameters may be indicative of origin, and we find them to be correlated. We also find them to be correlated with metallicity, another parameter suggested elsewhere to be a marker for origin. Open clusters with the highest eccentricities or the largest separations about the Galactic plane are found at low metallicity ([Fe/H] Solar < -0.2 dex). The resulting analysis points to four open clusters in the catalogue possibly being of extra-Galactic origin by impact of high velocity cloud on the disk: Berkeley21, 32, 99, and Melotte66, with a possible further four due to this origin (NGC2158, 2420, 7789, IC1311). A further three may be due to Galactic globular cluster impact on the disk i.e of internal Galactic origin (NGC6791, 1817, and 7044). The large astrometric database provided by Gaia, with parallaxes and proper motions measured with unprecedented accuracy and limiting magnitude, will mark a major step forward in the study of the Galactic orbits of open clusters, making it possible to accurately resolve different open cluster populations on the basis of their kinematic properties.

Globular Clusters in the ACS Virgo and Fornax Cluster Surveys

D. Villegas, ACSFCS collaboration

I will present results of the study of the globular clusters luminosity function in the full sample of galaxies included in the ACS Virgo and Fornax cluster surveys, as well as some discussion on the general properties of the sub-populations of clusters hosted by these galaxies.

These results will be preceded by a description of the data reduction and analysis procedure developed for these surveys.

GALEXtin: A VO-Service to estimate galactic interstellar extinction

E. B. Amôres, L. Sodré Jr, A. Moitinho, J. Lépine

It is very important and fundamental for several works to know the interstellar extinction distribution in our Galaxy. This could be useful to estimate distances of objects and color corrections for which the distance can be estimated by some other method, for star counts and brightness models of the Galaxy and also for spectrum extinction correction, among other applications. In this context, we are developing a VO-Service called GALEXtin that provides interstellar extinction estimate for any direction of the sky from: 2D maps and 3D models available and catalogs with
extinction measure as well diffuse emission. This is also very useful to study the distribution of interstellar extinction towards star clusters. The users can also provide a list with coordinates and distances that GALExtin provide as an output list with extinction estimate for each object for a chosen model. At the moment, is available the 2D maps provided by Burstein & Heiles (1982) and Schlegel et al. (1998) and the 3D extinction models provided by Amóres & Lépine (2005), Drimmel et al. (2003) and Marshall et al. (2006).
S6: Science Cases for Optical and IR Interferometry

What kinds of interferometric science will be feasible from the ground?

D. Buscher

I present a “bottom-up” approach to deciding what kinds of science are likely to be possible with interferometers in 2020. The approach attempts to map out the feasible regions of science parameter space, concentrating on the fundamental limitations set by the Earth’s atmosphere and by Fourier imaging theory.

The case of imaging at the VLTI and the need to combine up to 6 to 8 telescopes


Interferometry imaging is now becoming more and more common although still reserved for an handful of specialist whereas the science achieved with this technique is more easily grasped by the other astronomers. We will review the current status of interferometry imaging by recalling the latest results obtained at the VLTI but also at other facilities like CHARA. We will also present the results of simulations that shows what is required in order to make this technique available to the general user. Finally this presentation will conclude with possible plans to prepare the VLTI for such science.

Imaging protoplanetary disks around young stars: the first image obtained with VLTI/AMBER on MWC275

F. Malbet, S. Renard, M. Benisty, E. Thiébaut, J.-P. Berger

For the first time, milli-arcsecond images of the environment of a young intermediate-mass star is produced: model-independent H and K-band images by aperture synthesis of the surroundings of MWC 275 were obtained. The images reveal several significant features that can be related to an inclined asymmetric flared disk around this star with the strongest intensity at about 4-5 mas. Due to incomplete spatial frequency coverage, we cannot state if each of them individually has a peculiar meaning, but these images confirm that the morphology of the close environment of young stars is more complex than the simple models used in the literature so far.

Sub-milliarcsecond imaging of stellar sources at the CHARA array
The center for high angular resolution astronomy (CHARA) array and the michigan infrared combiner (MIRC) have achieved sub-milliarcsecond imaging capabilities in infrared interferometry. Complex model-independent imaging of stellar surfaces, binary stars and stellar discs have been demonstrated. With the introduction of a fringe tracking capability and the simultaneous combination of six beams CHARA and MIRC are expected to improve in sensitivity and imaging complexity, allowing the array to image in detail the discs of young stellar objects and detect sub-stellar companions and hot jupiters around main-sequence stars.

Interferometric observations and modelling of Massive Young Stellar Objects

R.D. Oudmaijer, W.J. de Wit, M.G. Hoare

High-angular resolution observations are of key importance to massive star formation if we are to understand how young massive stars accrete mass. Testing numerical predictions of accreting massive stars requires observations at milli-arcsecond angular resolution. After all, the often used SED modelling alone remains ambiguous and we need spatial constraints to make progress. Moreover, ongoing accretion activity will give rise to emission in the mid-IR wavelength range. We present an overview of our results to date in massive star formation using IR interferometry. The data of multiple MYSOs (accreting pre-main sequence stars just before the HII phase) at multiple baselines are nearly exclusively obtained using the Very Large Telescope Interferometer. These results involve the near IR instrument AMBER and the mid-IR instrument MIDI, supplemented by 2D radiative transfer modelling.

High-resolution 1-D imaging of the atmosphere of the red supergiant Betelgeuse in the 2.3 micron CO lines with VLTI/AMBER

K. Ohnaka

Despite its importance in governing the final fate of massive stars, the mass loss mechanism in red supergiants is still unclear. Studies of the dynamics in the inhomogeneous atmosphere are a key to understanding the mass loss process in these stars. We present high-spectral and high-spatial resolution observations of the best studied red supergiant Betelgeuse near 2.3 micron with the AMBER instrument at the Very Large Telescope Interferometer. With an angular resolution of 9 mas, our VLTI/AMBER observations mark the highest resolution ever achieved at any wavelength for Betelgeuse. The AMBER data taken 1 year apart reveal no or only marginal time variations in the continuum, contrary to the current 3-D convection simulations for red supergiants. On the other hand, the data in the CO lines show significant time variations, suggesting changes in the dynamics of the atmosphere in 1 year. We also present the first 1-D aperture synthesis imaging of Betelgeuse in the continuum as well as in the individual CO lines. The reconstructed intensity profiles in the continuum show only slight deviations (< 10%) from the uniform disk with the same angular size. However, the intensity profiles in the CO lines are extended to 1.5 stellar radii, much more than the hydrostatic photospheric model. This is the first (1-D) imaging of the warm molecular outer atmosphere of a red supergiant in the individual CO lines.

Resolving the nuclear dust structure in nearby AGNs

L. Burtscher, K. Meisenheimer, K.R.W. Tristram, W. Jaffe
Interferometric observations with MIDI/VLTI in the mid-infrared made studies of the central dusty tori of Active Galactic Nuclei (AGNs) possible and proved their existence in a number of nearby AGNs. Both type 2 and type 1 galaxies showed parsec-scale structures whose properties were comparable, thus confirming the unifying model for AGNs. On the other hand, the lack of hot dust in the Circinus galaxy and the unexpected orientation of NGC 1068’s dust disks with respect to its host galaxy’s axes were puzzling. More detailed observations of Centaurus A and the Circinus galaxy now show that the visibilities are actually not as smooth as one would expect from simple geometrical models for the dust distribution but that more complicated structures are needed to explain the data. After a short overview of the existing publications, I will present our recent observations and attempts to model them.

Stellar physics at very high angular and spectral resolution: from VEGA/CHARA to future large optical arrays.

D. Mourard, K. Perraut, N. Nardetto, O. Chesneau

Understanding the origin and the evolution of stars and planets is one of the main scientific questions for astronomers. Very large optical arrays can bring unique answers by opening the parameter’s space in the direction of the microarcsecond of arc in spatial resolution coupled with very high spectral resolution. Unique science niches in the field of stellar physics could then be explored and progresses are now made in this direction. With the recent successes of the VEGA visible instrument on the long baseline CHARA Array, original and unique stellar physics programs are now accessible. We will show how these programs are currently developing and how they are prefiguring some of key questions that future long baseline optical arrays will develop.

Probing the architecture of planetary systems down to the Earth-mass with SIM-Lite

F. Malbet, A. Leger

SIM-Lite can make extremely accurate measurements (0.06"as rms, end of mission accuracy) that allow the search for 1 Earth mass exoplanets in mid-habitable zone locations. In the context of GAIA and PRIMA which will both be able to detect Giant planets, SIM-Lite opens the possibility to continue the characterization of extrasolar planetary systems down to the Earth-mass. SIM opens therefore the possibility to characterize the end products of the formation of planetary systems and to reconstruct the history of this formation. SIM-Lite will also identify terrestrial planets in the Habitable Zones of the nearest, brightest stars; uniquely measure masses which is a critical characteristic for habitability; and determine orbits and ephemeris which are critical information for future large missions aimed at direct detection of atmospheric signatures including biomarkers.

Extragalactic Astronomy

Walter Jaffe

What aspects of AGN physics can be investigated by present or near-future ground based interferometers in the optical or IR? How many targets are accessible? What technologies are critical for advances? What are we learning at present from the VLTI and Keck and what can we expect from MATISSE, GRAVITY and the MRO?
**Extragalactic Astronomy**

*Sebastian Wolf*

Interferometers operating in the infrared to millimeter wavelength range nowadays allow to constrain the brightness distribution and thus the structure of circumstellar disks around young stars on angular scales of about 1-100 milliarcseconds. In nearby star-forming regions this corresponds to the size of the potential planet-forming region in these disks. Furthermore, near-future long-baseline interferometers, such as the Atacama Large Millimeter Array (ALMA) or the planned second generation instruments for the Very Large Telescope Interferometer (VLTI) will even allow to constrain complex structures in these disks which are indicative for selected phases of the planet formation process. In this review an overview of planet formation studies based on multi-wavelength observations of circumstellar disks with long-baseline interferometers will be given.

**Circumstellar Matter**

*Olivier Chesneau*

This presentation will summarize the large amount of interferometric observations of the circumstellar environments of evolved stars (from the low mass stars to the most massive ones). The talk will be particularly focused on the efforts made in linking the wind properties of the evolved stars and their mass-loss, probed at the highest spatial resolutions, and the building-up of circumstellar disks. These disk share many properties with the disks encountered around the Young Stellar Objects.

**Perspectives of Interferometry from the Ground**

*Andreas Glindemann*

Over the last decade, stellar interferometry has developed from a specialist tool to a mainstream observing technique. The user community has expanded well beyond the experts, attracting scientists whose research benefits from milliarcsecond angular resolution. As a result, the number of scientific publications has grown exponentially, showing the same trend as in radio interferometry some 30 years earlier. Stellar interferometry has become part of the astronomer’s toolbox, complementing single telescope observations by providing unique capabilities that will advance astronomical research. In the following, operating and planned interferometric observatories will be presented, their layout and suite of instruments discussed, and the typical performance will be given. The perspectives of interferometry will be derived starting from these facilities, discussing also the numerous ideas for direct imaging. The latter, although conceptually ingenious, presents serious technical challenges that need to be resolved before considering these concepts for next generation interferometers. Most interferometric instruments in operation are using the Michelson configuration when the remapping of the telescope apertures is not homothetic and the field of view is limited to less than an Airy disk. We will see that the atmosphere sets a severe limit to a useful maximum baseline for observing faint objects. Phase referenced imaging, providing an imaging mode for faint objects, is thus limited to ‘modest’ baselines of a few 100m. Astrometry, however, should be expandable to kilometric baselines, with subsequent sub-microarcsecond accuracy, if both stars are sufficiently bright. Thus, sticking to reasonably densely populated arrays stretching over <500 m should provide excellent opportunities for interferometric imaging of faint sources. Longer baselines permit the visibility measurement - for astrometry or imaging - of bright sources when the size of the object (and the subsequent lower visibility) sets the limit.
Fundamental Properties of Stars

Theo ten Brummelaar

Title: Fundamental Properties of Stars Authors: Theo ten Brummelaar CHARA/GSU Abstract

Contrary to the general feeling amongst a majority of Astronomers, the fundamental properties of stars are not well understood, and certainly not at the <1% level required for testing and improving our models of stellar evolution. For example, measurements from interferometers over the last few years have shown that current models consistently predict stellar diameters that are smaller than our measurements, and this has led to a frequent over-estimate of the effective temperature, and in the cases were we know the mass, an over-estimate of the density. In this talk I will give a summary of recent results from interferometers and briefly discuss how these have been affecting our understanding of the models currently available. I will end the talk with some thoughts about where we might be headed in the near future and what new abilities interferometers should give us in the next decade.

The Center of our Galaxy

Stefan Gillessen

Today, the 4 million solar masses black hole in the Galactic Center is the best case for the existence of an astrophysical black hole in general. The breakthrough in measuring the mass became possible with the advance of infrared astronomy and adaptive optics. Within a decade the observations have progressed from velocity dispersion arguments to tracking individual stars as test particles for the gravitational potential. Further progress can be expected from the ever growing time base as well as from near-infrared interferometry, namely the second generation VLTI instrument 'GRAVITY'. This is an adaptive optics assisted Beam Combiner built to provide high-precision narrow-angle astrometry and phase-referenced interferometric imaging in the astronomical K-band for faint objects. The most prominent goal is to observe highly relativistic motions of matter close to the event horizon of the Galactic Center massive black hole.

Posters

Science with the Carlina hypertelescope


Studies are currently underway to propose a generation of interferometers post-VLTI (Carlina, OHANA, Keops, etc.). Such interferometers will open new fields of research in astrophysics by imaging the surfaces of supergiant stars, gravitational microlensing, AGN, etc. To achieve these goals, they will have to respond to several criteria: to provide very high angular resolution (baselines > 100 m), to be equipped with a large number of mirrors in order to achieve a rich UV coverage, and to be able to accommodate high tech instrumentation such as an Adaptive Optics system and a coronagraph. Carlina fulfills all these criteria. Carlina is an optical interferometer configured like a diluted version of the Arecibo radio-telescope. Above the diluted primary mirror, made of fixed co-spherical segments, a helium balloon, or cables suspended between two mountains, carry a gondola containing the focal optics, and detector. At this moment, we are testing the entire optical train of
the hypertelescope (spherical corrector, pupil densifier, servo loop system, etc.) on a 10m baseline prototype at Haute-Provence observatory. Thanks to this prototype, we demonstrate that Carlina will provide a complementary instrument between ELTs and kilometer interferometers. It should be possible to build within the next 10 years a Carlina scientific demonstrator with baselines in the 100-300 meter range equipped with individual apertures of 30 cm in diameter. This instrument will be very sensitive (uv > 12) and it will provide imaging capabilities at extremely high angular resolution (typically 0.4 mas). We present and discuss the high-performances of Carlina which will deliver polychromatic images of AGN, stellar surfaces, binary systems, gravitational microlensing, Hot Jupiters, etc.

Understanding the dust formation and mass-loss process in C-rich AGB stars

C. Paladini, S. Sacuto, J. Hron, B. Aringer, S. Hoefner

Luminous carbon rich stars are evolved objects on the Asymptotic Giant Branch (AGB). They are characterized by dynamic processes like pulsation, dust formation and mass-loss. These stars are fundamental for the chemical enrichment of the ISM, and the chemical evolution of galaxies. Infrared interferometric studies made already an important contribution to the understanding of these objects, and the interpretation of interferometric observations based on static and dynamic models will be shown. The stellar parameters derived for mildly pulsating C-rich stars by combining spectroscopy and interferometry will also be discussed. In spite of these recent encouraging results, several questions are still open, in particular concerning dust formation and mass-loss process. The large potential of MATISSE to solve these questions will be illustrated. MATISSE, with its capability to observe in the L-band, will allow to study one of the most prominent molecular features of the C-rich stars due to C2H2 and HCN. C2H2 is an important probe for the atmospheric structure and the dust formation. It is the main precursor of carbon dust. This molecule is also very sensitive to temperature and density changes, as expected for dynamic atmospheres. MIDI already showed very interesting results for the region where molecules and dust interact between each other. But only L+M+N observations as foreseen with MATISSE will give a complete picture on the mass-loss process.

Relations between properties of magnetic and rotating stars

L.M.B.C. Campos

The assumption of energy transport by waves in the outer stellar layers is used to predict a significant set of stellar data from only two parameters: luminosity and brightness. These specify the temperature, mass density, pressure, velocity, sound speed and Mach number for “normal” stars. Also the magnetic field, magnetic pressure, Alfven speed and Alfven number for stars with a strong magnetic field. In addition the rotation period and tangential velocity for fast rotating stars. In all cases are obtained the mass and energy fluxes. Also the classes of phenomena present, like normal or rotatory shocks. This data can be predicted for a variety of stars, checked by comparison with observation and plotted in modified H-R diagrams.

VLTI-AMBER interferometry of the post-Red Supergiant IRC +10420

Oudmaijer, de Wit
We present multi-epoch, multi-baseline VLTI/AMBER interferometric data, some taken with FINITO, of IRC +10420. The data are complemented with quasi-simultaneous X-Shooter data. This rare post-Red Supergiant is evolving to the left in the HR diagram on its way to become a Wolf-Rayet star to ultimately become a Supernova. It is therefore one of the few objects that can give us information on the real-time evolution and shaping of the circumstellar environment of massive evolved stars. We discuss the geometry of the environment, present a simple model to interpret the data, demonstrate that spectro-interferometry of spectrally unresolved lines will underestimate the size of the emitting material by up to 50% and present crucial evidence, based on data of the NaI doublet that the object is surrounded by a pseudo-photosphere, confirming earlier suggestions.

Analysis of LBT LINC-NIRVANA simulated images

P. Ciliegi

LINC-NIRVANA (LN) is a Fizeau interferometer that will provide for the first time images with a very high angular resolution (about 9,12,17 mas in J,H and K bands) combining the beams from the two Large Binocular Telescope (LBT) arms, by adopting a Multi-Conjugate Adaptive Optics system (MCAO) that allows for atmospheric turbulence compensation. We are using a dedicated software for the simulation and analysis of different scientific cases (from nearby Young Stellar Objects to distant galaxies) in order to test the capability of LN in different astronomical contexts (high dynamical range, faint objects, etc.). In this contribution we will present the new results and improvements obtained in the reconstruction and analysis of LN-simulated images, together with an evaluation of the best observing procedure to be adopted for the scientific cases of interest.

Hα line forming region of HAEBE spatially resolved at sub-AU scales

Perraut, Mourard, Benisty, Rajabi, Bacciotti, Giovanardi

We present the very first observations of a young stellar object using long baseline interferometry at visible wavelengths with spectral resolution. We collected data on the prototype of the Herbig Ae, AB Aur, with the VEGA spectrometer installed at the focus of the CHARA array. We show that AB Aur is clearly resolved at a few milli-arcsecond resolution both in the Hα line and in a part of the continuum. The PCygni profile of Hα suggests that it is emitted in a wind. To reproduce the morphology of the wind and the physical conditions therein, we used the radiative transfer code RAMIDUS and tested various configurations (stellar wind, disk wind, X-wind) to simultaneously fit the line profile and the spectral visibilities. A spherical wind model originating on the star itself could be ruled out but instead our data seem compatible with a magneto-centrifugal mechanism for the production of the wind. It was difficult, however, to determine the exact morphology of the wind and disentangle the X-wind and the disk wind because of the extended reflection nebulosity that surrounds the system and additional data are needed.
S7: The Square Kilometre Array

The SKA challenge
D. DeBoer

The Square Kilometre Array (SKA) will be one of the Great Observatories to answer fundamental questions about the Universe: its life history, its inner workings and our place in it. The SKA is an ambitious program in part because from the start it has been international in scope both as a principle of collaboration and to address its ambitious breadth. A central premise of the SKA is that market technology drivers have driven the performance and cost of the central technologies such that sufficient quantities can be affordably deployed to achieve the huge increase in sensitivity called for by the science.

Cost and complexity are the key SKA challenges. Performance of the core technology is certainly adequate in order to meet the design goals; however can it be done at an appropriate price-point? Computing roadmaps predict that appropriate high-performance computing will exist; however can it be afforded? The cost of operating the facility is a key constraint; if we can afford to build it can we afford to operate it?

Although the goal is to keep sub-systems simple (and inexpensive), the huge numbers of sub-systems on different sensor platforms in a complex international stakeholder project introduces great complexity. Addressing these issues of costing and complexity head-on is needed to successfully deploy what could become one of the largest and most iconic science projects ever.

Science with SKA Pathfinders
T. Oosterloo

SKA will have an enormous impact on astronomy. Inspired by this prospect, radio astronomy groups around the world are preparing for SKA, both for the science of SKA, as well as for the technology. A number of new radio instruments are being constructed to pave the way for SKA. I will discuss some of the main science topics which will be addressed by these SKA Pathfinders. I will hope to show that even before the advent of SKA, radio astronomy will be very exciting.

Societal Impacts of SKA
S. Garrington

I will describe the Societal benefits from SKA, in terms of Human resource training and formation, the impact on ICTs, the Green Energy sinergies and the Global linkage between Science, industry and society.
The SKA new Instrumentation - Aperture Arrays

A. van Ardenne

Mid 1990s early R&D and science activities were mounted to build the case for a telescope being over an order of magnitude more sensitive, having wide field of view capabilities and over two decades of observing frequency coverage to mention a few. Now dubbed the Square Kilometre Array, its radio frequency window is planned to cover the wavelength regime from cm up to a few meters. For this range to be optimally covered, different antenna concepts are considered enabling different science cases. At the lowest frequency range, up to a few GHz, it is expected that multi-beam techniques will be used, increasing the effective field-of-view to a level that allows very efficient detailed and sensitive exploration of the complete sky. Although sparse narrow band phased arrays are as old as radio astronomy, multi-octave sparse and dense arrays now considered for the SKA require new low noise design, signal processing and calibration techniques. The successful implementation of these new array techniques has already been introduced for the use of phased array feeds upgrading existing reflecting telescopes and for new telescopes to enhance the aperture efficiency as well as hugely increasing the field-of-view. Other telescope architecture uses phased arrays without any additional reflectors. The phased array elements are small enough to see most of the sky intrinsically offering a large field of view. Especially the development of low cost array antenna design will allow a cost effective large scale implementation for the SKA. In the context of defining and developing for the next SKA phase the international Aperture Array Verification Program aims at furthering aperture arrays for the SKA. This presentation addresses the new science capabilities, emphasizing implementations for sparse (such as LOFAR) and other low frequency telescopes being build) and dense mode operation for higher frequencies. The work aims to provide insight in the status of enabling technologies and technical research on polarization, calibration and side lobe control required to fully unleash the potential of phased arrays for future radio astronomy synthesis arrays.

High energy astrophysics: the view at SKA

G. Bignami

We will discuss the Universe at high Energies and the synergies of SKA with major space facilities in X-rays and gamma-rays. In particular, XMM, e-Rosita, Fermi, and future prospects of observational synergies for GRE and IXO will be discussed.

SKA, Auger and fast time RadioAstronomy

H. Falcke

The Auger observatory is the largest cosmic rays observatory to date. It encompasses 3000 km² covered with 1600 particle detectors and 24 fluorescence telescopes. Auger has measured the spectrum and angular distribution of ultra-high energy cosmic rays up to energies above $10^{20}$ eV. Most notable in the spectrum is a depression at energies above 1019.5 eV. This energy coincides with the GZK cut-off energy, where extragalactic cosmic rays interact with the cosmic microwave background. The arrival direction of cosmic rays are anisotropic, with the strongest excess in the region towards the radio galaxy Centaurus A. A puzzling result is that the composition tends towards heavier elements at the highest energies. However, composition measurements are notoriously difficult to make. Hence, among others, a test radio array is currently installed at the Auger site, which will explore the radio detection method of cosmic ray as a complement to particle and fluorescence
detectors for composition measurements. The same technique will be used at the SKA-pathfinder LOFAR, providing highly complementary information. In order to detect cosmic rays with a radio telescope nanosecond time resolution is required. If one wants to detect cosmic rays at energies beyond $10^{20}$ eV, detector areas many orders of magnitude larger than Auger are needed. This can be achieved by observing the entire surface of the moon. Very energetic particles would lead to very short radio pulses, which could be detected by SKA or LOFAR. Hence, Auger, together with the next generation of radio telescopes promises a comprehensive view of the highest energy particle observable in the universe.

**The Early Universe (TBC)**

*R. Sunyaev*

We will describe the Early Universe and the detectability of radio emission lines from the interaction of CMB photons with forming structures.

**The Square Kilometre Array: Tracing the Universe from the EoR to the Present**

*S. Rawlings*

Understanding the history and role of neutral Hydrogen (HI) in the Universe from the dark ages to the present day is one of the two major science goals of phase one of the SKA (SKA₁). I will review simulations and results from current telescopes that demonstrate that SKA₁ will map the evolution in universal HI from the Epoch of Reionization to today, and prove technologies capable of revolutionizing the use of HI as a probe of large-scale structure, and hence cosmology. The science case for phase two of the SKA (SKA₂) will attack truly fundamental questions such as how the accelerating Universe is driven by dark energy and the masses of neutrinos.

**AGN, Star Formation, and the Nano-Jy Sky**

*P. Padovani*

I present simple but robust estimates of the type of sources making up the faint, sub-microJy radio sky. These include star-forming galaxies and radio-quiet active galactic nuclei but also two “new” populations, that is low radio power ellipticals and dwarf galaxies, the latter likely constituting the most numerous component of the radio sky. I then estimate the X-ray, optical, and mid-infrared fluxes these objects are likely to have, which are very important for source identification and for the synergy between the SKA and its various pathfinders with future missions in other bands, including SPICA, JWST, the ELTs, PAN-STARRS, LSST, WFXT, and IXO.

**Using HI to trace outflows from galaxies and feeding of AGN**

*R. Morganti*

Understanding the role of cold gas in the triggering and evolution of active galactic nuclei (AGN) is one of the goal of future cm and mm facilities. HI in absorption is one powerful diagnostic that can be used to explore these topics and probe the central regions of AGN. I will present the latest results in this field including the finding of fast, massive outflows of HI gas that may provide the negative feedback required by the galaxy’s evolution models to stop the growth of the BH and the star formation. I will discuss the requirements needed for the new radio facilities and in
particular SKA in order to provide a major step forward in the understanding of the distribution and kinematics of the atomic neutral gas close to the AGN. I will also show how the synergy with deep observations at other wavelengths (mm, IR, optical and Xray) is key for the interpretation of the radio data.

SKA, Precursors and Galaxy Dynamics

E. de Blok

I discuss some of the prospects of measuring and quantifying galaxy dynamics using proposed observations with some of the SKA precursors.

Transient Phenomena: Opportunities for New Discoveries

J. Lazio

Known classes of radio wavelength transients range from the nearby stellar flares and radio pulsars to the distant Universe (gamma-ray burst afterglows). Hypothesized classes of radio transients include analogs of known objects, e.g., extrasolar planets emitting Jovian-like radio bursts and giant-pulse emitting pulsars in other galaxies, to the exotic such as prompt emission from gamma-ray bursts, evaporating black holes, and transmitters from other civilizations. Pathfinders and Precursors to the Square Kilometre Array (SKA), and ultimately the SKA itself, are beginning to offer a combination of wider fields of view and more wavelength agility than has been possible in the past. As these instruments and facilities become operational over the next few years, the detection and study of radio transients will improve immensely.

Cosmic Magnetism: current status and outlook to the SKA

M. Haverkorn

Magnetism is one of the four fundamental forces and a major factor in the Universe. As most of the gas in the Universe is ionized, magnetism greatly influences many physical processes. Magnetic fields collimate jets and constrain gas flows. They bend cosmic ray trajectories up to the highest observed energies, and can either trigger or halt star formation. A number of indirect detection methods for cosmic magnetic fields exist, none of which is complete. Even combining these methods leaves significant gaps in the observable parameter space, and therefore in our understanding. Radio polarimetry is the most promising method to significantly enhance our understanding of large-scale magnetic fields threading galaxies, galaxy clusters and potentially intergalactic space. I will review the current status of cosmic magnetism research, and the major role that new radio telescopes will play in the near future. Also, I will look ahead to the SKA era and describe how fundamental new advances in the study of cosmic magnetic fields will become feasible with the SKA.

The SKA and High Resolution

A. Lobanov

Long baseline science with the SKA and SKA Pathfinders covers a broad range of topics in astrophysics and fundamental physics. In several research areas, complementing the improved brightness sensitivity of the SKA with a milliarcsecond resolution would uncover truly unique avenues and opportunities for studying extreme states of matter, vicinity of compact relativistic objects, and complex processes in astrophysical plasmas. At the same time, long baselines would secure making
excellent positional and astrometric measurements with the SKA and critically enhance the SKA image fidelity at all scales. The latter aspect may also have a substantial impact on the survey speed of the SKA, thus affecting several key science projects of the array. A brief overview of scientific and technical areas benefiting from extending the SKA to longer baselines will be presented.

**SKA in the context of space science and planetary exploration**

*L. Gurvits*

Over its entire history, the exploration of space is closely linked with the developments of radio astronomy. The next big technological step in radio astronomy, the Square Kilometre Array will provide a basis for new radio astronomy applications in space and planetary science and exploration. These include Planetary Radio Astronomy and Doppler Experiments (PRIDE) aimed at an ultra-precise characterisation of vector-states of planetary probes and other deep space craft. PRIDE measurements will address a broad range of science topics from fundamental physics to evaluation of habitability of interiors of various bodies of the Solar System. Another challenging task for ultra-sensitive radio astronomy facilities is a Direct-to-Earth (DtE) delivery of science data from planetary probes via low-power and low-gain on-board transmission systems. In both PRIDE and DtE applications, SKA and its pathfinders will be indispensable due to their frequency agility, superior sensitivity and signal processing capabilities.

In this presentation I will review the current status of radio astronomy segments of several planetary science and exploration missions. This will include the missions scheduled for launch during the implementation phase of SKA, thus relevant to the operational period of the SKA pathfinders and technology demonstrators, especially at frequency bands below 2.5 GHz. These bands are accepted as operational for radio communication systems of several prospective Mars exploration missions (such as ExoMars and MarsNet). At higher frequency bands, a number of SKA pathfinders will play an important role in planetary missions of the coming decade targeting Mars, Venus and Mercury. I will also present the case for major ESA and NASA flagship missions to outer planets, the Europa Jupiter System Mission (EJSM) and Titan Saturn System Mission (TSSM) accepted for pre-evaluation studies with the target launch dates around 2020 and later. Several scientific topics of these missions can be best addressed with a wide-field SKA as an Earth-based PRIDE and DtE facility.

**Jets in quasars and active galactic nuclei**

*Y. Kovalev*

The talk will present results of recent studies of apparent and intrinsic properties of jets in quasars and active galactic nuclei (AGN) from parsec to kiloparsec scales at radio frequencies. Attention will be given to a close physical relation between the synchrotron (radio) and inverse-Compton (high energy) emission. A discussion of prospects of AGN jet studies with the SKA, especially utilizing the long baselines, will conclude the presentation.

**Precision Astrometry - from GAIA to SKA**

*P. Charlot*

VLBI has been instrumental in establishing celestial reference frames based on extragalactic objects and measuring motions of objects within the Galaxy with unprecedented accuracies. During the
next decade, VLBI will be challenged by the upcoming Gaia space astrometric mission, while in
the long term SKA may also play a major role in the field. The presentation will review recent
highlights from astrometric VLBI and draw prospects for further progress in this area along with
the expectations from Gaia by 2015-2020. We also discuss the technical requirements for SKA so
that it can compete in accuracy and sensitivity with Gaia and bring a worthwhile synergy between
radio and optical measurements.

The ELT vision: synergies with the SKA
M. Kissler-Patig
The future 42-m European Extremely Large Telescope will be the world’s largest optical-IR tele-
scope for several decades to come. Thus, it will be part of the landscape of astronomical facilities in
which the SKA will operate. In this talk we will give an overview of the E-ELT and its capabilities.
We will present the current status of the project, and then review the E-ELT science case from the
perspective of synergies with the SKA.

Dark energy and Dark matter: the Euclid’s look at SKA
A. Refregier
We will describe the Euclid Space mission proposal importance in mapping and understanding the
dark content of the Universe and its wide survey sinergies with SKA large scale structure surveys.

Fundamental Physics with Pulsars
P. Freire
In this talk we present some of the basic concepts of pulsar timing and the implications it has
for fundamental physics: the study of gravitation in the strong-field regime, which has produced
some of the most stringient tests of Einstein’s theory of general relativity, the study of cold matter
at densities much larger than that of the atomic nucleus, and its role as part of a Galaxy-wide
detector of nano-Hertz gravitational waves. This will be complementary in frequency to detectors
like LIGO and LISA. All of these applications depend on the pulse timing precision, which will
greatly improve with the sensitivity of the Square Kilometer Array (SKA).

Posters

NA
J. Kijak and W. Lewandowski
Our recent observations have revealed new results in pulsar radio spectra. We have found a new
class of pulsars that show a maximum flux in the spectrum above 1 GHz and for these pulsars the
emitted energy decreases below 1 GHz, showing positive spectral index at lower frequencies. We
call these objects as Gigahertz-Peaked Spectra pulsars (GPS).

NA
Alla Miroshnichenko

Break steep spectrum is the interesting case of a steep radio spectrum when the radio spectral index has the value greater than 1 after the certain frequency. We reduce the location of the spectrum break to the frame of radio source. Main physical parameters (the linear size, the magnetic field strength, the characteristic age, and the luminosities at the decameter, centimeter, and optical bands) are determined for galaxies and quasars with break spectrum from the UTR-2 catalogue. The LambdaCDM-model of the Universe is used at our calculations. We examine the evolution of the break spectrum frequency, the luminosity, the spectral index for the sources from our sample. Also we compare the features of the break steep spectrum sources at the optical and radio bands.

NA

Claudio Maccone

SETI, the Search for Extra Terrestrial Intelligence, is a world-wide expanding activity. As of 2010, the leading SETI programs are conducted by Jill Tarter at the Allen Telescope Array and by the Berkeley SETI Group of Dan Warthimer at Arecibo. Europe, however, is now trying to catch up. LOFAR is doing SETI also, a SETI piggyback program is ongoing in Italy, one more in Argentina, and France, Russia, China, Japan, Korea, and probably more countries will do SETI soon. Finally, the SKA will probably dwarf all these SETI searches by capitalizing on all previous results. Not to mention the future SETI searches conducted from the Farside of the Moon. This paper is a synthetic review of current and future SETI activities all over the world.

NA

Ilian T. Iliev, Garrelt Mellema, Paul R. Shapiro, Kyungjin Ahn, Yi Mao, Jun Koda, Ue-Li Pen

Simulations of the early structure formation and the Epoch of Reionization have finally reached sufficient volume, dynamic range and resolution to make reliable predictions for the fundamental features and observable signatures of these epochs at the observationally-relevant scales. I will review recent progress we have made in this area, including performing the largest by far simulations of early structure formation and state-of-the-art radiative transfer simulations. These simulations enabled us to study the influence of small-scale structures on the reionization with an unprecedented detail, following the radiative transfer of both ionizing and Lyman-Werner bands radiation. The very small-scale structures give significantly boosted and highly spatially-varying recombination rates and shielding by minihaloes, while the radiative feedback effects of the first Pop. III stars hosted by those minihaloes provide strong self-regulation of the evolution. Together these effects yield a very different character of the reionization history and geometry. I will discuss the various observational signatures we predict. I will focus on the redshifted 21-cm emission, but will also briefly review results on other probes (small-scale CMB fluctuations, near-IR background fluctuations and Ly-a emitter surveys). I will discuss the best observational strategies for current and upcoming experiments at redshifted 21-cm line of hydrogen (LOFAR, GMRT, MWA and SKA) as suggested by our results. I will also briefly outline the current challenges we face in this area and how we plan to address them.

NA

John McKean on behalf of the LOFAR commissioning team
The Low Frequency Array (LOFAR) will operate between 10 and 240 MHz, and will observe the low frequency Universe to an unprecedented sensitivity and angular resolution. The main science goals of LOFAR are to i) carry out deep extragalactic surveys, ii) probe the epoch of reionization, iii) study cosmic magnetism, iv) investigate the transient sky, v) study solar physics and vi) observe ultra high energy cosmic rays. LOFAR will also provide an important testbed for the technologies (hardware and software) that will be used for the SKA. The construction of LOFAR is well underway, with over 25 of the Dutch stations and four International stations routinely performing both single-station and interferometric observations over the frequency range that LOFAR is anticipated to operate at. Here, I summarize the capabilities of LOFAR and report on some of the early commissioning imaging results.

NA

Mário Santos

In this talk I will describe the use of the high redshift 21cm signal to probe the very first galaxies to appear in the Universe. Using fast large volume simulations of the pre-Reionization epoch we have shown that the Lyman alpha radiation emitted from these young galaxies make a strong contribution to the 21cm signal on large scales at \( z \approx 20 \). With the current setup, SKA should be able to measure this signal, therefore making it probably the only telescope capable of giving us detailed information about the radiation emitted by the first stars and characterizing their host galaxies. I then discuss the use of the redshift space distortions as a way to further constrain the Lyman alpha signal and demonstrate that they can be used as a model independent way to extract this signature with the SKA.

Probing the first galaxies with the SKA

Marta B. Silva, M.G. Santos, J.R. Pritchard, R. Cen, A. Cooray

We describe the use of the high redshift 21cm signal to probe the very first galaxies to appear in the Universe. Using fast large volume simulations of the pre-Reionization epoch we have shown that the Lyman alpha radiation emitted from these young galaxies make a strong contribution to the 21cm signal on large scales at \( z \approx 20 \). With the current setup, SKA should be able to measure this signal, therefore making it probably the only telescope capable of giving us detailed information about the radiation emitted by the first stars and characterizing their host galaxies. We then discuss the use of the redshift space distortions as a way to further constrain the Lyman alpha signal and demonstrate that they can be used as a model independent way to extract this signature with the SKA.
SPS1: Astronomy Challenges for Engineers & Computer Scientists

NOT AVAILABLE IN THIS VERSION
SPS2: Radio-Astronomy in Iberia

NOT AVAILABLE IN THIS VERSION
SPS3: ESO: ALMA Early Science - opportunities and tutorials

NOT AVAILABLE IN THIS VERSION
SPS4: ESA: Elements of the science programme for JENAM2010

The Scientific Programme of ESA & its future: The Cosmic Vision 2015-2025 Long Term Plan

J. Clavel

The current status of the mandatory scientific programme of ESA will be briefly summarised, focussing on astronomy missions. In the second part of the presentation, I will present the Cosmic Vision 2015-2025 long term plan, the future missions which are currently under study or definition and the process by which these missions are being selected.

The ESA Herschel Space Observatory - first year in-flight and early science highlights

G. Pilbratt

The Herschel Space Observatory was successfully launched on 14 May 2009, carried into space by an Ariane 5 ECA launcher together with the second passenger Planck, both spacecraft being injected into transfer orbits towards L2 with exquisite precision. Herschel is the most recent observatory mission in the European Space Agency (ESA) science programme. It carries a 3.5 metre diameter Cassegrain passively cooled monolithic silicon carbide telescope. The focal plane units of the science payload complement - two cameras/medium resolution imaging spectrometers, the Photodetector Array Camera and Spectrometer (PACS) and Spectral and Photometric Imaging REceiver (SPIRE), and the very high resolution Heterodyne Instrument for the Far-Infrared (HIFI) spectrometer - are housed in a superfluid helium cryostat.

Herschel is the first large aperture space infrared observatory, it builds on previous infrared space missions including the ESA ISO and NASA Spitzer observatories, by offering a much larger telescope and pushes towards longer wavelengths. It will perform imaging photometry and spectroscopy in the far infrared and submillimetre part of the spectrum, covering approximately the 55-671 $\mu$m range. I will describe Herschel and its science capabilities putting it into perspective. Herschel is designed to observe the 'cool universe'; the key science objectives include star and galaxy formation and evolution, and in particular the physics, dynamics, and chemistry of the interstellar medium and its molecular clouds, the wombs of the stars and planets. Herschel is currently opening a new window to study how the universe has evolved to become the universe we see today, and how our star the sun, our planet the earth, and we ourselves fit in. I will outline the early inflight operations.
of Herschel and the transition from launch and early operational phases into the routine science phase. I will present the demonstrated science capabilities by providing examples of scientific highlights to date.

Herschel has been designed to offer a minimum of 3 years of routine science observations. Nominally ~20,000 hours will be available for astronomy, 32% is guaranteed time (GT) and the remainder is open time (OT) offered to the general astronomical community through a standard competitive proposal procedure. The time allocation for both GT and OT Key Programmes was concluded before the launch, and the first in-flight AO is underway. I will briefly mention future observing opportunities.

The Rosetta close encounters with two main-belt asteroids

R. Schulz

ESA’s Planetary Cornerstone Mission Rosetta is on its way to rendezvous with comet 67P/Churyumov-Gerasimenko in 2014 after which it will accompany the comet into the inner solar system, while releasing the Lander Philae onto the surface of the comet nucleus. During the long cruise phase to the main target the spacecraft was scheduled to perform close fly-bys of two main-belt asteroids, (21) Lutetia and (2867) Steins. These asteroids were selected after careful evaluation of the scientific significance of all reachable targets constrained by the available fuel budget. Rosetta has now performed both fly-bys successfully. Closest approach occurred on 5 September 2008 for (2867) Steins and on 10 July 2010 for (21) Lutetia. The fly-by strategy was arranged such that it allowed for continuous observations of each asteroid before, during and after closest approach whilst the spacecraft passed through phase angle zero. Most of the scientific instruments on board Rosetta were switched on for investigations of the asteroid and its surrounding environment, obtaining imaging and spectral observations from the UV to sub-mm wavelengths as well as particle and field measurements. Both targets have turned out to be extraordinarily interesting objects for close inspection. This is not just because (21) Lutetia is the largest asteroid, and (2867) Steins is the only E-type asteroid ever visited by a space mission, but rather the results reveal the complex morphology, dynamics, and composition of both. After completion of the detailed analysis of the data obtained by Rosetta these two objects will be among the best-studied asteroids and as such will add significantly to our understanding of the different types of asteroids. This in itself will help to solve the puzzle of how the solar system formed and has evolved.

Euclid: an ESA mission to map the geometry of the Dark Universe

R. Laureijs

Euclid is a high precision cosmology mission under development by the European Space Agency to investigate the properties of Dark Energy and Dark Matter. The mission is optimised for the measurement of two cosmological probes: weak lensing and baryon acoustic oscillations. Euclid will carry out an imaging and spectroscopic survey of the entire extragalactic sky of 20,000 deg$^2$. The technical capabilities of Euclid are such that the mission can also address other cosmological and astronomical topics, providing an unprecedented science legacy. Euclid carries a meter class telescope which feeds two instruments: a visible imager (VIS), a near-infrared photometer combined with a medium resolution spectrometer (NISP). The nominal mission period is 5 years. We describe the mission and its present status, the satellite, and the payload and operations concepts.
PLATO: Europe’s Next-Generation Planet Finder

M. Fridlund

PLATO (PLAnetary Transits and Oscillations of stars) is a proposed M-class mission of the Cosmic Vision 2015-2025 program. PLATO is building on the highly successful small CoRoT mission (CNES/ESA/Europe/Brazil), and on NASA’s KEPLER mission, but will offer more than an order of magnitude improvement of the amount and quality of the science product. The prime objective of the PLATO mission is to search for planetary transits (occultations) in front of stars that can be fully characterized in terms of fundamental physical parameters. This characterisation is done using the PLATO data themselves via asteroseismology, and supported from the ground using high resolution spectroscopy and some photometry.

The PLATO proposal was selected for an assessment study as part of the ESA’s Cosmic Vision 2015-2025 scientific plan, and requires ESA to build and construct a satellite that can for the first time observe planetary transits of a large enough sample to be:

- Statistically significant with respect to Earth-mass planets orbiting main sequence F-, G- and K-type (Solar Type) stars in the Habitable Zone. The goal is to detect Earth-analog systems within their habitable zones where the host stars can be fully characterised in terms of ages and size
- Determine the radius and mass of both the parental star and the planet(s) orbiting it, with an accuracy of about 1%, as well as provide an age estimate of the detected exoplanetary systems to better than 10%
- Provide a planetary mass function extending from Brown Dwarfs down to planets smaller than the Earth.

The PLATO science objectives will be met using long uninterrupted high precision photometric monitoring of large samples of stars. The number of cool dwarfs and subgiants down to mV=11 must be maximized. These observations will first allow us to detect and characterize planetary transits, allowing us to measure planet sizes and orbital periods, as well as to detect planet satellites and rings.

They will simultaneously provide us as well with measurements of frequencies, amplitudes and lifetimes of oscillation modes of the same sample of stars. The analysis of these asteroseismic measurements will yield precise information about the internal structure and rotation of these stars, and will allow us to determine accurately their masses, radii and ages.

The Spacecraft consist of a platform on which 34 120mm telescopes of a refractive (6 element) design are mounted. Observing the same field in the sky, this construction allow for a very large (> 1800 degree2) field-of-view (FOV), and by adding the signal from each sub-aperture one can also realise a large collecting area (roughly equivalent to a single telescope with 550mm aperture). Two of the telescopes will be dedicated to the brightest of the stars in the sample. The mission is planned to be launched on a Soyuz rocket to the L2 Lagrangian point in the Earth-Sun system. The mission is planned for an in-orbit lifetime of 6 years extendable for several years after this.

PLATO successfully passed a selection after the assessment study in December 2009 - January 2010 and is now in a competitive (with two other Medium class missions) development phase. The development work is also carried out competitively by two industrial contractors. A down select of the missions being developed is expected in late June 2011. In the meantime, an announcement of Opportunity for PLATO Payload and Science Ground Segment Components (Science consortium and payload development) and Independent Legacy Scientists in the PLATO Science Team have
been issued with a closing date of 29 October 2010.

**SPICA: The Space Infrared Telescope for Cosmology and Astrophysics**  
*K. Isaak*

The infrared waveband plays host to an extensive range of spectroscopic and photometric diagnostics which probe incisively the physical conditions found in a very wide range of different astronomical environments. The last 25 years have marked a golden age in space-based infrared astronomy, with the IRAS, ISO, AKARI and Spitzer satellites advancing fields from planetary science to star formation, and galaxy formation through to galaxy evolution. Early results from the far-infrared/sub-millimetre instrument suite on the Herschel underline the key role of the long-wave end of the infrared toolbox, while much is expected from the NIR/MIR capabilities of JWST. The successes of past missions have raised many key questions in planet formation and galaxy evolution that can only be addressed in the IR/MIR/FIR, yet that are “just” beyond the reach of Herschel and the JWST.

SPICA, the Space Infrared Telescope for Cosmology and Astrophysics will take the next step. Proposed as a Japanese-led mission with a launch date in the 2018 timeframe, SPICA will operate in the mid and far infrared wavelength range (5-210 µm) with unprecedented sensitivity, thanks to its 3 m-class cold telescope (< 6 K) and advanced instrument suite. A proposal for an ESA contribution to SPICA was selected in October 2007 as a candidate M-class mission for the ESA Cosmic Vision 2015-2025 programme, with the character of “mission of opportunity”. The proposed contribution from ESA comprises the cryogenic telescope assembly, access to an additional ground station, collaboration on science operations and management of interfaces between JAXA and the European instrument, SAFARI. SAFARI - a far-infrared imaging spectrometer and photometer - will be procured by ESA from a European consortium. US and Korean participation in the mission is also being discussed extensively. The SPICA observatory will be open to the worldwide community. In this talk I will give an overview of the mission, its scientific goals and the capabilities provided by its suite of instruments, as well as an update on the current status of the project.

**ESA Science Archives at the European Space Astronomy Centre (ESAC)**  
*P. Osuna*

The Science Archives and VO Team (SAT), part of the Science Operations Department of the European Space Agency, started building Astronomical Data Archives back in 1996. IT standards, tools, languages, etc. have had an evolution which could hardly be foreseen at the time. After more than ten years of the first public version of the Infrared Space Observatory (ISO) Archive, the SAT now hosts the following Science Archives: XMM-Newton, Herschel, ISO, Integral, SOHO, EXOSAT, Planck and ESA’s Planetary Science Archive (regrouping data from Rosetta, Mars Express, Venus Express, Smart-1, Huygens and Giotto). In the future, many more ESA Space Based Missions will have their archives located at ESAC, including Gaia and BepiColombo.

The latest developments at the SAT include building a state of the art “Archives Building System Infrastructure” that provides the building blocks for the creation of ESA Space Based Missions archives with renewed technologies and standards. As a demonstration of the goodness of the approach, two Science Archives, coming from two very different research fields, have been created.
from scratch using the new technology: the SOHO Science Archive and the EXOSAT Science Archive, both made public to the community in April 2009. The latest to be developed with the new technology is the Planck Science Archive (currently only released for the consortium). In this talk, an overview of the Science Archives available at ESAC will be shown, with special attention on the ESA New Generation Archives. Future plans for the Archives will also be discussed, and how the Archives and the Virtual Observatory are all interrelated.

The XMM-Newton Science Archive and its flexible interface to Data and Catalogues

N. Loiseau

The XMM-Newton Science Archive (XSA) contains raw and processed data of observations performed since the launch of XMM-Newton, ESA’s X-ray satellite, in December 1999. In addition, the XSA contains a number of catalogues based on these observations. At present, it is one of the most heavily used astronomical archives, giving access to X-ray data acquired simultaneously with its 6 sensitive, large field of view instruments. In this talk we show the most relevant of the functionalities of the interactive interface (XUI) and the batch job tool (XAIO), including the access to the 2XMM source catalogue, the XMM-OM Optical Monitor (optical/UV) source catalogue, and the XMMSL Slew Survey source catalogue. We will show some recent science cases to highlight how the XSA can be used for a variety of scientific projects. We will also comment on the future developments of the XSA and links to the VO tools.

The Herschel Science Archive

E. Verdugo, B. Merin and D. Baines

At present, the Herschel Science Archive (HSA) contains around 9000 scientific observations. Most of them are under proprietary rights protection but there are already around 10% which are public observations. We will present the different capabilities of the HSA User Interface to browse the content of the Archive, to perform queries based on many different observations and proposal parameters and to retrieve full observations and/or single products. One of the most powerful sub-systems of the HSA is the scriptable interface, the HAIO. We will show how this interface allows the interaction with other systems, such as the Herschel Interactive Processing Environment (HIPE), through VO protocols. Finally, we will show some examples of spectra and images taken with Herschel and how they are already compatible with standard VO tools, such as VOSpec and Aladin.

Science Using the Virtual Observatory: Probing the disks, accretion and formation of pre-main sequence stars

D. Baines

The Virtual Observatory (VO) is opening up new ways of exploiting the huge amount of data provided by the ever-growing number of ground-based and space facilities, as well as by computer simulations. The Science Archives and VO Team (SAT), part of the Science Operations Department of the European Space Agency, has been involved in the VO for many years, and has developed a number of tools to publish data and to access data in the VO. Using the tool VOSpec, a multi-wavelength spectral analysis tool developed by the SAT and new developments on scripting with VOSpec (VOScript), we have started to undertake a comprehensive study of spectral data in the
VO on young stars, Herbig Ae/Be and also T Tauri stars.
The Herbig Ae/Be stars are intermediate mass pre-main sequence stars that bridge the gap between the low mass T Tauri stars and the Massive Young Stellar Objects. This is an important mass range for understanding the formation of massive stars, as it is here that the acting star forming mechanism switches from magnetically controlled accretion from disks with inner holes to a not well known mechanism, likely to involve direct disk accretion onto the star. By studying the line strengths, variabilities and spectral energy distributions, from the X-ray to the sub-mm, we aim to gain insights into the accretion rates, processes and disk properties of a large sample of these objects, and to probe the question: Where does the star formation mechanism switch? In this talk I will discuss the initial findings and give a brief overview of the VO Tools developed by the SAT (VOSpec and VOScript).
SPS5: Astronomy Planning in Europe - Towards an Even Stronger European Astronomy

Introduction

J. Andersen

A range of coordinated planning initiatives are currently under way in Europe. This session will provide an overview of these activities and their current status and provide an opportunity to discuss their future.

Status of ASTRONET activities

J.-M. Hameury

Astronet was established as an FP6 Eranet in 2005, and is being extended under FP7. Astronet now includes most European countries in which astronomy is present. Its goal is to establish a strategic planning mechanism for all of European astronomy, from the Sun and Solar System to the limits of the observable Universe, using observational tools from the radio domain to gamma-rays and particles, on the ground and in space. I shall present the current status of Astronet, after 4 years of existence, as well as the objectives for the period 2011-2014.

A European Strategy for Astroparticle Physics ASPERA and APPEC

S. Katsanevas

Abstract: Astroparticle Physics emerged worldwide, in the last 20 years, from a field of charismatic pioneers transgressing disciplinary frontiers using risky and innovative detection techniques to a full blown global science activity involving many hundreds of researchers and hundred million or billion dollar scale projects. I will report on the recent effort to develop a strategic vision, roadmap and action plan for this field in Europe, performed under the auspices of ApPEC (Astroparticle Physics European Coordination) and in the context of the European Union ERANET program ASPERA in coordination with ASTRONET. I will mainly describe developments in the world context and organisational issues that emerged from the action plan as well as the many links that tie the proposed large observatories to the corresponding efforts worldwide as well as the efforts for a global coordination in the context of the OECD Global Science Forum.
RadioNet FP7
C. Vogt

RadioNet is an EC integrating activity that brings together all the major radio observatories in Europe, covering the frequency range of 10 MHz to 1 THz. The overall aim is to support the radio astronomy community in general, and to improve the capabilities of, and enhance access to, the major radio astronomy facilities in Europe and beyond. RadioNet FP7 involves 27 partners contributing to Networking Activities, Joint Research Activities and Transnational Access programmes. The networking activities ensure knowledge transfer within the community, between astronomers, engineers and students and by doing so preparing the radio astronomy community for the challenges of new telescopes like LOFAR and SRT. The aim of the transnational access programmes is to improve the access of European astronomers to the major radio astronomical infrastructures that exist in, or are owned and run by, European organisations. It also draws together all of the European radio facilities under one umbrella. The joint research activities combine together Europe’s expertise in developing innovative technologies for radio astronomy. One important role for RadioNet is to stimulate new scientific activities aimed at taking full advantage of new experimental possibilities which will be offered by future radio telescopes such as the Square Kilometre Array (SKA) and ALMA.

OPTICON, Integrating Astronomy in Europe via EC framework programmes
J. Keith Davies

I will give a brief summary of OPTICON’s achievements and plans in FP7. In particular I will report on our efforts to optimise access to Europe’s 2-4m telescopes via our common time allocation process, which had its first successful call in spring 2010 and will be open again for both semesters in 2011

2-4m OIR telescopes: the work of the ETSRC
J.E. Drew

The work of the panel convened by Astronet to consider rationalisation of Europe’s 2-4m nationally-funded telescopes will be summarised, along with its recommendations.

Role of ING in implementing the ETSRC recommendations
M. Balcells

I will present how the observatory is planning its decisions on science priorities, instrumentation development, and organisational model for the next decade.

Initiatives in astronomical software: The Astrophysical Software Laboratory
M. Steinmetz

Sophisticated numerical simulations are of increasing importance for the future of astronomy. However, these simulations rely on techniques and codes that are too complex to be developed and/or implemented from scratch by students and post-docs. Consequently, numerical methods and codes
need to be provided to astrophysicists throughout Europe, which simultaneously are well tested and at the forefront of the field. The Astrophysical Software Laboratory is an initiative to establish a laboratory without walls in order to coordinate and fund astrophysical software development and support, user training, and to set standards. Training and development funding is planned to ensure that codes remain at the cutting edge of the field for extended periods. Development funding would also ensure that supported codes conformed to modular standards.

**Initiatives in Laboratory Astrophysics**

*J. Tennyson, L. D'Hendecourt and P. Sarre*

Laboratory Astrophysics was highlighted in the ASTRONET Science Vision recommendations as a high priority for all of astronomy. This was developed in the ASTRONET Infrastructure Roadmap in which the requirements needed to address the Science Vision questions were identified. Currently much effort is being devoted to establishment of a new European Talk Force for Laboratory Astrophysics (ETFLA). The aim of ETFLA will be to develop a strategy to optimize and promote the field of laboratory astrophysics in relation to ground- and space-based astronomy and (inter)planetary missions. The field encompasses all physical, chemical, biological, geological and interdisciplinary experimental sciences of relevance to astronomical inquiry, including theoretical, computational and modelling research, from the nuclear and atomic/molecular level to application on astronomical scales. The ETFLA will aim to facilitate new initiatives in laboratory astrophysics including workshops, fellowships and research funding, and welcomes extensive input and feedback from the community.

**Posters**

**Recent upgrades of the 2-meter telescope at NAO Rozhen**

*T. Bonev*

The 2 meter reflector of the National Astronomical Observatory (NAO) Rozhen offers two main modi of observations: imaging in the Ritchey-Chretien (RC) focus and spectroscopy in the Coude focus. In the direct imaging mode a back-illuminated CCD camera VersArray 1330B is used, comprising 1340x1300 px with a spatial scale = 0.25arcsec/px. A faster alternative for direct imaging is provided by a two-channel focal reducer. This instrument allows observations in the blue and red spectral region simultaneously. It transforms the focal ratio from f/8 to f/2.8 and offers several additional modi of observations: narrow-band imaging, polarimetric imaging, Fabry-Perot imaging, low-dispersion spectroscopy. The Coude? spectrograph allows obtaining high signal-to-noise, high resolution (up to 35000) stellar spectra. Several upgrades of the 2 meter telescope will be presented: recoating of the optics in 2008, installation of a new telescope control system in 2009, planned implementation of an echelle spectrograph, and of an optical fiber connection to the external world. These upgrades are funded by the Bulgarian Academy of Sciences and by the National Science Fund under contract DO 02-85.

**Opportunities for Deployable-Integral-Field Spectroscopy**
The next generation of Extremely Large Telescopes (ELTs) will be able to address major science issues of the next two decades, due to the huge gains in sensitivity, resulting from larger collecting areas than available today. However, building the telescopes and its instrumentation is a challenge as the size, complexity, and cost increases with the telescope diameter, if using current technologies. New and innovative approaches in instrument layout, system engineering, and manufacturing strategies are required.

A consortium of institutes from Potsdam, Lyon, Sydney and Göttingen investigates a concept, which offers various advantages: huge science gains due to a high multiplex factor and a flexible deployment, low cost due to small sizes of individual units, easy scaling because of a modular approach, and minimum risk for proven technologies.

ERASMUS-F is a funded concept study for a possible 3D-instrumentation for the 42m European Extremely Large Telescope (E-ELT). The study investigates the feasibility to combine a broadband optical spectrograph with a new generation of multi-object deployable fibre bundles to undertake a massive multi-integral-field spectroscopic galaxy survey.
SPS6: New Trends in Global Astronomy Education

The Galileo Teacher Training Programme - Now the future starts

R. Doran

GTTP was launched during the International Year of Astronomy 2009. This cornerstone project is an important legacy of IYA2009 as it is now a program group of the International Astronomical Union (IAU), under Commission 46. Nearly 100 nations have nominated GTTP representatives and a strong network of educators, all of whom are trained in the use of modern tools for science teaching, is being built. At the curriculum level, astronomy is becoming a very important part of science education. Teachers involved in the training are developing a completely new strategy for science content teaching, and students attitudes towards topics related to maths and science is now shifting under the use of this hands-on, new technology driven effort. It is important to use the momentum created by all these efforts and engage the community in productive discussions on this topic. Concrete proposals at a European level are very important and during this symposium we hope to gather several different experts on the field to share their vision of this important topic.

European Hands on Universe

Roger Ferlet

The EU-HOU project is a collaboration of hundreds of teachers and scientists from 14 European countries with the purpose of creating a way for students to get excited by science, primarily through the use of astronomy. The project offers the chance to use real astronomical data to investigate volcanoes and craters on Mars and the moons of Jupiter, to discover a new planet outside our Solar System, or to weigh a galaxy, etc, which can engage our students in the wonders of scientific discovery, and excite the natural scientist contained in all people young and old alike. Research into how people learn has shown that active learning is the best way to create true engagement of students in a subject and has also been shown to lead to better understanding and retention of material than traditional lecture-style instruction. The exercises developed by EU-HOU are designed to promote such active learning by giving student real astronomical data, and to tools to analyze it simply and easily in their own classroom. The key to unlocking all this learning is the free software Salsa J. This software is simple to install, runs on most systems (Windows, MacOS, and most flavors of Linux) requires almost no on-site maintenance, and has been translated into many languages (English, French, Spanish, Italian Polish, Greek, Portuguese, Swedish, Northern Sami, Arabic, Chinese). A major goal of the project is the training of teachers to these new
New Trends in Using GLOBE at Night Data

Constance Walker

Many educators are interested in students working with real data to understand real problems and make connections between astronomy and real-life situations. One way to do this is to engage students in citizen science. Such opportunities better enable students to become lifelong learners of science. Light pollution is a serious, growing problem worldwide. For the last 5 years the National Optical Astronomy Observatory (NOAO) has played a leadership role in the GLOBE at Night worldwide star counting program. This international citizen science program allows participants to assess the brightness of their night sky by visually noting the faintest stars in Orion or by taking measurements with a digital meter and posting their results to the Internet. The database now contains 52,000 observations from 5 annual two-week campaigns. Students can use the database to study affects of light pollution on animals, plants, human health, safety, security, energy consumption, and cost. Students can compare data over time to look for changes and trends. They can compare the data to population density or with nighttime photography and spectroscopy of lights. The data can also be used in a lighting survey, to search for dark sky oases or to monitor ordinance compliance. The workshop is for educators and people who have interest in participating in GLOBE at Night, using this data in their classrooms or making changes in their community. Participants will receive a CD Rom containing all GLOBE at Night data from the last 5 years in 6 different formats, as well as other data files stated herein. We will model the types of comparisons and analyses that can be made. We will also share tips and experience on how to implement a successful program. Outcomes The workshop participants will - Receive a collection of materials (e.g., a CD Rom) with the GLOBE at Night data, data sets in environmental sciences, health, and energy conservation, and analysis tools.

Peak into the Past - An Archaeo-Astronomy Summer School

D. Brown, N. Neale, and R. Francis

Our Landscape has been shaped by man throughout the millennia. It still contains many clues to how it was used in the past, giving us insights into ancient cultures and how they applied their astronomical knowledge in their everyday life. We trailed a summer school that uses Astronomy and Archaeology as a focus for an effective out-of-classroom learning experience. It demonstrates how a field trip to non-traditional science venues can be used to its full potential and utilise ancient monuments as outdoor classrooms. Additionally, it illustrates how astronomy influences our society on a national and global level, now and in the past. Our oral presentation will show how such a summer school can be in linked to the secondary curriculum and embedded into effective planning and follow-up work. We present advice, examples of activities and sites to visit; and summarise the impact our work has had. This includes how notable barriers associated to the use of the out-door-classroom can be over come.

Early Science Education in Primary Schools

J.M. Rodríguez-Espinosa
We live in a society that is more educated than just decades ago. The number of students obtaining a degree is now substantially larger than it has ever been. However, science education lags behind these trends, and the society is not really reaping the benefit of an inclusive scientific education. The Spanish Confederation of Scientific Societies is aware of this problem and has started a programme to promote science education in the early infancy, as a seed for the future scientific education of our society. The ENCIENDE project tries to help primary schools teachers to cater for the naturally inquisitive minds of children. The programme aims to cover all branches of science, but is starting with Astronomy. Partly because it started in year 2009, the international year of astronomy, but most importantly because children very early in their infancy look to the sky, notice that it is day and night, see the moon up in the sky, watch the stars that help them dream... In my talk I will explain what ENCIENDE is and how we are implementing it.

Art and Science Performance for all generation

Nataša Stanić

Performance for kids ”Balloon, glass of water and a cell phone” is a kind of educational experiment which could successfully unify science, art and fun. This 45 minutes activity inspires the public of all generations (especially the youngest) by beauty and mystery of the Universe we live in. Balloon, glass of water and cell phone is a triple/simple demonstration of the expansion, composition and size of the Universe. Blowing the balloon and, at certain moment, drawing a small fuzzy things on it to introduce the galaxies is the beginning. Story-telling about the Big Bang (BB) and history of the Universe continues with a glass of water and introducing one part of the water molecule, hydrogen atom, as the most abundant element in the Universe created in the BB (video presentation of art photography inspired by water element, collected from the best art photographers in Serbia). But where the other part, oxygen, came from? Stars shine, but much more important is that they produce the chemical elements that we all are made of (in the background music plays “We are all made of stars”). Hydrogen “burns” in central part of a star and gives the helium, then helium “burns” into carbon, and so on (video presentation of supernova remnants, Hubble images). The distance to the Sun, particular star or galaxy we define by time we need to receive cell phone call from there (presentation of the book Star Cities, galaxies by Natasa Stanic). Poetry-telling is present during the whole performances (poems by famous Serbian poets: Miroslav Antic, Ljubivoje Rsumovic, Laza Lazic and others). Using the everyday things like balloon, glass of water, a cell phone, as well as music, poetry and photography is far more attractive to the public (of all ages) than traditional lecture. This interactive lecture is a new trend in global astronomy education in Serbia since it uses elements of art performance (poetry, photography, video, theatre) as well as science lecture basic elements. Performed 20 times in one year (april 2009 - april 2010) this show has been developed according to excellent cooperation with school teachers, high school and university professors and offers a great opportunity for all natural sciences (biology, geography, mathematics, physics) to get closer to each other and astronomy at the first place. Future development of new trends in global astronomy education in Serbia considers a on-line astronomy education at the website www.zvezdanidetektivi.weebly.com (zvezdani detektivi means star detectives in English). After the performances visitors have chance to take more free astronomy lectures, ask questions and get answers, being informed about astronomy news, books, public lectures, amateur work etc. Open blog star detectives should help most of people in Serbia to be directly connected to the Universe, new theories and astronomy events around the globe.
Astronomical Education in Georgia

N. Kochiashvili

Significant changes in Georgian Educational System gave us possibility to open Master and PhD courses of Astronomy in recently founded Ilia State University (http://www.iliauni.edu.ge/index.php?sec_id=1;id=ENG). Although Astronomical Education existed on every level (at Secondary Schools, University and Abastumani Observatory) number of students diminished since 1990s. But interest to Ground-based and Space projects and new astronomical achievements, is rather significant in Georgian youth. Current state and problems of Astronomical Education are presented in this talk.

Astronomy for Students DVD

A.M. Mickaelian

A DVD “Astronomy for Students” has been created to support astronomy education of the students from the Yerevan State University (YSU) and the Armenian State Pedagogical University (ASPU). It is a collection of useful information, including scanned or downloaded from Internet 90 textbooks, practical exercises, 8 astronomical encyclopedia and dictionaries, latest review papers, lectures from summer schools (including the Byurakan International Summer Schools 2006 and 2008), talks at recent meetings and other presentations, 3D atlas of the Universe, astronomical catalogs, software (including SciSoft VII), photos, movies, information on BAO, Viktor Ambartsumian, etc. The main formats of the books and papers are djvu and pdf. The presentations are in MS Powerpoint (ppt). Most of the materials are in English which may help the Armenian students to learn the astronomical terminology in English as well. Other materials are in Russian (textbooks) and Armenian. The DVD may be used for educational and scientific purposes as well as may be copied and freely distributed.

Astro Book Drive - Sharing materials to improve astronomy education

T. Heenatigala

Astro Book Drive serves as a global initiative to share astronomy materials with developing countries to improve astronomy education. The materials are donated by astronomy related groups from wealthy countries. These materials are used towards teaching and conducting programs for students, teachers and public. As a result of running book drives, groups build a special bridge between them which leads up to various other programs as well.

HOU Spain - Recent Developments

Victor Gudiel

The project G-HOU has as objective the innovation in scientific education at mid and high school levels. G-HOU introduces pupils in open problems associated with current investigation. G-HOU is a consortium of more of the 20 institutions over the world. They have developed exercises, instrumentation and computing applications to motivate pupils in the study of science at large. During the international year Astronomy, the International Astronomical Union (IAU) set up the Galileo Teacher Training Program (GTTP). G-HOU collaborates with the IAU world wide to implements these training programs. HOU Spain (HOU-España) was set in 2002 as the Spanish
branch of G-HOU. In this contribution we report on our more recent activities. HOU-Spain exercises are based on current research on space navigation, extrasolar planets and the Moon. The exercises are thought to fit smoothly in the Spanish curriculum for secondary and high school (target ages 14-16 year old students). They are oriented to mathematics and physics teaching. HOU-España has recently partnered with the foundation Astrohita to provide students/teachers with astronomical facilities adapted to the educational space.

Teachers Formation and Practical Activities in Astronomy for the 1º CEB

Lucilia Santos

The motivation of this study in the context of a PhD project, is science education, based on changes at the level of teaching practice and learning that will result in pupils’ motivation for science and in the development of skills, allowing the participation in a scientific literacy society. It presents a training course for teachers, on primary school based activities, aimed at developing specific skills in astronomy with an interdisciplinary approach and seeks to know the impact of implementing these practical activities in astronomy student learning.

Posters

Astronomical activities: an alternative to inclusion of educational games and web-based activities at elementary school, middle school or high school

A. Antunes, E.B. Amores, A. Bogado, K. Pereira and M. Vieira

Astronomy has been included in learning activities as an interdisciplinary science. We have associated games with concepts related to Biology-Chemistry-Physics. As main activities our team has produced games to description of physical, chemical and biological concepts involving scales, maps, chemical composition of the planets among others. We have elaborated activities to elementary school, middle school or high school with the main objective of diffusion and science popularization in Federal University of Uberlândia. As complementary activities a serie of web-based activities are proposed to student interaction with concepts worked in the games introduced in the classroom. We also have worked with training courses for teachers aiming that allow them to use it in their classroom activities.

New Trends in Global Astronomy Education

R. Pokhrel

Astronomy is the very important part of science education. Development of any country has its basis on science. Hence science education should be emphasized in every country. The decrease in interest of students in science education as seen in past few years may be regarded in some way as due to traditional teaching methodology. Now the time has come to shift ourself from this traditional method to modern system in which we can take support of interactive and catching programmes and recent popular findings of astronomy. The things that NASO has done for introducing this
kind of education system in schools will be explained including our challenges, future goals and outcomes.

Mathematics Education through Astronomy in the middle school

Villone, B. Vanda

In this world, I discuss teaching Mathematics to children (11-13 yrs) through astronomy (through gravitation law, geometrical features of planets trajectories, Lagrangian points, long-term effects, tides complexity etc). I think, it would be an interesting experience teaching mathematics starting from astronomy, rather than the inverse. Some example are given: gravitational law (notion of function), Lagrangian points (equilibrium) and Moon-Earth (long-term effects).
Beyond the International Year of Astronomy 2009

P. Russo

(IAU/ESO) The year 2009 is still in our heads. For all involved or touched by the International Year of Astronomy 2009 (IYA2009): astronomers - hobbyists as well as professionals, space enthusiasts, educators, teachers, journalists, students and hopefully the society at large was an unique and memorable event. As a global celebration of astronomy, the IYA2009 has fostered a global appreciation of the role and value of science, technology and astronomy as a unifying activity for humanity. The response from all corners of the world echoes an extremely positive, unique and very successful endeavour. This presentation outlines the main results and achievements of IYA2009 global projects and activities, as well as the plan for a sustained legacy of IYA2009.

Sustainability Beyond the International Year of Astronomy 2009: Recycling “From Earth to the Universe”

K. Kowal Arcand

As part of the International Year of Astronomy 2009 (IYA2009), an astronomical exhibition series “From the Earth to the Universe” (FETTU) was developed and made internationally available through an open-source and community approach to science outreach. A thousand sites across the globe acquired the digital FETTU materials free of charge and exhibited them in unique locations such as in town squares, metro stations, and shopping malls. Several findings have emerged from evaluations and participant feedback of the FETTU project that can be used to refine future similar events. One new avenue that may provide a way to sustain the initiative includes NASA’s Year of the Solar System (YSS). YSS will be a celebration of Solar System mission milestones that will begin in Fall 2010, and continue for one Martian year, 687 Earth days, ending in late Summer 2012. A new, proposed “From Earth to the Solar System” (FETTSS) project could take a similar grassroots-type of approach as FETTU and emphasize the point that science learning experiences can be everywhere and all around us through astronomy displays placed in unexpected locations.

Dark Skies Awareness Beyond IYA2009

C.E. Walker

Programs from the IYA2009 Dark Skies Awareness (DSA) Cornerstone Project have been success-
fully implemented around the world to promote social awareness of the effects of light pollution on public health, economic issues, ecological consequences, energy conservation, safety and security, nightscape aesthetics and especially astronomy. The Dark Skies Awareness Cornerstone Project will continue most all of its programs beyond IYA2009. The International Dark-Sky Association as well as the Starlight Initiative will be endorsing and helping to continue with some of the most successful programs from the DSA. The GLOBE at Night campaign is adding a research component that looks at light pollution’s affects on wildlife. Dark Skies Rangers activities are being implemented in Europe through the Galileo Teacher Training Program. The new ‘One Star at a Time’ will engage people to protect the night sky through personal pledges and registration of public stargazing areas or StarParks, like the newest one in Italy. DSA will again oversee the Dark Skies portion of Global Astronomy Month, in which the International Dark Sky Week will be celebrated. DSA will be collaborating with Belgium’s ‘Night of Darkness’ to endeavor to make that lights out event a more global event. DSA will endeavor to support dark skies education worldwide, as in Northern Ireland. DSA will seek to expand light pollution prevention campaigns like Austria’s. People whose homes meet the criteria of good lighting are invited to put a sticker from Austria’s biggest newspaper in their front window to show their support. DSA also seeks to collaborate with the IAU Office for Astronomy Development. The presentation will focus on the sustainability of the IYA DSA programs, as well as the expansion to other programs worldwide, with particular emphasis in communicating dark skies awareness with the public and its educational value in attracting young people to study science and technology. See www.darkskiesawareness.org for more information on the programs.

**ESO’s (beyond) IYA2009 Activities**

*L. Lindberg Christensen*

The European Southern Observatory (ESO) has played a major role in the International Year of Astronomy 2009 (IYA2009) project since planning began in 2003. ESO is hosting the IAU’s IYA2009 Secretariat, which coordinates the Year globally and is now in the process of close-out. ESO is an Organisational Node and one of the Organisational Associates of IYA2009, and was also closely involved in the resolution submitted to the UN by Italy, which led to the UN’s 62nd General Assembly proclaiming IYA2009. There has been a range of ESO-specific activities throughout 2009, from local to global in scope, and aimed at a range of levels of interest. In addition to its ESO-specific activities, ESO is involved in many of the IYA2009 Global Cornerstone projects, and is playing a leading role in four of them. ESO’s plans for the future of these projects are also revealed.

**She is as astronomer in Spain**

*I. Marquez Perez*

We present the work of the Spanish node from the IYA2009 Cornerstone project. She is an Astronomer. The Spanish team has developed several projects with the common goal of promoting gender equality and women participation in professional and amateur astronomy, and supporting the training of young women researchers and technologists. The main projects were: Calendar “Women astronomers who made history”. We have highlighted exceptional women, from different epochs and countries, whose contributions to the advancement of science deserve to transcend anonymity and occupy a place in history. “Women in the stars”. Series of 8 TV programs devoted to the contribution of Spanish women astronomers. Made in collaboration with the Universidad de
Educacion a Distancia, UNED. “Women in Spanish Astronomy: analysis of a peculiar situation: A universe to discover”. First sociological study, including both a quantitative analysis and several individual and group surveys. Exhibition “She Astronomer”, devoted to women astronomers from different times and places, whose contributions had a great relevance. The main aims of the Committee for Women and Astronomy, recently created within the Spanish Astronomical Society, are briefly described.

A. Noronha: Ciência Viva and IYA2009

Title: (Abstract not submitted, but it was invited by organizers)

IYA2009 in Portugal: highlights, lessons learned and legacy

J. Fernandes

In the IYA2009 in Portugal more than 440 institutions were involved organizing more than 4000 activities throughout the year 2009, in more than 300 cities, towns and Portuguese villages. Among the institutions involved one can find universities, research centers, municipalities, museums, science centers, scientific societies, various associations, etc. More than 3000 people (mostly volunteers) have been involved in the organization IYA2009 activities for hundreds of thousands, either locally or nationally. In these talk we will point out the highlights of these enormous effort, the lessons learned and what we expect (and wich) for the IYA legacy in Portugal. The IYA2009 in Portugal was organized by the Portuguese Society of Astronomy, with the collaboration of the Foundation for Science and Technology, Calouste Gulbenkian Foundation, the Museum of Science, University of Coimbra, the Ciência Viva Agency and the European Astronomical Society.

The legacy of IYA2009 in the UK

I. Robson, S. Owens

IYA2009 was a tremendous achievement, both worldwide and in the UK. This paper gives a very top-level overview of the event types, their evaluation and the legacy value of the activities undertaken for IYA2009 in the UK.

IYA2009 and beyond - the largest public event ever happened in Romania

M. Stavinschi

On 11 August 1999, the last total solar eclipse of the 20th century had its maximum in Romania. Moreover, the central totality line passed right through the park of Bucharest Observatory. We believed then that such an astronomical event would never happen again in the public’s interest. The preparations had started 5 years before, and time went by we could hardly cope with the invasion of questions and many other things, which, naturally, reached the climax on eclipse day, namely: visits at the highest level from the president of our country and the general manager of NASA, ministers, ambassadors, as well as from an extremely curious public from home and from abroad. However, 2009 was to prove and one should never say “that was it”. Never in the history of my country have we remarked a larger interest in astronomy as during IYA2009. The final report registered over 100 events with tens thousands participants (certainly, their number was much higher). Most of these events were part of the 12 international cornerstone projects organized by
IAU. Even so, the participants’ imagination was even richer. I should like to give just one example to this effect: “She is an astronomer” was celebrated on 8 March, the international day celebrating woman. On that occasion an inestimable number of women received the traditional “martzishor”, the name for the red and white string, from which usually a small decoration is tied, and which is offered by people on the 1st day of March. This time the ‘decoration’ was the logo of IYA2009. The logo was offered then all year, replacing the traditional string with the tricolor of my country.


M. Villar Martín

IYA2009 has been a success in Spain. More than 3100 activities were organized by 1600 entities all over the country. Our analysis shows that the number of Astronomy outreach activities in 2009 was at least three times higher than other years. Between 200 and 400 IYA2009 activities were ongoing almost every month, reaching at least 10 million people. IYA2009 has appeared more than 1500 times in Spain’s digital press in Spanish. The mobilization this celebration has generated in our country and the great diversity of science outreach activities it has promoted have no precedents. Recognizing the importance of maintaining the spirit and goals of IYA2009 in the future, the National Commission of Astronomy, maximum responsible for IYA2009 in Spain, has created the “Spanish Network for Astronomy Outreach”.

ReachOut: beyond the planetarium

L. Canas, A. Pedrosa, P. Borges, N. Carvalho, M. Silva, B. Correia

Committed to reach those that usually don’t attend science outreach activities for planetariums, for IYA2009, Navegar Foundation developed ‘ReachOut’, a project composed of a set of events in order to lead planetarium theatres into new grounds. Navegar Foundation develops astronomy outreach activities on regular basis, since 2000. In 2009 in order to reach those that usually don’t attend science outreach activities for planetarium environments and capture general public’s attention by captivating them through peculiar and innovative events. With this goal set we camped in our planetarium; turn our traditional planetarium into an immersive cinema; disguised ourselves as medieval astronomers and, finally, turn our planetarium into a restaurant-spaceship and dined through the Solar System. From traditional planetarium system to state of the art digital projectors, ‘ReachOut’ tries to redefine the role of planetarium theatres in informal education and challenge ourselves as science communicators.

European Planetary Media Center - A public tribune of planetary scientists

E. Chatzichristou, Europlanet-RI Outreach Team

The Europlanet Research Infrastructure (Europlanet-RI) links more than 100 laboratories in Europe and around the world, helping planetary scientists get the best out of their Solar System research by organising networking activities, developing new facilities and field sites and creating online access to planetary science data. Europlanet-RI has a dedicated Media Centre (EPMC) to help distributing important scientific results at the national and European level. In this way, scientific communication is supported within Europe and the excitement of planetary science is revealed to the public. The relevant scientific outcomes and the public support and engagement are furthermore likely to engage the principle stakeholders in supporting those technology developments that will
Global Astronomy Month - Inaugurating a New Annual Celebration of the Universe

T. Heenatigala, R. Cardoso Reis

Global Astronomy Month (GAM) is an annual worldwide celebration of astronomy in all its forms which has captured the energy of the International Year of Astronomy 2009 (IYA2009) and refocused it as an ongoing annual celebration of the Universe. GAM 2010 saw professional and amateur astronomers, educators and astronomy enthusiasts from around the globe participating together in the spirit of IYA2009 and provided a global stage for established programs and a framework for partnerships. The outstanding public participation experienced in this month-long series of outreach events has led Astronomers Without Borders and its partners to declare Global Astronomy Month an annual event to take place each April and several global projects launched during GAM 2010 will continue throughout the year as ongoing Astronomers Without Borders programs.

Hands on Minds on - Inquiry based learning after the International Year of Astronomy

S. Trifourki

The International Year of Astronomy created a feast of opportunities for educators and science communicators to engage young people and community members in discovering the universe. A number of hands on activities were produced by a number of nations which were shared within the astronomy education community. To continue the legacy of IYA, Astronomers Without Borders launched the Global Astronomy Month with the aim to continue engaging citizens with their universe. The talk will highlight the educational activities that were produced for IYA and GAM and how these activities and materials can be replicated through an open source system.

The schoolyard as an observatory IAU-NASE Programme Group

R.M. Ros

Teachers from a lot of different science branches (mechanics, electricity, chemistry, biology, etc.) are able to say that it is not possible to work correctly in a school without a laboratory. In this sense, astronomy teachers tend to be happy because they always have an astronomic laboratory. All schools have a place where students play: the court or the schoolyard. But the court is not only a playtime place, it is also an astronomic laboratory: a place that offers the possibility to carry out practical astronomic activities. If we have a laboratory in every school, it seems opportune to use it! For introducing more Astronomy in the school it is necessary to educate teachers in an appropriate way promoting observation. The teachers with enough instruction can use the court as observatory. The NASE PG organises every year two or three new schools for primary and secondary school teachers in a different region of the Earth. After the course, a small group of teachers should be put together, in coordination with the NASE PG can then continue organising courses every year in the country. Mainly the courses and materials will be produced in several languages: English and Spanish at present, Arabic and Portuguese or French in the future.

The Astroquiz Project
In the context of the International Year of Astronomy, Centro de Astrofísica da Universidade do Porto is conducting a study to ascertain the degree of understanding of several key astronomical concepts by students in the last 6 years of the Portuguese school system (years 7-12). This is based on a multiple-choice 20-question quiz that students are asked to fill in 30 minutes. At the time of writing, about 2000 students have done so. The study also contrasts our results with the national curriculum standards in the relevant areas and searches for any factors that might affect student performance, including gender, geographic/economic or environmental (the national school rankings being a proxy for the latter). We will present preliminary results of the study and offer some thoughts on its implications.

She is an Astronomer’s e-mentoring scheme

H. Walker

One of the recurring themes of the profiles ‘She is an Astronomer’ gathered, from female astronomers around the world, was the importance they attached to being mentored. In countries where there are a lot of female astronomers it is possible to find a suitable mentor, but many women are isolated as a small minority in their country or the only female scientist in their group. ‘She is an Astronomer’ is exploring the possibility of using an existing face-to-face mentoring scheme as a model for e-mentoring. Astronomers at all levels reach points in their careers when they need to explore their options with a colleague, and for isolated female astronomers it can be impossible to find a suitable mentor within a reasonable distance. For this generation, electronic means of communication are natural, and so we can break down the barriers and distance is no longer a problem. Mentors and mentees would be matched according to issues and experience, and would communicate by email or skype. The applicant (whether mentor or mentee) would follow several training modules on-line and then join the pool. Mentors would pick a mentor from two or three possibilities and make the initial contact. Although the language of the scheme is English, there is nothing to prevent mentors and mentees using another language for their own communications, and hopefully the scheme can be offered in other languages. It would involve women mentoring women, and it would be astronomers mentoring astronomers. This would be a mentoring scheme about careers and professional matters, and not a counselling service, job-market, or legal-advice provider!

Nontraditional efforts of communicating astronomy with the public - outreach or outrageous?

O. Sandu

The aim of this talk is to encourage non-traditional approaches of communicating astronomy with the public by presenting some of the innovative initiatives done in Romania by Astroclub Bucharest in collaboration with multiple partners during the International Year of Astronomy 2009 and to organise them into a cluster of concepts that can be adapted and used in future outreach projects.

Posters
Astronomy in popular newspapers at the end of the 20th century - A space oddity.

R. Brito Fonseca

This presentation aims to discuss the public understanding of science and technology, namely, it aims to question the last quarter of the XXth century astronomy, in Portuguese popular newspapers. The space oddity it is, probably, the most popular face of astronomic knowledge, but there is much more about astronomy in popular newspapers. Taking astronomy published in national newspapers has representative and source of the whole astronomy media coverage, this presentation goal it is to build a portrait of astronomy media coverage, between 1976 and 1999. It seems clear that for scientific activity to be understood, the communication of science plays a central role. This ‘popular astronomy’ it is a good measure of lay people astronomy knowledge. The representation of science by the mass media possesses, thus autonomy before the scientific activity playing, relatively to this, different social functions. This period was marked by huge progresses in astronomic knowledge. In this period, the world lived crucial events, such as: energy crisis, the end of cold war, the end of the Soviet Union, the beginning of new space oddities and new astronomic knowledge. The analysis of popular newspaper coverage can give important information about our common popular idea of astronomy. Based on, a quantitative and qualitative, analysis of randomly selected 576 newspaper editions (2 per month, along the whole period) of a major national popular Portuguese newspaper, this presentation develops a portrait of what has been the media coverage of astronomy, and discusses trends and transitions, between 1976 and 1999. This discussion it is a chapter of a wider research that aims to discuss and characterize the presence of science and technology in the Portuguese newspapers, supported by FCT - Foundation for Science and Technology.

The sky is not the limit

V.-M. Matei

International Year of Astronomy was an excellent opportunity to organize educational activities in my school and for my community, in order to attract students into Astronomy and Space Science. The children discovered the beauty of Universe in many extracurricular activities: She is an Astronomer, 100 Hours of Astronomy, Yuri’s Night, One giant leap for mankind, World Space Week, Galilean Nights, Journey around the Earth in 90 minutes. Our participation in NASA ISS EarthKAM program was one of the most important achievement. These activities had a positive impact for my community. This year, in the Global Month of Astronomy, I organized a training course ‘A Methodology Approach in Teaching Astronomy’ for twenty-seven science and math teachers. Oradea’s City Hall approved ‘The Universe, closer to us’ project that aims to open an Astronomy and Space Science Club in Oradea, Romania.

Astrophysics Laboratories of the National and Kapodistrian University of Athens

E. Antonopoulou, N. Nanouris, D. Koutsokosta

Astronomy and Astrophysics has always been a course in the teaching program in the Physics Department of National and Kapodistrian University of Athens. Since 1985 laboratories in Astrophysics have been included in the teaching program while since 2000 a 40 cm telescope, which is located on the top of the building of the Physics Department, is helping in the students training.
SuperNova, Austria's first and only Astronomy show on TV

D. Lorenz

Many countries have open TV channels offering the possibility to produce your own TV show. Why not make your own Astronomy show? We are producing one in Austria and you can do it too. Since internet platforms like YouTube can be reached worldwide, you can upload your productions and offer it to all people around the globe. It is time to use all possible communication tools, pimp the general view of science in public and let everybody know how exciting Astronomy can be!

Ukrainian planetaria activities for IYA2009 and beyond

K. Nataliya

Projects performed by Ukrainian planetaria during IYA2009 are discussed, their feedbacks are evaluated, future projects are proposed.

The International Year of Astronomy 2009 at the island of Madeira

P. Augusto

Numbers: 230 thousand inhabitants, eight islands in three groups, only one group inhabited (Madeira and Porto Santo). Two groups were visited during the IYA09-Madeira (three islands). A total of 229 events in 2009 at Madeira (roughly one per 1000 residents). 1382 official photos taken (see reports and photos at www.uma.pt/iai09/relatorios.htm). 370 news in local newspapers (one per day) of which 27 made it into the first page! A0 posters of the IYA09 spread all over the island, some in places of very high visibility (tens of thousands of vehicles per day). 30 regional TV appearances (a few made it international) and 17 on regional radio (a few made it national). Over ten thousand directly involved in IYA09-Madeira activities (one per 20 residents) and hundreds of thousands are estimated, when including exhibitions. Twenty different initiatives: Astronomical Christmas street lighting (2008/9 and 2009/10); Carnival 2009; Schools Sport Party 2009; Kids Singing Festival 2009; two official postage stamps; competitions and exhibitions (four different, one itinerant - Astronomy & Society); dance performance and music concert; eight black outs to see the night sky properly; 1000 students in hands-on projects; meteor watch in optical and... radio; Astronomical Book Week; Universe discussion; Ferryboat astronomy sessions (cinema and observing); Senior Citizen International Day; two Astronomy Weeks; two AstroParties; 49 talks, 30 astronomical documentaries (commented), 75 observing sessions. See http://www.uma.pt/iai09/index.htm. The (very extensive) final report is there. A summary will be given at JENAM2010. Long live Astronomy!

The Jodcast: 4 years of astronomy podcasting

S. Lowe, J. Gupta, The Jodcast Team

Since 2006 we have been producing a regular podcast covering astronomy and space science. We report a summary of our experiences over the past four years including our listener/viewing figures, feedback and a description of our live episode recorded in late 2009.

The sky is not the limit

V.-M. Matei
During International Year of Astronomy was many unforgettable moments: the joy of one little girl when she looked at Saturn through telescope, students’ curious eyes when they looked our presentations. The sick children from a local hospital received space shuttles, rotating maps and we talked them about beautiful starry sky. A rocket launch in the Children’s Educational Center in Oradea have made many children feel part of the excitement of those who attended the Saturn V launch 40 years ago. The pictures taken from International Space Station in NASA EarthKAM program are beautiful and give a unique perspective of our planet. The children from Astronomy and Space Science Club in Oradea are very passionate about science. The poster will include the best moments of educational activities carried out in 2009-2010.

The Archaeo-Astronomy Project

*Daniel Brown, Andrew Alder and Robert Francis*

Field trips and the outdoor classroom are important to create excitement and a long lasting memory of the learnt subject. Especially astronomy and our astronomical heritage can be understood using ancient monuments, e.g. Stonehenge. However, there is clear evidence provided by the Peak District National Park Authority on how neglected e.g. the Peak Park sites are by Primary and Secondary schools. They quote inaccessibility and other common barriers associated to the outdoor classroom.

The archaeo-astronomy project is the logical next step from the similarly themed successful summer school triggered by the IYA 2009 and presented at JENAM 2009. It envisages the development of an Elearning environment allowing FE/HE students and pupils (Key Stage 2-4) to experience and explore ancient landscapes e.g. in the Peak Park. This project would allow schools to overcome the initial problems of the outdoor classroom.

The project is based at Nottingham Trent University and spans a large age range from secondary school pupils up to undergraduate students. Additionally, it is collaboration between different departments and highly interdisciplinary including aspects of Astronomy, Physics, Ecology, and Archaeology. The outcomes are used to bridge the gap from HE to secondary schools and colleges. Thereby, students represent role models and support the learning and teaching experience at school level. As a result, young people are enthused and attracted to science and technology subjects.

The overall goal of the project within the context of the outdoor classroom for both schools and higher education is outlined. Contributing projects will be used to illustrate the impact and success we have had until now.

13 Poster Exhibition: Una estrella mediocre, pero... es la nuestra
Los Otros
Esferas de gas
Ellas también mueren
La edad del Universo
Millones de soles juntos
El Universo es todo
Otros ojos para ver
El Universo desde fuera de la atmósfera
Las estrellas en la cultura
Un largo camino por la igualdad
Con A de astrónoma
I. Marquez Perez

This is a history that begins thousands, perhaps hundreds of thousands, of years ago. A time when our female ancestors first looked up at the sky and wondered what was in it. Women have been asking questions about the Sun and the Moon ever since.

Thousands of years later, more women have fixed their eyes on the Cosmos and devoted their professional lives to their pursuit of its mysteries. They are women astronomers and there have been many, very many, of them. They have been there throughout every period in history. Their hard work and dedication have been crucial to astronomy’s progress. They have made some truly ground breaking discoveries. This exhibition is designed to celebrate women’s contribution to astronomy together with their advancement, ambition, happiness and learning. In the past and in the present. The legacy is slightly bitter though, because women have faced many obstacles as they have sought to expand their knowledge.
SPS8: Amateur and professional astronomers in Europe: how pro-am cooperation is changing astronomy

The pro-am cooperation in the framework of the International Year of Astronomy

P. Russo

Overview of the International Year of Astronomy 2009 (IYA2009) activities involving professional and amateur astronomers

Amateur Astrophysics

J. Ribeiro

Do the ProAm collaborations in astrophysics deserve the effort, or are they merely a fashion issue? The answer to this question is at the hands of the professional and amateur astronomers, both beginners in this matter. Some professionals see the future ProAm collaborations in massive brainless actions such as Galaxy Zoo, which has already achieved good results. Nevertheless, some deep research ProAm collaborations must be taken into account. Photometry has been historically the subject of the ProAm collaborations. However, the development by the French of spectroscopes capable to reach scientific standard, is changing this scenario. The 2008-2009 WR140 periastron international ProAm campaign was a success and will be object of refereed publications [http://www.stsci.de/wr140/index_e.htm]. The present international campaign for the 2009-2011 eps Aur eclipse is following its course, and data is being collected either in photometry, either in spectroscopy [http://www.hposoft.com/Campaign09.html]. The BeSS database, leaded by the Paris-Meudon observatory has been a success since 2007. It is a Be-stars database that provides spectra to the European Virtual Observatory, and is fed by spectra acquired by professionals and amateurs [http://basebe.obspm.fr/basebe/]. An online tool, the ArasBeam, outcome of ProAm brainstorming, inform each night the Be-star observers for the most favorable targets [http://arasbeam.free.fr/]. Some refereed papers on the CoRoT Be-stars seismology mission resulted from this effort (Neiner et al. 2009), (Gutiérrez-Soto et al. 2009). Collaborations with the Astronomical Institutes of the Academy of Sciences and of the Charles University of the Czech Republic resulted in refereed papers, such as a recent work on Pleione (Nemravova et al. 2010). An international ProAm workshop on stellar winds in interaction was held in Convento da Arrábida, Portugal, in May 2010 [http://astrosurf.com/joseribeiro/e_arrabida.htm]. From this workshop the
Group ConVento was born. ConVento stands for ‘WithWind’ in Portuguese, as well as monastery. It is the first ProAm international group covering all the wavelengths used in astrophysics, from radio to gamma-rays! All the above seem to indicate that ProAm is solid and fruitful. Long-term combined observation campaigns as well as some occasional data gathering are areas where ProAm effort proves its strength in scientific research.

High resolution spectrographs in amateur spectroscopy

_G. Avila, V. Burwitz, C. Guirao, J. Rodriguez_

We present the status of high resolution spectrographs in the amateur astronomy community and the science programs in course (survey of variable stars, detection of exoplanets, etc.). We show how the concept, drawings and construction of an echelle spectrograph as well.

Contemporary Observatory Techniques for Amateurs, Schools and Universities

_M. Risch_

Today amateur-astronomers and schools can afford astronomical instruments which will enable them to cross the performance border to do real science. For relatively small money Universities can teach students in contemporary observing techniques and help closing the huge gap between major science projects and amateur activity. Large but lightweight telescope mirrors, robotic telescope mounts with high accuracy drives, CCD camera with high sensitivity, Spectrographs and even completely remote controlled observatories are becoming almost common for Universities and Astro-amateurs as well. This is a short overview about new techniques which have been developed in the last few years.

Searching For Stellar Tidal Streams in Nearby Spiral Galaxies: A Pro-Am Collaboration

_D. Martínez-Delgado_

Within the hierarchical framework for galaxy formation, minor merging and tidal interactions are expected to shape large galaxies to this day. As part of a pilot survey, we have carried out ultra-deep, wide-field imaging of some isolated spiral galaxies in the Local Volume with data taken at small (0.1 to 0.5-meter diameter), robotic telescopes that provide exquisite surface brightness sensitivity. Our observational effort has led to the discovery of previously undetected giant stellar structures in the halos of these galaxies, likely associated with debris from tidally disrupted satellites. In addition, we confirm several enormous stellar over-densities previously reported in the literature, but never before interpreted as tidal streams. Our collection of galaxies presents an assortment of tidal phenomena exhibiting strikingly diverse morphological characteristics. In addition to identifying great circles-like features that resemble the Sagittarius stream surrounding the Milky Way, our observations have uncovered enormous structures that extend tens of kiloparsecs into the halos of the central spiral. We have also found remote shells, giant clouds of debris within galactic halos, jet-like features emerging from galactic disks and large-scale, diffuse structures that are almost certainly related to the remnants of ancient, already thoroughly disrupted satellites. Together with these remains of possibly long-defunct companions, our observations also capture surviving satellites caught in the act of tidal disruption. Some of these display long tails extending away from the progenitor satellite as seen in cosmological simulations. Our comparison with available stellar halo
simulations set in a Lambda-Cold Dark Matter cosmology suggests that this extraordinary variety of morphological specimens detected in our survey could represent one of the first comprehensive pieces of evidence to support that the hierarchical formation scenarios predicted by these theoretical models apply generally to galaxies similar to the Milky Way in the Local Volume.

**Europlanet Joint-Research Activities: Empowering the amateur community**

A. Heward, Europlanet RI/UCL, A. Christou, J. Oberst, S. Miller, H. Rucker

Astronomy benefits from its large and knowledgeable amateur community, capable of making research-level contributions to the field. Europlanet sees the amateur community as part of the essential infrastructure for European planetary science, and will take steps to improve professional-amateur collaborations. Through its Joint Research Activity (JRA) programme, Europlanet is developing European infrastructure involving equipment and techniques that will empower the amateur community to benefit European planetary science missions. The study of meteoroids, linked to Europlanet’s Observational Infrastructure Networking activity and one of Europlanet’s main science themes, is being taken as a test case. The initiative is led by Armagh Observatory (AO) and supported by Deutches Zentrum Fur Luft und Raumfahrt (DLR), and the Technisches Universität Berlin (TUB). It will develop: o Observing Post for Lunar Impact Flashes. Meteoroids impacting the Moon release a portion of their kinetic energy in the form of light flashes that can be observed by Earth-based cameras. This task will lay the basis for ground-based observation programmes to observe impact flashes, using CCD cameras with high light-gathering power optics that can be attached to standard telescopes. The JRA will develop software and techniques for lunar tracking, event detection and reporting, and system calibration that can be easily implemented by amateur astronomers, using their own PCs. o Digital Meteor Station. Future planetary missions will observe meteors in the atmospheres of Venus, Mars and planets beyond. The JRA is developing a prototype meteor detection network involving state-of-the-art digital cameras available at DLR, image analysis software, and network infrastructure, which can be utilized by the amateur community. Meteor data will be processed for meteor trajectories and physical characteristics. The prototype station will be enhanced by a detector for ultra-low frequency waves. Products will be distributed through Europlanet’s Integrated and Distributed Information Service (IDIS). By September, two field trips in Southern Greece to observe the Perseid meteor shower will have taken place. The field trips, in August 2009 and August 2010, have been hosted by local astronomical societies and involved personnel from DLR, TUB and AO. Some material regarding the 2009 trip may be found at www.spartastronomy.gr/astroteams/meteors

**Unravelling the sky’s mysteries and isolating its anomalies: the Unidentified Aerospace Phenomena Observations Reporting Scheme**

P. Ailleris

Since the beginning of time, gazing up at the night sky has been a source of wonder, a subtle mix of fear and an unstoppable need to question our origin and destiny. Today, the mysteries of the night sky continue to awe many novice observers viewing something entirely unfamiliar for the first time. Throughout the last 60 years the subject of UAP (popularly known as UFOs) has generated intense interest and invaded the modern consciousness on a worldwide scale. Although
that the vast majority of events reported as UAP sightings can be explained in conventional terms, the existence of a small residue of cases remaining unexplained after analysis gives the subject a strong aura of mystery and fascination. Despite the lack of incontrovertible scientific evidence, there is a need to keep an attitude of humility and scientific open-mindedness since some UAP reports might represent events worthy of research. Rare atmospheric events, near-earth space phenomena, unexpected consequences of human activity (space debris, electromagnetic signals, and pollution), social, cultural, and psychological phenomena, or interactions among these may be revealed by further study. However, as the bulk of the reported UAP sightings can be attributed to a misidentification of some astronomical, natural or man-made phenomena, an excessive amount of UAP researchers’ time is spent handling spurious data. Launched under the framework of International Year of Astronomy 2009 (IYA2009), the Unidentified Aerospace Phenomena (UAP) Observations Reporting Scheme aims to alleviate this. The Scheme has two main objectives: 1) providing amateur and professional astronomers a formal mechanism (a questionnaire) for reporting any unexplained phenomena they observe when studying the night sky, and 2) contributing towards a better understanding of transient atmospheric phenomena by explaining the most common causes of UAP misidentifications for the general public. All of this is available on one easily accessed Website. As the project reaches its one year milestone, I will give during this talk an overview of the current status of the initiative, highlighting preliminary results in terms of questionnaires received, infrastructure, outreach activities, website traffic reports and overall feedback; while exploring ideas for the future. In this context, the 2010 Joint European and National Astronomy Meeting represents a unique opportunity for collecting inputs from the astronomical community and further advertising the project.

BRAMS, the Belgian RAdio Meteor Stations: a collaboration between professionals and radioamateurs

H. Lamy, S. Ranvier, J. De Keyser, S. Calders, E. Gamby

In the last months, we have been developing a Belgian network for observing radio meteors using forward scattering technique. This network is called BRAMS for Belgian RAdio Meteor Stations. Two beacons emitting a circularly polarized pure sine wave toward the zenith act as the transmitters at frequencies of 49.97 and 49.99 MHz. The first one located in Dourbes (South of Belgium) emits a constant power of 150 Watts while the one located in Ypres (West of Belgium) emits a constant power of 50 Watts. The receiving network consists of about 20 stations run by radio amateurs, including the network of the Belgian Association of Amateur Astronomers (VVS). We will describe this new meteor observing facility, present the goals we expect to achieve with the network and emphasize the importance of the collaboration between professionals and radioamateurs.

A new breed of 19th century amateur astronomers

V. Bonifácio, I. Malaquias

The availability of better, larger and more expensive research equipment and facilities coupled with the drive towards science professionalization and specialization led to a profound transformation of the amateur astronomical community in the last decades of the 19th century. In particular, a series of amateur astronomical societies were created, some of them still flourishing today. These ‘new’ societies typically provided their members with a discussion forum, a library access and journal(s) where their results could be published. Simultaneously amateur astronomers specialized in research
fields largely untapped by the professional community. In some specific areas, like for example, variable star observations, a symbiotic co-operation between the two communities, amateur and professional, was, in our opinion, established. In this paper we will overview the development of the amateur astronomical movement during the late 19th and early 20th centuries and discuss the characteristics of the Portuguese situation in this international context.

Posters

Study of Cataclysmic Variables as a Good Example of Collaboration of Amateur and Professional Astronomers

I. Voloshina

Detection and classification of variable stars of various types requires numerous routine observations day by day. Usually the lack of observational time, due to the many observational programs in observatories throughout the world (especially on large telescopes), does not permit professional astronomers to provide such rigorous observations. However, the public interest in the various astronomical objects, such as Novae, Supernovae, X-ray transients, Black Holes, and so on, has substantially increased in recent years; the study of cataclysmic variables is a particularly attractive field of investigation for amateur astronomers, due to the very interesting properties which these objects manifest. The detection of outbursts of Novae, Dwarf Novae, and even Supernovae, represents a good example of collaboration between amateur and professional astronomers. The various observational campaigns which were organized in different countries are the best evidence of successful work of such kind. The well-known nets, such as VSNET, AAVSO, and others, not only permit professional astronomers to know the right moment for making their observations, but also supply them with numerous data, helping them to provide detailed analysis of their objects.

Catching the Comet - Amateur discoveries with professional telescopes

N. Howes

Nick Howes talks about his observations of the break-up of comet C/2007 Q3 using the Faulkes Telescope, which helped show that it is possible for amateurs to do professional-grade astronomy. When Martin ‘Dill’ Faulkes first envisaged large, computer-controlled educational telescopes available to UK and European schools and societies, he probably hoped that they might be involved in some interesting science. The Faulkes telescopes, now located in Hawaii and Australia, are a pair of two-metre research-grade telescopes fitted with state-of-the-art cooled cameras, providing schools and amateur societies with outstanding facilities. Users have imaged the standard Messier and NGC objects, through to comets, asteroids and pretty much anything else you could imagine, but recently one UK amateur astronomer hit international headlines with his discovery of a comet nucleus fragmenting.
SPS9: 30 years of IRAM

IRAM: Recent Developments and Future Prospects

P. Cox

The Institut de Radioastronomie Millimetrique (IRAM) was founded 30 years ago. I will first overview recent developments that have increased in a significant way over the five last years the performances of both the 30-meter telescope and the Plateau de Bure interferometer. The progresses in the capabilities of the IRAM facilities will be illustrated with recent results obtained on nearby galaxies to the most distant systems known today. In a second part, I will outline future prospects and present NOEMA (NOrthern Extended Millimeter Array), a project that will transform the current IRAM interferometer into an even more powerful facility.

Recent Results on Astrochemistry: the Role of IRAM

J. Cernicharo

Protoplanetary Disks

A. Dutrey
SPS10: CERN: The particle accelerator / astrophysics connection

The LHCf experiment

K. Kasahara, LHCf collaboration

Abstract: LHCf is an experiment specially designed to observe high energy neutral particles emitted in the very forward region of LHC collisions. The physics goal is to provide data for calibrating the hadronic interaction models that are used in the study of high-energy cosmic-rays ($10^{15} \sim 10^{20}$ eV). LHC provides us collisions at center-of-mass energy of $\sqrt{s} = 0.9$ to 14 TeV, which is equivalent to the Lab. energy of $4.3 \times 10^{14}$ to $10^{17}$ eV. The origin, particle nature and propagation of such high energy cosmic rays are of absorbing interest in the astrophysical point of view. They are, however, not yet well established, or in other words, there are controversial observations or interpretations. Ultra high energy cosmic rays ($10^{19}$ eV) might have some connection with physics beyond the standard model. Such high energy cosmic rays are exclusively observed via air showers. M.C simulations of air showers are indispensable for deriving the primary energy and particle type of individual air showers. The development of electro-magnetic component of air showers is governed by high energy particles among generated particles in the collision of cosmic ray and air nucleus. Thus, LHCf has relevance to the problem in spite of its small aperture (observable pseudo rapidity range is $> 8.4$ or emission angle $< 3.3 \times 10^{-4}$); we have two rather similar detectors located at $\pm 140$ m from the Atlas interaction point. We will show the detector structure, performance and some preliminary results based on the data at $\sqrt{s} = 0.9$ and 3.5 TeV.

Nuclear Physics at Isolde and its implications on Nuclear Astrophysics

H. Fynbo

ISOLDE is an experiment at CERN with the goal of producing and studying exotic atomic nuclei. In this presentation I will present the facility and give examples of how this facility provide much needed data on properties of nuclei that play a role e.g. in energy production in stars, or explosive phenomena such as novae, super-novae and bursters. Finally I will give some prospects for the future of the facility.

Antimatter at Cern AD and the measurement of fundamental constants

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E. Widmann

The Antiproton Decelerator of CERN is currently the only facility world-wide providing low-energy antiprotons. The physics program is mostly focussed on the production and study of antiprotonic atoms and especially cold antihydrogen, the simplest antimatter atom. The ASACUSA collaboration has been studying antiprotonic helium, an exotic three-body system consisting of an antiproton, an electron, and a helium nucleus, having a series of highly excited metastable states. Using laser and microwave spectroscopy and comparing the results to state-of-the-art three-body calculations, the most precise values for the mass and magnetic moment of the antiproton could be obtained. The results can be used as a test of CPT symmetry or, by assuming that CPT is conserved, contribute to the value of the proton mass.

Because hydrogen is among the best known atoms, the precision spectroscopy of antihydrogen offers some of the best tests of CPT symmetry. Two collaborations, ATRAP and ALPHA, have succeeded in producing antihydrogen and are aiming at trapping it and measuring the 1S-2S two-photon transition. ASAUCSA is preparing an experiment to measure the ground-state hyperfine structure of antihydrogen. Both quantities for hydrogen are among the best known values with relative precision of $10^{-14}$ and $10^{-12}$, resp. The AEgIS collaboration has proposed to measure the gravitational acceleration of antihydrogen, which will be the first measurement ever for antimatter. This talk will give an overview of the status and prospects of antimatter research at CERN-AD.

Reference measurements for neutrino and cosmic rays physics with NA61

I.C. Maris, NA61/SHINE collaboration

Cosmic rays of ultra high energy can be measured only indirectly via the secondary particles produced air shower cascades in the atmosphere. The mass composition of cosmic rays can constrain acceleration models at astrophysical sources as well as the propagation of charged particles through the intergalactic medium. It is inferred by comparing the measured secondary particle observables with simulations of air showers. These simulations are based on extrapolations of hadronic interaction properties to phase space regions presently no covered by particle physics experiments. NA61/SHINE is a fixed-target experiment to study hadron production in hadron-nucleus and nucleus-nucleus collisions at the CERN Super Proton Synchrotron. Due to a large acceptance and good particle identification in the forward direction, NA61/SHINE is well suited for measuring particle production to improve the reliability of air shower simulations. Another goal of the NA61/SHINE experiment is to improve the prediction of the neutrino flux for the T2K (Tokai to Kamioka) neutrino oscillation experiment at J-PARC by measuring the production cross sections for pions and kaons with a precision of 5% and below. First analysis and results for the pion yield in proton-carbon interactions at 31 GeV/c taken during 2007 run will be shown and compared to predictions from hadronic interaction models. Preliminary spectra for positive and negative pions will be presented and an overview of the foreseen program of measurements will be given.

LHC status

M. Ferro Luzzi

A report on the LHC status will be given, covering the past eleven months since the 2009 start-up,
with some emphasis on the most recent achievements. The report will discuss machine performance and (selected) highlights from the LHC experiments. Prospects for LHC operation in the near future will also be briefly outlined.
SPS11: Teacher Training Session

The Dark Skies Ranger Program for GTTP

Constance Walker

The arc of the Milky Way seen from a truly dark location is part of our planet’s natural heritage. Yet, with half of the world’s population now living in cities, many urban dwellers have never experienced the wonderment of pristinely dark skies and maybe never will. The challenges come in explaining the importance of what they’ve lost to artificial sky glow, making them aware that light pollution is a concern on many fronts and convincing them that it’s worthwhile to take steps, even small ones, to help redress this issue. Children should be a main focus of dark skies education programs. Approaches that offer involvement on many levels, from cursory to committed, and via many venues should be employed. The programs and resources should be as turn-key as possible for educators and include ways to visualize the problem with simple, easily grasped and enjoyable activities. Activities like these were created by the U.S. National Optical Astronomy Observatory (NOAO) for grades 3-12 in a program called “Dark Skies Rangers”. The activities address how light pollution affects safety, energy conservation, cost, health and wildlife, as well as our ability to view the stars. They are downloadable on-line and available on CD as part of a dark skies kit. The central part of the kit is the light shielding demonstration, which illustrates the reasons for lighting responsibly. The capstone activity to the Dark Skies Ranger program is the participation in the GLOBE at Night citizen science campaign in March, which is also discussed. The session will be for educators who have an interest in incorporating dark skies education in formal or informal educational settings. Workshop participants will be invited to try some of the activities and report back during a discussion on incorporating the activities in their setting. Participants will receive a CD Rom containing all 8 activities on dark skies education and other helpful materials. We will share our tips and their concerns in making this program successful. Outcomes The workshop participants will Receive a collection of materials (e.g., a CD Rom) on dark skies education that can be used in formal or informal educational settings. Experience some of the activities that illustrate light pollutions effect on in astronomy, environmental sciences, health, and energy conservation. Be actively engaged in a discussion of how to use the dark skies education activities effectively and successfully within participants’ settings. Have NOAO Education and Public Outreach staff as a resource for future questions. Websites: www.darkskiesawareness.org/DarkSkiesRangers and www.globeatnight.org.

Star Reporters - Astronomy Journalism in Schools

Anita Heward
There are increasing opportunities for schools to become involved in projects that bring the excitement of space and astronomy into the classroom. Astronomy has the power to inspire many young people, whether students are making night-sky observations, meeting or working with local scientists or participating in educational projects such as European Hands on Universe and the Faulkes Telescope, which provide schools across Europe with access to state-of-the-art astronomy tools. Schools’ astronomy education activities may also be of interest to the local community and, in some cases, to the media. Publicising these activities can raise the profile of the school and encourage young people within schools and in the wider community to engage with space and astronomy. This presentation will give tips on how schools can publicise their activities and how students can become astronomy journalists, reporting on their experiences through writing press releases, articles and blogs.

The International Asteroid Search Campaign
_Ana Costa and Leonor Cabral_

This presentation will illustrate a very successful program promoted by the "Global Hands-on Universe Association". It is a very user friendly process that allows students to collaborate in the search for Asteroids. Schools from several countries around the world are experiencing the power of this unique program as a fantastic trigger for the interest of students in science and research.

Teaching Spectroscopy in the Classroom: a Practical Demonstration
_Vadim Burwitz_

In our presentation we will give an overview of what can be learned about spectroscopy in a classroom using a compact teaching spectrograph. Also the development such a spectrograph will be addressed and how it can be used for real observations. The talk will be rounded off with a practical demonstration of how to make use of the versatile compact DADOS spectrograph that we have designed specially for these teaching purposes.

Salsa J - Processing astronomical images school (Part I)
_Maria Luísa Almeida_

During this workshop teachers will get acquainted with the use of Robotic Telescopes in classroom and with the use of the image processing software Salsa J. These are modern tools being largely used by schools all over the world. It enables teachers to promote different science topics using cutting edge technology and involve students in a highly innovative perspective of actual research and the scientific method.

Salsa J - Processing astronomical images school (Part II)
_Maria Luísa Almeida_

During this workshop teachers will get acquainted with the use of Robotic Telescopes in classroom and with the use of the image processing software Salsa J. These are modern tools being largely used by schools all over the world. It enables teachers to promote different science topics using cutting edge technology and involve students in a highly innovative perspective of actual research and the scientific method.
Elisabeta Ana Naghi

Education of young people through astronomy, especially for students, plays an important role in the development of the key competences - maths and science - but also for transversal ones - social. This project shows the activities coodinated by me in Sibiu and in the rest of Romania in 2009. Here are some examples: “The local opening of AIA 2009”, “Official opening of AIA 2009 RO”, “She is an astronomer”, “100 hours of astronomy”, “Galileoscope RO”, “Sky Towers”, “Cassini - Scientist for a day”.

NA

Elisabeta Ana Naghi
On Alfvén waves in the solar wind

L.M.B.C. Campos

The propagation of Alfvén waves in the solar wind is affected by: (i) the radial mean flow velocity, that exceeds the wave speed beyond the critical point; (ii) the radial variation of mass density; (iii) the non-uniformity of the magnetic field. These waves are not sinusoidal because of non-uniform moving background, and do not satisfy equipartition of energies. It is shown that: (i) the magnetic energy tends to dominate the kinetic energy; (ii) that an initial white noise spectrum tends to a Kraichnan spectrum resembling hydromagnetic turbulence; (iii) that waves can be reflected or absorbed at the critical level where the wave speed equals the mean flow speed. These properties depend on the solar wind profile, e.g. are distinct for the 'solar breeze'.

On the generation of magneto-acoustic-gravity-inertial (MAGI) waves in stars

L.M.B.C. Campos

The generation of waves in stars is affected by: (i) the compressibility of the gas (acoustics); (ii) the ionization of the fluid or plasma (magnetism); (iii) the stratification in layers (gravity); (iv) Coriolis forces due to rotation (inertial effects). These four effects (i-iv) are generally coupled, leading to magneto-acoustic-gravity-inertial (MAGI) waves. The wave equation describing the propagation of MAGI waves is obtained: its source terms specify generation by turbulence and inhomogeneities; its solution leads to a radiation law for the wave energy flux.

A statistical study of the UV Mg II resonance lines’ parameters in 20 Be stars

A. Antoniou, E. Danezis, E. Lyratzi, L. C. Popović, M. S. Dimitrijević

In this paper, using the GR model, we analyze the UV Mg II resonance lines in the spectra of 20 Be stars of different spectral subtypes, taken with IUE, in order to detect the presence of Satellite
Absorption Components (SACs) and Discrete Absorptions Components (DACs). From this analysis we can calculate the values of a group of physical parameters, such as the apparent rotational and radial velocities, the random velocities of the thermal motions of the ions, as well as the column density and the Full Width at Half Maximum (FWHM) of the independent regions of matter which produce the main and the satellites components of the studied spectral lines. Finally, we present the relations between these physical parameters and the effective temperature of the studied stars.

On The Gravitodynamics of Moving Bodies

A. W. Mol

It is known that Einstein’s General Theory of Relativity, as usually understood at the present time, which had started from a profound but simple physical concept, the equivalence principle, when applied to the universe through the standard FL cosmology with its currently accepted $\Lambda$CDM model introduced a increasing list of freely specifiable parameters. Though they become more and more precise these realizations have been achieved at the expense of simplicity. In the present work we propose a generalization of Newton’s gravitational theory from the original works of Heaviside and Sciama that encompasses both approaches and accomplishes in a simpler way than the standard cosmological approach. The established formulation describes the local gravitational field related to the observables and effectively implements the Mach’s principle in a quantitative form that retakes the Dirac’s large number hypothesis. As a consequence of the equivalence principle and the application of this formulation to the observable universe, we obtain as an immediate result that Omega is 2. We construct a dynamic model for a galaxy without dark matter, which fits well with the recent observational data, in terms of a variable effective inertial mass that reflects the present dynamic state of the universe and that replicates from first principles, the phenomenology proposed in MOND. The remarkable aspect of these results is the connection of the effect dubbed dark matter with the dark energy field, which makes us possible to interpret it as longitudinal gravitational waves.

North-south asymmetry of Ca II K regions determined from OAUC spectroheliograms: 1996 - 2006

Dorotovic I., J. Rybak, A. Garcia, P. Journoud

The level and evolution of solar activity (SA) is not identical in the northern and southern Sun’s hemispheres. This fact was repeatedly confirmed in the past by analysis of a number of long-term observations of various solar activity indices. Therefore, north-south asymmetry (NSA) is a significant tool in analysis of the long-term SA variations. This paper presents a software tool to determine the NSA of the area of bright chromospheric plages, as measured in the Ca II K3 spectroheliograms registered since 1926 in the Observatório Astronómico da Universidade de Coimbra, Portugal, as well as evolution of surface areas in the period of 1996 - 2006. The algorithm of the program is limited to determining the total area of bright features in the emission line of Ca II K3 defining the threshold value of the relative brightness, but it does not perceive differences in the brightness of individual chromospheric features. A comparison and cross-correlation with the N-S asymmetries found for the sunspots and coronal green line brightness is added. In the near
future we intend to: 1) determine the NSA of area of bright chromospheric Ca II K3 regions back to the year 1926, 2) compare the evolution of surface area in the period 1970 to 2006 with the evolution of the index of magnetic observatory Mt. Wilson and Kitt Peak, which would enable to construct a proxy reconstruction of the magnetic index also back to 1926. Since 2007 are new spectroheliograms recorded using a CCD camera and therefore we will in future address this issue also for the period of 2007 - present.


Surovy P., Dorotovic I., Karlovsky V., Lousada J. L., Rodrigues J. C., Rybansky M., Fleischer P.

Many studies indicate that the solar activity (SA) can affect tree growth induced by changes in climatic conditions on Earth’s surface evoked due to SA variations. In previous work (Surovy et al., 2008), we found that cork oak (Quercus suber L.) bark growth was lower in the period of maximum of the 23rd SA cycle (2000-2002) than in the SA minimum period (around 1996). In this work we focused on a similar analysis of the data for the annual growth of cembra pine (Pinus cembra) grown in the North-east of Slovakia. The database covers the period of 1406 - 1970, but sunspot data (minima and maxima), is only available since 1610 at the NGDC site, moreover, the most reliable sunspot numbers data are only from 1749. The results of this analysis confirm the fact observed in the previous work, i.e. negative impact of high SA on cembra pine growth, but it should be noted, however, that the statistical significance of results is low. We applied also wavelet analysis to data on the evolution of tree growth, the results indicate periodic variations in the growth period of about 25 years (duration of approximately two solar cycles or one magnetic cycle, respectively), also periodicities of 30, 35, and 70 years were observed. A negative impact of the SA was also observed, in the growth of an 90 year-old maritime pine (Pinus pinaster) tree grown in the North of Portugal. The width of the annual rings was smaller in the years of maximum SA; furthermore it was found that it is the latewood growth that it is affected while the earlywood growth is not affected, as a corollary the percent of late wood also shows a significative negative correlation with SA.

Broad Absorption Lines with DACs and SACs in the spectra of PG 0946+301 and PG 1254+047

Lyratzi, E. Danezis, L. C. Popović, M. S. Dimitrijević and A. Antoniou

Assuming that the Broad Absorption Line Regions - BALR are composed of a number of successive independent absorbing density layers, which have the random, rotational and radial velocity, we investigate the physical properties of Broad Absorption Line Regions (BALRs) of the BALQSOs PG 0946+301 (Z=1.216) and PG 1254+047 (Z=1.024) by applying GR model on their spectra. Specifically, we study the C IV 1548.187, 1550.772 A and Si IV 1393.755, 1402.77 A as well as the Lya ? 1215.68 A spectral line and the N V 1238.821, 1242.804 A, UV resonance lines. The observed peculiar profiles of these lines can be explained by the DACs and SACs phenomena, as they are created by a number of components. Finally, we calculate some kinematical parameters such as the apparent radial (Vrad) and rotational (Vrot) velocities of the regions where the studied lines are created, as well as the random velocities (Vrand) of the studied ions.
On Formation of EHB Objects in Close Binary Systems

Vladislav Pustynski, Izold Pustylnik

This research continues our studies of EHB (Extreme Horizontal Branch) binary progenitors. The system is assumed to fill in its Roche lobe near the tip of the RGB. Shrinkage of the initial orbit occurs due to combined effect of angular momentum loss and accretion onto the low mass companion on the hydrodynamic timescale. We discuss ranges of initial parameters of the progenitor system for which formation of a close binary EHB object is possible. Factors that influence the formation probability of close binary EHB are analyzed.

Electromagnetic drift waves and coronal heating

J. Vranjes and S. Poedts

The solar atmosphere is structured and inhomogeneous both horizontally and vertically. The omnipresence of coronal magnetic loops implies gradients of the equilibrium plasma quantities like the density, magnetic field and temperature. These gradients are responsible for the excitation of drift waves that grow both within the two-component fluid description (in the presence of collisions and without it) and within the two-component kinetic descriptions (due to purely kinetic effects). In the present work the effects of the density gradient in the direction perpendicular to the magnetic field vector are investigated within the kinetic theory, in both electrostatic and electromagnetic regimes. The electromagnetic regime implies the coupling of the gradient-driven drift wave with the Alfvén wave. The growth rates for the two cases are calculated and compared. It is found that, in general, the electrostatic regime is characterized by stronger growth rates, as compared with the electromagnetic perturbations. Also discussed is the stochastic heating associated with the drift wave. The released amount of energy density due to this heating should be more dependent on the magnitude of the background magnetic field than on the coupling of the drift and Alfvén waves. The stochastic heating is expected to be much higher in regions with a stronger magnetic field. On the whole, the energy release rate caused by the stochastic heating can be several orders of magnitude above the value presently accepted as necessary for a sustainable coronal heating. The vertical stratification and the very long wavelengths along the magnetic loops imply that a drift-Alfvén wave, propagating as a twisted structure along the loop, in fact occupies regions with different plasma-$\beta$ and, therefore, may have different (electromagnetic-electrostatic) properties, resulting in different heating rates within just one or two wavelengths. Acknowledgments: The results presented here are obtained in the framework of the projects G.0304.07 (FWO-Vlaanderen), C 90347 (Prodex), GOA/2009-009 (K.U.Leuven). Financial support by the European Commission through the SOLAIRE Network (MTRN-CT-2006-035484) is gratefully acknowledged.

Observations of Optical Pulsars with two high time resolution Photometers at Asiago and NTT

Cesare Barbieri

We have built two single photon very high speed photometers (Aqueye for the Asiago 1.8m telescope and Iqueye for the 3.5m ESO NTT) as prototypes of a quantum photometer for the 42m European
Extremely Large Telescope (E-ELT) The two photometers are the most accurate ‘time machines’ available to optical astronomy. The arrival time of each detected photon is referenced to UTC with a precision better than 50 picoseconds, continuously for hours of data acquisition. Light curves for three optical pulsars (Crab, B0540-69, Vela) will be reported.

**Multiplicity of Herbig Ae/Be stars**

*Nicole S. van der Bliek, Bernadette Rodgers, Sandrine Thomas, Greg Doppmann, Jerôme Bouvier*

One of the most interesting constraints on star formation models comes from the study of multiplicity of young stars as a function of mass. While multiplicity studies of low-mass T Tauri stars have been quite exhaustive, an unbiased and systematic investigation of multiplicity among intermediate-mass Herbig Ae/Be (HAEBE) stars is still lacking. We are therefore conducting a photometric and spectroscopic survey of HAEBE stars to detect companions, establish their physical association with the primary and investigate their properties. The frequency and degree of multiplicity of HAEBE systems will provide new constraints on their formation mechanisms. In this poster we present the survey and some of the first results, based on high resolution NIRI/Altair imaging data and GNIRS spectroscopic data.

**Implementing Maxwell’s aether illuminates the physics of gravitation, yielding galaxy dynamics without CDM, high-a.m. planetary systems, and how high-mass stars are built**

*Miles F. Osmaston*

Relativity Theory (RT) incorporates two serious inconsistencies:- (1) embracing the function of transverse e.m. waves as perfect messengers but denying the presence of a Maxwell’s equations aether, essential for their existence; (2) overlooking that force communication between two electromagnetically defined objects is progressively velocity-limited to c (Heaviside 1889), so this is what happens in electromagnetic accelerators, not mass-increase. Both have hampered progress in understanding the physics of the mass property. A rewarding substitute, Continuum Theory (CT), (A) implements Maxwell’s aether as a massless all-pervasive quasi-superfluid elastic continuum of (negative) electric charge, and (B) follows others (1860-1960) in seeing mass-bearing fundamental particles as vortical constructs of aether in motion. To encompass that motion, these cannot be infinitesimal singularities. Electron-positron scattering provides guidance as to that size. For oppositely-charged particles, one sort contains more aether and the other less, so particle-pair creation is easy. This defines mean aether density as $> 10^{30}$ coulombs/cm$^3$, constituting the near-irrotational reference frame of directional devices. It also offers an unfathomable force capability should the means for displacing its local density exist; that, we show, is the nature of gravitational action and brings gravitation into the electromagnetic family of forces. Under (B) the particle mass is measured by the aether-sucking capability of its vortex, positive-only gravitation being because mutual convergence is the statistically prevalent expectation. This activity maintains a radial aether density gradient - the Gravity-Electric (G-E) Field’ - around and within any gravitationally retained assemblage, so Newton’s is an incomplete description of gravitation. The effect on c of that
charge density gradient yields gravitational lensing. G-E Field action on plasma is astronomically ubiquitous. This strictly radial outward force has the property, shared with radiation pressure, of increasing the angular momentum of outward-moving material, but at constant tangential velocity. Spiral galaxies no longer require CDM to explain this. The force has comprehensive relevance to the high a.m. achieved in solar planet formation, to their prograde spins and to exoplanet observations [Osmaston, EPSC Abstr. 4, EPSC2009-264]. The growth of high-mass stars is impossible if radiation pressure rules, whereas G-E field repulsion is low during dust-opaque infall, driving their prodigious mass loss thereafter.

**Continuum Theory (CT): implications of its continuous autocreation (CAC) cosmology for the construction and morphological evolution of galaxies and clusters**

*Miles F. Osmaston*

The findings of my poster (174) "Implementing Maxwell’s aether illuminates..." are:- (A) Maxwell’s aether is a continuum of extremely high charge density; (B) fundamental particles are ‘made out of it’ as vortical constructs of its motion (hence the name Continuum Theory), so reproduction (‘autocreation’) of more of them is ‘easy’; (C) Newtonian gravitation is accompanied by the presence of a radial electric field, the Gravity-Electric (G-E) field, whose action on plasmas is astronomically ubiquitous, yielding net repulsion without change of tangential velocity; so this pattern in spiral galaxies doesn’t need CDM. Here I show that if particles are ‘made out of aether’ the associated random aether motion generates the CMB and imposes four transmission effects upon electromagnetic waves, one of which - a distance-cumulative redshift - is the cosmic redshift and intrinsic redshifts in stellar and galaxy ‘atmospheres’. So there was no BigBang. In the resulting no-expansion cosmology the entire mass content of the universe has grown from the aether’s original random motion, by autocreation over time, whose local rate experiences positive feedback and acceleration as accumulations drive energy levels higher. Hence the clumpiness of galaxy distributions. Interestingly, CAC cosmology is available near-by for direct study. The infall of cosmogonically young material from the autocreation auras of clusters has 4 major implications. (1) It completely inverts the BigBang perspective that low-metallicity material is very ancient. (2) Low-metallicity Irregulars can illustrate the early stage of galaxy build-up and morphological evolution. (3) Quasi-axial infall onto a Spiral will spread out in the galactic plane, driven radially from the ionizing bulge by the G-E field, maintaining constant tangential velocity. This pattern means that the arms, although trailing, are actually being blown outward (unwrapping) and ruptured by the disk wind, and act as filters for it. (4) In cluster interiors, other cluster members may deflect the two infall streams onto a Spiral, introducing a dynamical ro-tational couple near the centre, with an axis roughly in the galactic plane, to produce a Barred Spiral. Cessation of infall then results in endwise collapse of that bar, yielding a fattened Elliptical. Images and diagrams are presented in support and elaboration of (3) and (4).

**Variations of solar EUV radiation and coronal index of solar activity**

*Lorenc M., Pastorek L.,Dorotovic I., Rybansky M.*

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This is a follow-up contribution of the paper Lukac and Rybansky “Modified Coronal Index of the Solar Activity” MCI (Solar Phys (2010) 263: 43-49). While MCI has been derived from measurements of the spectrometer CELIAS/SEM onboard the SOHO satellite, in this poster we focused on use of measurements from the satellites TIMED SEE for the same purpose, i.e. for their use in replacement of ground-based coronal measurements in compiling the coronal index of solar activity.

A multi-wavelength approach to the properties of Extremely Red Galaxy populations: SFRs and dust content, AGN fraction, morphology, and stellar masses

Hugo Messias, José Afonso, Andrew Hopkins, Bahram Mobasher, Tânia Dominici, David M. Alexander

I will present our contribution to the study of Extremely Red Galaxy (ERG) populations presenting a multi-wavelength analysis of these objects, selected in the GOODS-South/Chandra Deep Field South field. By using all the photometric and spectroscopic information available on large deep samples of Extremely Red Objects (EROs, 645 sources), IRAC Extremely Red Objects (IEROs, 294 sources) and Distant Red Galaxies (DRGs, 350 sources), we derive redshift distributions, identify AGN powered and Star-formation powered galaxies, and, using the radio observations of this field, estimate robust (AGN- and dust-unbiased) Star Formation Rate Densities (SFRD) for these populations. Applying a redshift separation (1 < z < 2 and 2 < z < 3) we find a significant rise (a factor of 2 or higher) of SFRD for EROs and DRGs toward high-z, while none is observed for IEROs. As expected, we find a significant overlap between the Extremely Red Galaxy populations, and investigate the properties of “pure” (galaxies that conform to only one of the three ERG criteria considered) and “combined” (galaxies conform to all three criteria) sub-populations. We find ERG sub-populations with no AGN activity and intense star-formation rates. With average values of ~200 Mo yr⁻¹ at 2 < z < 3, they reasonably contribute to the global star-formation rate density, reaching a 20% level. Strong AGN behaviour is not observed in the ERG population, with AGN only increasing the average radio luminosity of ERGs by ~10%. However, AGN are frequently found, and would increase the SFRD estimate by over 100%. Thus, and while the contribution of SF processes to the radio luminosity in galaxies with AGN remains uncertain, a comprehensive identification of AGN in these populations is necessary to obtain meaningful results. The dust content to each population is also derived by correlating UV and Radio SFRs, giving a higher obscuration for more active SF sources. Known to be among the most massive objects in the universe, we also estimate stellar mass densities. Finally, preliminary and promising results are presented on the morphologies of ERGs (CAS and Gini/M20 parameters) based on the latest HST-ACS GOODS-S images (v1.9).

Color Selection of AGN at High-z with JWST

Hugo Messias, José Afonso, Mara Salvato

The last decade has seen the appearance of various MIR colour criteria for the selection of AGN candidates. Mainly using IRAC (Spitzer) observations, they are effective at lower redshifts (z~<2).
However, at the $z > 3$, where the ELTs and JWST are expected to play a major discovery role, the current MIR AGN selection criteria become degenerate, failing to distinguish AGN emission from that due to star-formation. In this talk I will present a new set of MIR AGN-selection criteria particularly suited for JWST observations and effective to the highest redshifts ($z \sim 7$).

**On-sky testing of the seeing behavior to optimise flexible scheduling in astronomical observatories**

*Lupercio Braga Bezerra, Alberto Einstein Pereira de Araújo, Emmanuel Félix Lopes da Silva, Emerson Peter da Silva Falcão*

Spatial resolution of ground-based telescopes is limited by the optical turbulence of the atmosphere. Characterising optical turbulence above a specific astronomical site from a quantitative point of view can optimise flexible scheduling of scientific programmes and instruments. In addition, some of the most challenging scientific programmes to be carried out with ground-based telescopes require excellent turbulent conditions (seeing) to be successful. The aim of this project is establish an observational programme to measure atmospheric turbulence averaged on some selected natural stars. As a first step in this direction, we obtain sky field CCD exposures, comparing real and theoretical star coordinates (atmospheric differential refracting). Subsequent efforts are dedicated to the estimation of stars centroid coordinates (employing an algorithm with gaussian adjustment) from measurements of their separation. Finally, manipulating the FWHM of the star and the scale, we will be able to estimate the seeing. The final goal is acquire enough data to plot seeing behavior all year long, predicting temporal windows of favourable atmospheric conditions in an useful way. We will present results issued from a first analysis of the collected data, reporting on the current status of our research. Furthermore, we examine the reasoning behind speculations about the possible association of bad seeing on the observing site due to its proximity to a large mass of water. Our site target is the vicinities of the small town of Itacuruba (Brazil), an isolated spot located 481 km from Recife, which houses some astronomical facilities with telescope apertures ranging from 0.5m to 1.0m. Future surveys will be able to extend the local sky coverage by using artificial stars (laser guide stars).

**A New Insight into the Classification of Type Ia Supernova Spectra**

*Vladan Arsenijevic*

The spectroscopic diversity of Type Ia Supernovae (SNe Ia) is multidimensional. A new parameter is introduced to distinguish between different progenitor scenarios and/or explosion mechanisms. SNe Ia spectra are studied regarding the coefficient of the largest wavelet scale in their decomposition coupled with the SN colour. Apart from the group of normal SNe, another distinctive trend is found, characterised by intrinsically redder colours and consisted of many different SN events that exhibit diverse properties such as the interaction with the circumstellar material, the existence of specific shell-structure in or surrounding the SN ejecta or super-Chandrasekhar mass progenitors. These SNe that depart from standard SN population may violate the standard width-luminosity relation, which could considerably influence the cosmological results if they were all calibrated equally, since their fraction among SNe Ia in our sample exceeds about 30 per cent.
TSCorr - a tool for time-series correlation

A. Falcão, J. F. Ferreira da Silva and I. Dorotovic

This work describes a tool to assist the astronomical community scientists in analysing time-series containing non-categorical numerical data. It aims to contribute with a set of easy-to-use functionalities that aid in the detection of correlations among multiple time series, and the detection of periodicities associated to them, as well as a novel tool to detect and measure causality between parameters expressed in time series. The tool is a graphical user interface with support for multiple platforms, that provides plotting with zoom capabilities and an intuitive navigation. With a set of time-series loaded into the tool, the user is able to detect positive and negative correlations, between two parameters or in sets of more than one parameter. Detection of correlations taking into account time differences associated with the parameters is possible, with the tool providing a visual feedback of the correlation values for various deltas. An efficient approach is also provided for detection of periodicities within parameters. Graphical representations of the corresponding 11-year solar cycle and superimposed Gleissberg cycle, for example, can be seen using the tool. Care has been taken to efficiently handle large time-series, and a variation of the correlation method was developed to detect correlations in time-series caused by prominent peaks, such as a particular solar case study used to develop this feature. In the latest stages of development, we have explored the issue of causality direction between parameters, which cannot be handled by correlation metrics.
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