Oral Programme Abstracts

Monday, 18th July 2011

Galaxy-wide star formation processes

Prof Robert Kennicutt | Institute of Astronomy, University of Cambridge
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Abstract

Thanks to an infusion of multi-wavelength observations of star-forming galaxies near and far, we are now able to study the systematic patterns and scaling laws governing large-scale star formation in unprecedented detail. These new observations reveal deeper insights into the physical regulation of star formation, as well as new complications and inconsistencies which challenge the simple empirical prescriptions and theoretical descriptions which underlie most models and simulations of star-forming galaxies. This talk will review the current state of this rapidly evolving subject, and identify key issues to be addressed with ALMA and other new facilities.

Notes

The formation and evolution of the galaxy population

Prof Simon White | MPA
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Abstract

The current and past systematic properties of the galaxy population – abundances and clustering as a function of mass, size, characteristic velocity, morphology, star-formation rate and metallicity, as well as scaling relations between these properties – provide our principal source of information about the processes regulating the formation and evolution of galaxies. Techniques for simulating the global properties of large populations of galaxies, rather than the detailed internal structure of one or a few systems, began to be developed in the late 1990's and have made dramatic progress in the subsequent decade. It is now possible to follow the formation and evolution of the full galaxy population from Local Group dwarf spheroidals to giant cluster cD's within a single simulation, and so to investigate how observed abundances, clustering and scaling relations constrain the efficiency and parameter dependences of processes such as the sequestration of baryons in galaxies, galaxy merging, the growth of central black holes, and the ejection of mass, energy and heavy elements in galactic winds. The largest simulations to date follow the formation and evolution of hundreds of millions of galaxies within volumes similar to those planned for next generation cosmological surveys. Recent technical advances of importance in this area include the implementation of MCMC techniques for the systematic exploration of high-dimensional parameter spaces, the development of a scaling scheme which allows a dark matter simulation carried out in one cosmology to represent structure formation in any other cosmology consistent with current CMB and large-scale structure constraints, and the construction of virtual telescopes which allow past light-cones in the simulations to be rendered as images directly comparable to those of deep HST or ground-based surveys. These developments open up the possibility of investigating directly and systematically how uncertainties in galaxy formation physics will affect the precision of cosmological inferences from future surveys.

Notes

Clues to galaxy formation from local populations

Dr Guinevere Kauffmann | MPA
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Abstract

I will discuss what the past generation of large spectroscopic galaxy surveys have taught us about relations between the physical properties of galaxies, as well as the relations between the physical properties of galaxies and their environments and dark matter halo masses.

I will then focus on the so-called “galaxy bi-modality”, reviewing the physical processes that might be at work in shaping this fundamental relation. I will attempt to elucidate the kinds of observations that may finally clarify why the LCDM Universe produces two such different classes of galaxy.

Notes

Late galaxy evolution ($z < 2$)

Prof Simon Lilly | ETH Zurich
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Abstract

I will briefly review some of the main observational results concerning the evolution of the galaxy population, especially at z 2 and later. I will introduce the broad range of phenomena concerned, including flows of gas onto and off of galaxies, but will mostly focus on those underlying simplicities of the galaxy population that have emerged from large surveys. These can be used to derive the analytic form(s) for the dominant evolutionary processes concerned.

Notes

Star formation at intermediate redshift

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Abstract

Most present-day stars were formed at intermediate redshifts, i.e. $z = 0.5$–2.5. This is also the epoch when the cosmic star formation history peaked and started to decline until present-day. The cause of this decline has been a major theme of debate and various physical mechanisms have been invoked to explain it ranging from a drop of the rate of mergers to the quenching of star formation from AGN feedback or simply the exhaustion of the gas content of galaxies. Imaging with HST of the dominant galaxy population at these redshifts revealed the presence of large clumps of star formation suggesting that the gas reservoirs participating to these major events of star formation were subject to strong dynamical instabilities. These instabilities could either result from major mergers of galaxies or be driven by intergalactic infall of material through filaments, the so-called cold flows. The recent finding that star formation obeyed some simple scaling laws at all redshifts relating star formation in galaxies with their stellar mass and gas content, extending the Schmidt-Kennicutt relation to high redshifts, has been invoked to favor the cold flow scenario.

However, the determination of the star formation rate of galaxies suffers from strong uncertainties due to dust obscuration. With Herschel, it is now possible to determine with unprecedented accuracy the actual SFR of distant galaxies and make a major step forward in the understanding of the dominant factors playing a role in the building of present-day galaxies. We will review some of the recent results obtained in this context and present evidence for an infrared scaling law for star-forming galaxies.

Notes

SPH simulations of the formation and evolution of galaxies

Dr Joop Schaye | Leiden University
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Abstract

I will review methods and recent developments in large volume SPH simulations of the formation and evolution of galaxies. I will also present some recent results from the OWLS project.

Notes

Gas flows in galaxies: mergers versus bars

Dr Sara Ellison | University of Victoria
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Abstract

Bars and galaxy-galaxy mergers represent the two main mechanisms for triggering gas inflows that lead to central star formation in galaxies. I will present a comparative study of these two mechanisms which uses the star formation rates and gas-phase metallicities measured in SDSS galaxies to probe the efficiency of gas flows. These results will reveal the relative contributions of bars and merger-induced gas inflows in contributing to the build-up of the stellar bulge.

Notes

Quantifying the mixing due to bars

Dr Patricia Sanchez-Blazquez | Universidad Autonoma de Madrid
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Abstract

We will present star formation histories and the stellar and gaseous metallicity gradients in the disk of a sample of 50 face-on spiral galaxies with and without bars with the aim of quantifying the redistribution of mass and angular momentum in the galactic disks due to bars by comparying both the gas-phase and star-phase metallicity gradients on the disk of barred and non-barred galaxies. Numerical simulations have shown that strong gravitational torque by non-axisymmetric components induce evolutionary processes such as redistribution of mass and angular momentum in the galactic disks (Sellwood & Binney 2002) and consequent change of chemical abundance profiles. If we hope to understand chemical evolution gradients and their evolution we must understand the secular processes and re-arrangement of material by non-axisymmetric components and vice-versa. Furthermore, the re-arrangement of stellar disk material influences the interpretation of various critical observed metrics of Galaxy evolution, including the age-metallicity relation in the solar neighborhood and the local G-dwarf metallicity distribution. Perhaps the most obvious of these aforementioned non-axisymmetric components are bars - at least 2/3 of spiral galaxies host a bar, and possibly all disk galaxies have hosted a bar at some point in their evolution. While observationally it has been found that barred galaxies have shallower gas-phase metallicity gradients than non-barred galaxies, a complementary analysis of the stellar abundance profiles has not yet been undertaken. This is unfortunate because the study of both gas and stars is important in providing a complete picture, as the two components undergo (and suffer from) very different evolutionary process.

Notes

Transforming spirals into S0s

Prof Alfonso Aragon-Salamanca | University of Nottingham
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Abstract

Evidence is mounting indicating that S0s were once spiral galaxies that ceased forming stars and subsequently changed their morphology. Studying the timing, location and physical mechanism(s) involved in this transformation is not only interesting in itself, but it can also provide very useful clues on how galaxies evolve and the possible role of the environment. During the last few years we have been following several lines of research to test whether this transformation is indeed taking place, find out where it happens, and look for the physics driving it. At low redshift we have studied in detail the final products of the transformation - the S0s themselves - while at intermediate redshifts ($z\sim0.5$) we have concentrated on the putative progenitors - spiral galaxies - and the galaxies caught in the act of transforming. In this talk I present some of our more interesting results. Although there are still some loose ends, a coherent picture may be emerging.

Notes

Flattening dark matter cusps with supernova feedback: a physical model

Dr Andrew Pontzen | Kavli Institute for Cosmology, Cambridge
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Abstract

Recent simulation work (Governato et al. 2010) has produced dwarf galaxies which are both bulgeless and have an observationally consistent 'cored' dark matter central profile (Oh et al. 2010). Both effects are thought to be the result of outflowing gas. While adiabatic expansion was previously known to be capable of modifying dark matter profiles in response to outflows, it was not clear whether the effects could be large enough to resolve the observational cusp/core discrepancy (e.g. Navarro et al 1996, Gnedin & Zhao 2002, Read & Gilmore 2005). It is therefore imperative to reach a full understanding of the detailed physical mechanism at work in flattening cusps into cores in Governato et al's work. I present new simulations and a physical model aimed at doing just that. In the new picture I present, the 'burstiness' of the outflows is crucial, allowing for a much more pronounced effect than generally supposed from adiabatic calculations. I outline possible observational tests of the scenario.

Notes

Mapping dark and stellar haloes with integral-field spectrography

Dr Anne-Marie Weijmans | Dunlap Institute for Astronomy & Astrophysics, University of Toronto
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Abstract

From galaxy formation theories, we expect galaxies to be embedded in massive haloes of dark matter. For early-type galaxies these haloes are not always straightforward to detect: they often lack the large cold gas discs that are used as tracers of the gravitationally potential in spiral galaxies and we are therefore forced to use other, less accessible tracers. As a result, for only a handful of early-type galaxies the dark haloes have been mapped. This poses a problem for direct comparisons of theoretical predictions of galaxy formation models against observations. We have therefore started a programme within the Atlas3D Survey to increase this number. Using integral-field spectrographs such as SAURON and VIRUS-P, we have obtained spectra out to 3-5 effective radii in a number of early-type galaxies, over the full galaxy field. We not only obtain stellar and gas kinematics, which are used to construct mass models of the dark halo, be we also measure line strengths to infer the properties of the stellar halo population. I will show our recent results, and discuss the properties of the stellar and dark halo that we can obtain with these measurements.

Notes

The Bolshoi Cosmological Simulations and Their Implications

Prof Joel Primack | University of California, Santa Cruz
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Abstract

The highest resolution cosmological simulation based on current cosmological parameters is the Bolshoi simulation. This simulation has been the basis for a series of papers based on halo abundance matching, and new papers in preparation based on semi-analytic modeling. There are also larger and smaller simulations in the Bolshoi/MultiDark series. In this talk I will summarize the key results both from the Bolshoi simulation suite and the research based on it.

Notes

Galaxy evolution from weak lensing with CFHTLenS

Prof Mike Hudson | University of Waterloo
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Abstract

Halo masses are a key ingredient for understanding galaxy evolution. Galaxy-galaxy lensing provides a new way to approach this problem. The CFHT Legacy Survey Wide component has been analyzed by the CFHTLenS team, providing accurate shapes and 5-band photometric redshifts over 170 sq degrees. I will present results from this unique dataset, allowing the determination of galaxy-scale halo masses as a function of galaxy luminosity, colour and redshift.

Notes

Clustering and Number Density Selection of High-z Galaxy Descendants

Dr Nelson Padilla | Universidad Católica de Chile
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Abstract

We will present a method to select descendants of high redshift galaxies, motivated in results from numerical simulations. If the number density and clustering amplitude of a sample of galaxies is known, these can be matched to a population of dark-matter haloes at the same redshift in EPS theory or numerical simulations. The latter can be followed to lower redshifts, where the properties of the descendant population can be inferred. The observational sample that shares this properties at this new redshift can be considered as statistical descendants of the higher z sample. Applying this method to ETG galaxies in the MUSYC survey, we find that between $z = 1$ and 0, these galaxies undergo $\sim 1 - 4$ mergers with little star formation activity.

Notes

Alpha-enhanced stellar populations models for studying massive galaxies

Dr Alexandre Vazdekis | Instituto de Astrofísica de Canarias
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Abstract

Massive galaxies are known to show stellar populations that are enhanced in alpha-elements, which may indicate very short formation timescales. We present a new generation of stellar population models predicting alpha-enhanced SEDs at moderately high resolution. These predictions are based on the empirical stellar library MILES, with the aid of theoretical stellar atmospheres. We show that these models provide significantly better fits to observed galaxy spectra, absorption line-strengths and colours. We also introduce web-based tools for building-up model SEDs for varying star formation histories, which include these alpha-enhanced predictions.

Notes

Galaxy luminosity function: dependence on halo mass

Dr Jon Loveday | University of Sussex
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Abstract

The Galaxy and Mass Assembly (GAMA) survey has determined dynamical masses for 14,000 galaxy groups of 10^{10} to 10^{17} Solar masses over 150 square degrees to redshift $z \sim 0.4$. I will present measurements of the galaxy luminosity function (LF) in the ugriz bands for these groups, highlighting the evolving dependence of LF on halo mass.

Notes

The Simplicity of Galaxy Evolution and Environment Quenching in SDSS

Mr Yingjie Peng | Institute of Astronomy, ETH Zurich
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Abstract

The galaxy population appears to be composed of infinitely complex different types and properties at first sight, however, when large samples of galaxies are studied, it appears that the vast majority of galaxies just follow simple scaling relations and similar evolutional modes while the outliers represent some minority. The underlying simplicities of the interrelationships among stellar mass, star formation rate and environment are seen in SDSS and zCOSMOS. We demonstrate that the differential effects of mass and environment are completely separable to $z \sim 1$, indicating that two distinct physical processes are operating, namely the "mass quenching" and "environment quenching". Considering the unique features of the environment quenching, we then suspect that the environment quenching is actually satellite quenching, through which the star formation of the star forming galaxies are quenched as they fall into larger haloes and become satellites. The new SDSS DR7 group catalogues are employed to investigate the dependence of various galaxy properties on environment, especially the distinction of environment quenching effect on centrals and satellites. We find excellent agreements between the observations and the predictions from Peng et al. (2010) model. The mass functions of centrals and satellites follow almost perfectly with the predictions of our model. I will also discuss the global evolution of the mass functions in different environments from high to low redshifts, with some other interesting implications from this model.

Notes

Are Galaxy Growth and Halo Growth Correlated?

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Abstract

It is well known that galaxy bimodality depends on environment; red, dead, early-type galaxies primarily live in high-density regions. This is especially true for sub-$L_\star$ red galaxies. Dark matter halos exhibit a similar effect, known as assembly bias; at fixed halo mass, old, slow-growing halos form preferentially dense environments. This effect is strongest for halos of mass $M_{\rm halo} < 10^{12}\ M_\odot$, the types of halos that house galaxies with $M_{\rm gal} < 10^{10.5}$ at their centers, a quarter of which are quenched of their star formation. Using a galaxy group catalog to determine the halo masses of galaxies, and to decompose the galaxy population into central and satellite galaxies, I explore the environmental dependence of galaxy properties for these low-mass galaxies. I will demonstrate that the fraction of red-and-dead galaxies is independent of environment (at any scale larger than the halo scale) at fixed stellar and halo mass. I will compare these results to N-body simulations that track the growth of halos. The ansatz that quenched field and void galaxies live in halos that have stopped growing is clearly excluded by the data, implying that halo growth and galaxy growth are uncorrelated for low-mass objects. This represents a conundrum for the subhalo abundance matching paradigm, in which galaxies of the same stellar mass occupy halos of the same dark mass, regardless of whether the galaxies are forming stars or not. If quenched galaxies live in halos that grow at normal rates for their mass, red galaxies should live in different halos that blue galaxies at fixed $M_{\rm gal}$. Possible resolutions are that these galaxies only recently quenched their star formation, or that sub-$L_\star$ galaxies move back and forth between the blue cloud and red sequence.

Notes

The GAMA Galaxy Group Catalogue: Probing the Universe One Halo at a Time

Dr Aaron Robotham | University of St Andrews
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Abstract

We present the GAMA Galaxy Group Catalogue (G3C). This is the highest fidelity group catalogue ever constructed, virtue of the GAMA redshift survey being nearly 100% complete over 144 sq. deg. of the sky- containing in total ∼130K redshifts. This catalogue allows us to observationally probe the halo mass function (HMF) down to 10^{12} solar masses. As well as offering a new constraint to the temperature of dark matter, this also means we can now probe environment as a function of halo mass -not density- a much more fundamental discriminator when attempting to pick apart the roles stellar mass and environment have on the fate of galaxies.

Notes

Environmental dependence on Herschel-ATLAS galaxies

Dr Qi Guo | National Astronomical Observatories, Chinese Academy of Sciences
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Abstract

We us low-redshift ($z < 0.5$) far-infrared selected galaxies in the PhaseI field of the Herschel-ATLAS (H-ATLAS) survey, optically selected galaxies from the Galaxy and Mass Assembly (GAMA) redshift survey and group catalogue based on GAMA galaxies to investigate how the distribution and formation of FIR galaxies depend on environmental effect, e.g. dark matter halo mass.

Notes

The evolution of the galaxy mass assembly and star formation activity from z=1 to z=0 as a function of environment

Miss Benedetta Vulcani | INAF - Padova observatory
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Abstract

The properties of galaxies change in a systematic way with galaxy mass, with redshift and with environment. Understanding which factor is the most important in driving galaxy evolution is one of the main goal of the astrophysics. It is well known that several galaxy properties are largely determined by the stellar mass. I will present the first determination of the mass function of galaxies in clusters, as a function of the galaxy morphological type, and how it evolves between z=0.8 and z=0. A results that has several far reaching implications for the mass assembly, the mass segregation with environment and the morphological evolution of galaxies. I can show how strong is the evolution of the total mass function, and of the mass function of EACH morphological types (ellipticals, S0s and late-types) in clusters, and discuss the possible processes that cause this. I will also show how much the morphology-mass relation depends on redshift, according to the evolution of the morphological fractions. Then, fixing a redshift, I will present how much the mass distribution varies among different environments (clusters, groups, field). Moreover, I can present the first study of the difference of the stellar mass – star formation rate relation between clusters, groups and field at high-z, and what this means for the mechanisms proposed to explain the quenching of star formation (Vulcani et al. 2010 ApJLetter 710 L1, and Vulcani et al. 2010 MNRAS in press, arXiv:1010.4442)

Notes

Direct observations of the evolving group luminosity function of massive red galaxies since $z \sim 0.7$

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Abstract

We present an empirical study of the group luminosity function around massive red galaxies in the redshift range $0.3 < z < 0.7$ using SDSS imaging data. We select objects that are identified as Luminous Red Galaxies from SDSS-III BOSS spectra and associate their group members statistically using randomly selected regions within the same SDSS fields. The derived luminosity function therefore represents the group mass over-density in respect to its surroundings. We show that the group luminosity function around the most massive red galaxies has evolved significantly in the last six Gyrs and estimate the total mass contribution of satellite accretion to the central galaxy. We also compare our results with a study of local groups at $z \sim 0.1$ and discuss the implications of our findings to show that stellar mass growth in massive ellipticals is heavily influenced by minor mergers. This is especially relevant in light of recent observations that show significant size growth in massive galaxies since $z \sim 2$ despite only moderate growth in mass.

Notes

The emergence of the red sequence

Prof Marijn Franx | Leiden University
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Abstract

One of the surprising results of the last decade is the discovery of quiescent galaxies at redshifts > 1.5, and their remarkably high density and small size. I review the new results which have come out, including kinematic measurements and very deep photometry, leaving no doubt that they are truely compact and very massive. These galaxies can be found to redshifts beyond three, but remakably enough, their star forming progenitors have not been identified yet - even though they should be easier to find. Comparisons of the evolution of the mass size relation with theoretical predictions are presented.

Notes

From dwarfs to giants: the history of star formation since z∼1

Dr David Gilbank | SAAO
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Abstract

Motivated by suggestions of 'cosmic downsizing' in which the dominant contribution to the cosmic star formation rate density (SFRD) proceeds from higher to lower mass galaxies with increasing cosmic time, we have recently completed a survey aimed at directly exploring for the first time the spectroscopic star-formation activity in low mass galaxies ($8.5 < \log \mathrm{Ms} < 9.5$) at z∼1. I will present results from ROLES (the Redshift One LDSS-3 Emission line Survey) which, combined with other higher mass surveys, has measured the cosmic star-formation rate density (SFRD) as a function of stellar mass at z∼1. By comparison with a local sample drawn from the SDSS (which is also used to assess the calibration of our SFR indicators), we can measure the mass-dependent star-formation history of the Universe over half its age. I will also discuss how the observed timescales for star-formation compare with the predictions of the Durham semi-analytic model, Galform.

Notes

Oral Programme Abstracts

Tuesday, 19th July 2011

Clues to galaxy formation from the Milky Way and Local Group perspective

Prof Amina Helmi | University of Groningen
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Abstract

I will review our current understanding of the Milky Way and its satellites, with emphasis on the properties of their stellar populations and their internal dynamics. These systems are unique since we can study them in incredible detail by measuring the kinematics, ages and abundances of individual stars. Together with the many ongoing large surveys this has allowed us to put strong and very complementary constraints on cosmological models of galaxy evolution.

Notes

The satellites of the Milky Way as a probe of the nature of dark matter

Prof Carlos Frenk | Durham University
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Abstract

The ΛCDM model accounts suprisingly well for an impressive amount of data on the cosmic large-scale structure, ranging in scale from a few gigaparsecs to a few megaparsecs. On megaparsec scales the model cannot be tested with the same degree of rigour as on larger scales where microwave background radiation data and measures of galaxy clustering provide clean and well-understood diagnostics. Yet, it is precisely on small scales where the nature of the dark matter manifests itself most clearly. For example, N-body simulations of galactic dark matter halos made of cold (CDM) or warm (WDM) dark matter look completely different: the former produce a very large number of substructures, the latter (in the case of a dark matter particle of mass $\sim$ 4Kev) only a few because of the cutoff in the power spectrum due to free streaming. Characterising the nature of structure on subgalactic scales is therefore a key to understanding the nature of the dark matter.

In this talk I will review how we can learn about dark matter from the properties of the satellites of the Milky Way. There are three aspects which are particularly informative: (i) the luminosity function of satellites, (ii) the dynamics of the satellites and (iii) the combination of (i) and (ii). I will show that CDM has no difficulty in explaining the luminosity function because galaxy formation is strongly suppressed by reionization and supernova feedback in small subhalos, although this success comes at the expense of a large population of barren or dark subhalos. Similarly, it is possible to find subhalos in high resolution CDM simulations whose potential wells are consistent with the available spectro-kinematic data for the Milky Way satellites. There is a problem, however, when (i) and (ii) are considered together: current CDM models place the correct satellite luminosities in subhalos that are much too massive compared with observations. Equivalently, models that match the dynamical data, require the brightest satellites to form in medium sized halos, rather than in the most massive whose dark matter distribution is much too concentrated to be compatible with the data. There are three possible solutions to this discrepancy: (i) the Milky satellite system is not typical; (ii) the dark matter is not cold but warm; (iii) there are complex feedback processes not included in current models. I will use both semi-analytical techniques and cosmological simulations to illustrate possibilities (i) and (ii).

Notes

Dissecting the Milky Way's Stellar Disks

Prof Hans-Walter Rix | Max Planck Institute for Astronomy
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Abstract

The stellar-population-dependent structure and kinematics of our Galaxy's disk has historically been an important testbed for shaping our thinking about disk galaxy formation and evolution. New data sets, providing detailed kinematics and abundances for large stellar samples beyond the solar neighborhood in the Milky Way, have great potential to provide qualitatively new ways to test internal and external disk evolution mechanism. I'll discuss recent results and insights, in particular ones based on SDSS/SEGUE.

Notes

Secular evolution of galaxies

Prof Francoise Combes | Observatoire de Paris
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Abstract

In galaxy formation scenarios, slow dynamical processes, where the galaxies remain in quasi-equilibrium, while continuously accreting matter from cosmic filaments, compete with more violent evolution, triggered by galaxy interactions and mergers. Galaxy disks develop non-axisymmetric waves, such as bars and spirals, to transfer efficiently the angular momentum outwards, and concentrate the mass. Perpendicular bar resonances form pseudo-bulges, which are frequently observed in particular in late-type galaxies. The relative importance of the two formation/evolution scenarios to assemble mass will be discussed. Secular evolution may alleviate the problem of too massive bulge formation in the standard LCDM theory. The observed bar frequency can also quantify the amount of slow gas accretion all along a galaxy life-time. Typically a galaxy would double its mass in about 10 Gyr. Cosmological simulations confirm the importance of accretion.

Notes

Galactic Stellar Haloes in the CDM model

Dr Andrew Cooper | Max Planck Institute for Astrophysics
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Abstract

I will present simulations of the formation and destruction of satellites in Milky Way-like dark haloes. We have developed a new technique for these simulations, combining N-body and semi-analytic methods. With a spatial resolution of ∼200pc, these are currently the only fully cosmological models of galactic stellar haloes that resolve the cold streams of faint dwarf galaxies. I will focus on results that compare the latest Milky Way and M31 observations with explicit predictions from CDM galaxy formation models. I will then present a method for quantifying the degree of substructure in halo star surveys, based on a phase-space correlation function. I will use this method to compare our simulations to data from SDSS and address the issue of 'in situ' halo star formation. Finally I will describe ongoing work with the Millennium II simulation. This provides a theoretical basis for the systematic study of diffuse light around large samples of galaxies (from SDSS and PanSTARRS, for example). By combining such surveys with HI observations we aim learn more about the role of satellite accretion in galaxy evolution.

Notes

Stellar tidal streams in nearby galaxies: mapping the minor merger rate in the local Universe with small telescopes

Dr David Martinez-Delgado | Max-Planck Institut fur Astronomy
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Abstract

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 universe 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. Our collection of galaxies presents an assortment of tidal phenomena exhibiting strikingly diverse morphological characteristics. 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.

I will also present the discovery of a tidal stream around a nearby dwarf irregular galaxy with our small telescopes. Follow-up observations with Subaru telescope show this stream completely resolved into stars, providing observational evidence of a minuscule merger in a LMC-type system in the local universe. This result suggests that dwarf accretion could play an important role in the star formation history and evolution of nearby dwarf galaxies.

Notes

Substructure Depletion in the Milky Way Halo by the Disk

Dr Elena D'Onghia | Harvard University
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Abstract

We employ numerical simulations and simple analytical estimates to argue that dark matter substructures orbiting in the inner regions of the Galaxy can be efficiently destroyed by disk shocking, a dynamical process known to affect globular star clusters. We carry out a set of fiducial high-resolution collisionless simulations in which we adiabatically grow a disk, allowing us to examine the impact of the disk on the substructure abundance. We also track the orbits of dark matter satellites in high-resolution Aquarius simulations and analytically estimate the cumulative halo and disk-shocking effect. Our calculations indicate that the presence of a disk with only 10% of the total Milky Way mass can significantly alter the mass function of substructures in the inner parts of halos. This suggests that there is no inner missing satellite problem and calls into question whether these substructures can produce transient features in disks, like multi-armed spiral patterns.

Notes

The Chemodynamical Disection of the Galactic Thin and Thick Disks with RAVE

Prof Matthias Steinmetz | Leibniz-Institute for Astrophysics Potsdam (AIP)
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Abstract

Large spectroscopic surveys of the Milky Way allow us to take a systematic view at the combined chemical and dynamical properties of the Milky Way. The Radial Velocity Experiment RAVE has meanwhile spectroscopically observed about half a million Milky Way stars. Beside radial velocities, stellar parameters and abundance rations could be derived for the majority of the RAVE stars. Among many possibilities, RAVE thus provides means to study the remnants of past accretion events, local resonances and the general velocity and abundance distribution of the extended the solar suburb. I will describe recent results investigating these phenomena and trends with RAVE data.

Notes

The Implications of a First Infall Scenario on the Star Formation Histories and Kinematics of the Magellanic Clouds

Ms Gurtina Besla | Harvard University
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Abstract

Recent high precision proper motions from the Hubble Space Telescope suggest that the Large and Small Magellanic Clouds (LMC and SMC, respectively) are either on their first passage or on an eccentric long period ($>$ 6 Gyr) orbit about the Milky Way (MW). This differs markedly from the canonical picture in which the Clouds travel on a quasi-periodic orbit about the MW (period of $\sim$ 2 Gyr). Without a short period orbit about the MW, gravitational interactions between the Clouds and the MW can no longer be considered as the main driver for the morphological evolution of the Magellanic System. Instead, we propose that tidal interactions between the LMC and SMC are sufficient to explain the observed morphology, star formation histories and kinematic properties of the Clouds, without relying on a previous pericentric passage about the MW. We will furthermore discuss the broader implications of this dwarf-dwarf tidal interaction scenario to our general understanding of the star formation histories and evolution of dwarf galaxies in our local volume.

Notes

The Stellar Populations of Ultra Faint Dwarf Galaxies

Dr Sakurako Okamoto | Peking University
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Abstract

There are many dwarf galaxies around the Milky Way, most of them are considered to be both dynamically and chemically simple, with the high M/L ratio. The number of Galactic satellites is doubled in recent years thanks to systematic surveys in the SDSS data archive. These newly discovered ultra faint dwarf (UFD) galaxies are roughly 10 to 100 times fainter than the well-known "classical" dSphs, having amorphous morphology and too low surface brightness to be found by the photographic plate. Because of their faint luminosities and apparently large sizes in the sky, the general natures of UFDs, such as star formation history (SFH) and detailed structural properties are still unclear. Here, we present the deep colour-magnitude diagrams (CMDs) of Galactic dSphs, including six UFD galaxies. The images taken by Subaru/Suprime-Cam are sensitive enough to derive the stellar ages based on the main sequence turn-off, and wide enough to study the spatial distribution of stars in each galaxy. The brighter galaxies have relatively younger populations than these of fainter ones. In the brighter dSphs, the younger populations are more spatially concentrated to the galaxy center than old stars, indicating that the star formation in the central region continued at least a few Gyr, consistent with the different spatial distributions of red and blue HB stars. On the other hands, the CMDs of the faintest satellites show a single epoch of star formation as a metal-poor Galactic globular cluster. This result indicates that the gas in the progenitors of UFDs were removed more effectively than those of brighter dSphs at an occurrence of their initial star formation. This is reasonable if the UFD progenitors were likely to belong to the less massive halos than those of brighter dSphs.

Notes

Insights on the Andromeda Satellite System: A deep view of the faintest of galaxies and what they can tell us about their host

Dr Nicolas Martin | MPIA, Heidelberg
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Abstract

Recent discoveries of faint dwarf galaxies around both the Milky Way and Andromeda have expanded the realm of galaxies to systems that are 100 to 1,000 times fainter than known only 10 years ago. In particular, the PAndAS survey has revolutionized our view of the Andromeda satellite system. Based on both the panoramic survey data, and deep photometric follow-up, I will present the detailed properties of individual, faint Andromeda satellite galaxies, as well as their global properties, how they relate to their environment (luminosity function, sizes, 3D distribution, etc) and can help us understand the formation of the Andromeda galaxy.

Notes

Measuring the Distribution of Dark Matter in Dwarf Spheroidal Galaxies

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Abstract

Dwarf spheroidal galaxies (dSphs) are the smallest and faintest galaxies in the known Universe, and as such they play a key role in constraining galaxy formation models within a cosmological context. Several authors have shown that the amount of dark matter enclosed within the luminous radius of a dSph can be strongly constrained by modelling the kinematics of individual stars. Unfortunately, the strong degeneracy that exists between dynamical mass and velocity anisotropy has hindered thus far any meaningful derivation of how dark matter is spatially distributed in these galaxies. In this talk I will show that for dSphs that contain spatially/kinematic distinct stellar components this degeneracy can be broken, thereby allowing us to measure for the first time the density profile of dark matter haloes on galactic scales of a few hundred parsecs. Early results found for the Fornax and Sculptor dwarf spheroidals will be shown and discussed.

Notes

LSB Galaxies and their Dark Matter Halos

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Abstract

Dark matter-dominated galaxies like low surface brightness (LSB) galaxies provide powerful tests of the predictions of the CDM model on galaxy scales. If LSBs are found to reside in cuspy NFW-like CDM halos, constraints can be placed on CDM halo concentrations and on the values of cosmic parameters such as σ_8. If cuspy halos are not present, the observations will provide useful constraints on theory/simulations of baryonic physics (e.g. feedback). A growing body of high-quality kinematic and photometric data for LSB galaxies shows that they are more consistent with spherical cored dark matter halos than the predicted triaxial cuspy CDM halos. Sophisticated low mass galaxy simulations have used feedback from star formation to remove baryons and low angular momentum gas to change an initially cuspy halo into a cored halo. We confront the feedback scenario with the star formation histories and merging histories of seemingly undisturbed, quiescent LSB galaxies to determine the applicability of these models.

Notes

Gas in Galaxies - an HI perspective

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Abstract

The processes of accretion and depletion of gas in galaxies plays an important role in their formation and evolution. Radio observations in the 21cm line of atomic hydrogen provide a unique perspective as they reveal environment-dependent physical processes like minor mergers, ram-pressure stripping and tidal interactions that remain unnoticed otherwise. Moreover, numerical simulations have now reached a level of sophistication that allows for meaningful comparisons with the observations at the scales of galaxies. I will present a brief overview of the current state of HI affairs and discuss the future opportunities for large scale HI surveys with SKA pathfinders like ASKAP, MeerKAT and Apertif on the WSRT.

Notes

Cold Gas in Massive Galaxies: Results from the GALEX Arecibo SDSS Survey

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Abstract

The main obstacle to understanding the formation and evolution of galaxies is our limited knowledge of the role played by gas. In particular we still lack measurements of the HI gas, which is the reservoir for future star formation, for large and unbiased samples for which ancillary data on stellar and star formation properties are also available. To this end we are carrying out the GALEX Arecibo SDSS Survey (GASS), an ambitious programme to assemble the first unbiased inventory of atomic hydrogen in massive galaxies. Using the Arecibo radio telescope, we are acquiring HI spectra for 1000 galaxies selected uniquely by stellar mass ($M_* > 10^{10} M_\odot$) and redshift ($0.025 < z < 0.05$), covered by both SDSS spectroscopic and GALEX imaging surveys. Our selected stellar mass range allows us to probe the interesting region where galaxies transition from blue and star-forming to red and passively evolving. In this talk I will discuss how the gas content of massive systems depends on their structural and star formation properties. I will argue that gas scaling relations are not only necessary to characterize the average gas properties of the local galaxy population, but are also a very useful tool to identify objects that might be transitioning between blue, star-forming cloud and red sequence. In particular, objects with HI excess are good candidates for systems that might have recently accreted gas from the surrounding medium. Lastly, taking advantage of the unbiased nature of the GASS sample, I will illustrate a relation between baryonic mass and velocity for massive systems that does not involve morphological pruning, and thus is more suited to comparison with theoretical models.

Notes

The non-universality of the Molecular Gas Depletion Timescale in Massive Galaxies

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Abstract

We are conducting COLD GASS, a legacy survey for molecular gas in massive galaxies. The survey's aim is to understand the link between atomic gas, molecular gas, star formation and global galaxy properties in the local universe. Using the IRAM 30m telescope, we measure the CO(1-0) line in 350 massive galaxies ($\log M^*/M_\odot > 10.0$). The sample is purely mass selected, and therefore provides an unbiased view of the distribution of condensed baryons between the stellar, atomic gas and molecular gas phases. In these massive galaxies, while MH2 is a constant fraction of stellar mass, it is mostly decoupled from the atomic gas mass. Contrary to the scenario established by resolved CO maps of a significantly smaller number of galaxies, we find that the molecular gas depletion timescale is not universal, but rather varies by a factor of $\sim$6 with most global galaxy properties (stellar and dynamical masses, concentration index, mass surface density,...). The strongest correlation is in the depletion time-specific star formation rate plane, where a cohesive picture emerges, linking local normal star-forming galaxies and extreme ULIRGs, as well as $z = 1$ and 2 star-forming and sub-millimeter galaxies. The position of a galaxy in this plane is determined solely by its gas fraction and the importance of dynamical effects affecting it.

Notes

The evolution of the molecular gas fraction of star-forming galaxies

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Abstract

We present new IRAM Plateau de Bure interferometric detections of CO ($J = 1 \rightarrow 0$) emission from a 24μm-selected sample of galaxies at $z = 0.4$. These relatively 'normal' star forming galaxies bridge the gap between local 'quiescent' star forming discs and more active disc galaxies at high-z. We have used the new gas mass estimates to piece together the evolution of the molecular gas fraction of star-forming galaxies since $z \sim 2$. The CO ($J = 1 \rightarrow 0$) luminosities imply that the disks still contain a large reservoir of molecular gas, contributing $\sim$20% of the baryonic mass, but have star-formation 'efficiencies' similar to the local gas poor quiescent disks *and* gas-dominated disks at $z \sim 1.5$–2. We reveal evidence that the average molecular gas fraction has undergone strong evolution since $z \sim 2$, with $f_{\rm gas} \propto (1+z)^{\sim 2 \pm 0.5}$. We show that the latest predictions for the evolution of the molecular gas fraction in semi-analytic models of galaxy formation within a ΛCDM Universe are supported by these new data, and discuss how the observations fit into our overall picture of gas accretion / depletion in galaxies over cosmic time.

Notes

Cosmic evolution of star formation and the gas content of galaxies

Miss Claudia Lagos | Durham University
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Abstract

We investigate the star formation and the gas content of galaxies by splitting the interstellar medium into its atomic and molecular hydrogen components, using the galaxy formation model GALFORM in the CDM framework. We calculate the ratio of molecular to atomic hydrogen, H2/HI, in each galaxy self-consistently and calculate the star formation rate based on the H2 content. We are able to predict the HI mass function, the CO(1-0) luminosity function, the correlations between H2/HI and stellar and cold gas mass, and the far-infrared-CO luminosity relation, which are in good agreement with local and high redshift observations. We also predict the HI and H2 mass functions up to z=8 and find that these are characterised by radically different evolution: for HI the number density of massive objects decreases slowly with increasing redshift, while for H2 the maximum number density of massive objects is reached at $z \sim 2$. We also find that the ratio H2/HI is strongly dependent on stellar and cold gas mass, and also on redshift. The predicted cosmic density evolution of HI agrees with the observed evolution inferred from damped-Lyα systems, and is always dominated by the HI content of low and intermediate mass halos. We predict that the star formation rate vs. stellar mass plane should have two sequences of "active" and "passive" galaxies, in agreement with local observations, and show that the evolution of this plane offers a means to constrain the SF law.

Notes

The role of the cluster environment on the star formation cycle of galaxies

Dr Luca Cortese | European Southern Observatory
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Abstract

Even though it has been known for decades that the properties of galaxies are tightly linked to the environment they inhabit, we still miss a coherent picture about the role played by the cluster environment on galaxy evolution. Until very recently, one of the main problems has been the lack of information about the properties of the different baryonic components (e.g., gas, stars, dust and metals) taking part in the star formation cycle of galaxies and their variation with local density. Now, wide-area multi-wavelength surveys are finally under way, making it possible to investigate separately the effects of the environment on the different constituents of galaxies. In this talk, I will combine new multiwavelength data (e.g., GALEX-UV, SDSS-optical, Arecibo-HI, Herschel-FIR/submm) for the Herschel Reference Survey, a volume-, magnitude-limited sample of nearby galaxies in different environments, to investigate how the star formation cycle changes from high to low density regions. I will explore how the cold gas, dust and metal content and star formation activity of galaxies vary when moving from the field to the center of Virgo and discuss the implications of these results for galaxy evolution models.

Notes

Exploring Star Formation in Clusters with the Herschel Space Observatory

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Abstract

Nominally designed to locate high-redshift galaxies magnified by 44 massive foreground clusters, the "Herschel Lensing Survey" (HLS; PI: Egami) also provides deep 5-band, far-infrared (FIR) imaging of the galaxies contained within those clusters. For sources at these redshifts ($z \sim 0.2 - 0.4$), Herschel photometry spans the peak of the dust component, allowing us to constrain the dust properties, measure total infrared luminosity and hence derive obscured star formation rate. Although a large fraction of galaxies in massive clusters are quiescent early-types and therefore remain undetected by Herschel, the far-infrared highlights regions of activity within the system. The FIR effectively probes the transitional phases of cluster galaxy evolution, exposing starburst mechanisms such as tidal interactions and mergers, as well as the remnants of the as-yet un-quenched in-fall population. Here we focus on two particular, contrasting clusters at $z \sim 0.3$: the famous merging system known as the Bullet Cluster, and a relatively undisturbed cluster MS2137. We locate the FIR-bright cluster members and characterize their dust component, allowing us to study the distribution of star formation in the two systems as a function of morphology and local environment. In addition, we investigate an intriguing subpopulation of FIR-luminous galaxies with dust component SEDs that do not conform to the templates derived from local field galaxies, yet are also unlike any sources observed at higher redshift.

Notes

Galaxy Formation, Durham, Tuesday, 19th July 2011

Star Formation in Galaxy Clusters Over the Past 10 Billion Years

Prof Kim-Vy Tran | Texas A&M University
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Abstract

Understanding how galaxies form and evolve in clusters continues to be a key question in astronomy. The ages and assembly histories of galaxies in rich clusters constrains both stellar population models and hierarchical formation scenarios. Is star formation in cluster galaxies simply accelerated relative to their counterparts in the lower density field, or do cluster galaxies assemble their stars in a fundamentally different manner? To answer this question, I summarize results on 1) star-forming members and active galactic nuclei from our Spitzer/MIPS Infra-Red Cluster Survey at ($0 < z < 1$) and 2) the astoundingly high star formation rates and reversal of the star-formation density relation discovered in the core of one of the most distant galaxy clusters known at a look-back time of nearly 10 billion years ($z = 1.62$).

Notes

Caught in the Act - The Assembly of Massive Cluster Galaxies at $z = 1.62$

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Abstract

The assembly of the most massive galaxies in the universe is a classic problem for galaxy formation models. Current hierarchical galaxy formation models invoke late assembly times for very massive galaxies via the merger of smaller galaxies that formed the bulk of their stars at $z > 2$. However, the observations of massive cluster galaxies at $z < 1$ are not entirely consistent with this picture. The best way to disentangle the merger and star-formation histories is to study the progenitors of massive galaxies at $z > 1.5$ in over-dense regions – i.e. at the time and place of intense star-formation and merger activity. We present the recent merger history of massive galaxies in a spectroscopically-confirmed proto-cluster at $z = 1.62$. Using HST WFC3 near-infrared imaging from the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS), we find that the merger rate of the massive proto-cluster galaxies is 5-10 times higher than the merger rate of massive field galaxies at $z \sim 1.6$. Half of these mergers are dissipationless, as indicated by their red rest-frame optical colors and low 24 micron and UV emission. We discuss the implications for massive galaxy assembly in proto-cluster environments.

Notes

Oral Programme Abstracts

Wednesday, 20th July 2011

SPH simulations of the formation of individual galaxies

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Abstract

The formation of realistic galaxies in the Cold Dark Matter model has been a major open problem of cosmology and astrophysics for nearly two decades. A combination of increased resolution in simulations and improved sub-grid recipes of star formation and feedback processes has allowed to produce disk galaxies with realistic sizes in the past few years, with either SPH or AMR grid based codes, alleviating the angular momentum "catastrophe". However, until now all these simulations were still suffering from other issues, notably an excesse of low angular momentum material in the center, resulting in bulge-to-disk ratios much higher than those of typical spirals, and an excesse stellar mass rendering simulated galaxies inconsistent with several observational constraints.

In this talk I will show how a major step forward is made once stars are formed at densities comparable to those of the actual star forming gas phase in the ISM, namely molecular clouds. This can be achieved with sufficient hydrodynamical resolution to resolve at least the giant molecular complexes. In this new regime an inhomegenous ISM naturally arises, star formation becomes more clustered and supernovae explosions become an order of magnitude more efficent in heating the surrounding gas, driving spontaneously outflows without ad hoc momentum deposition. As a result, galaxies with realistic structural properties, from low mass dwarfs the size of the LMC with slowly rising rotation curves to late-type spirals akin to the Milky Way, can be finally produced within the CDM model, without fine tuning of parameters in sub-grid recipes. In addition, these galaxies do not suffer from an excesse stellar mass. Comparisons with galaxies in the THINGS survey shows remarkable agreement. I will also discuss past and new preliminary results concerning the formation of massive ellipticals and SO galaxies in the same framework and conclude with outlining a new model for the formation of supermassive black holes in massive galaxies. In the latter model black hole seeds with masses $> 10^5 M_\odot$ form from direct collapse of supermassive gas clouds assembled on very short timescales ($< 10^6$ yr) at the center of gas-rich major mergers at $z < 10$.

Notes

The middle ages of galaxy evolution ($z = 2$-3)

Prof Dr Reinhard Genzel | Max Planck Institute for Extraterrestrial Physics
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Notes

Atomic and molecular gas in galaxies

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Notes

Connecting Galaxies to Dark Matter Halos: HOD, CLF, SHAM, and All That

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Abstract

Twenty-first century galaxy surveys inspired an array of new interpretive methods that connect the observed distribution functions and clustering of galaxies to the theoretically predicted population of dark matter halos in which they reside. The key assumption of these modeling techniques — commonly acronymed as HOD (halo occupation distribution), CLF (conditional luminosity function), and SHAM (subhalo abundance matching) — is that the average galaxy content of a dark matter halo depends on its mass but has no direct knowledge of the halo's larger scale environment. Some of the key insights to emerge from applying these methods to observations are: (a) that galaxies form with maximum efficiency in halos of mass $M \sim 10^{12} M_\odot$ over a wide range of redshift, (b) that the observed luminosity dependence of galaxy clustering is driven primarily by the increase of central galaxy luminosity with halo mass, (c) that the color dependence of clustering is driven primarily by the large fraction of red galaxies that are satellites in massive halos, (d) that the luminosity-halo mass relation has large scatter at the high end, (e) that there is a factor $\sim 10 - 20$ gap between the minimum halo mass required to host a central galaxy and the halo mass needed to host a satellite of the same luminosity, and (f) that the central galaxies of $10^{11} - 10^{12} M_\odot$ halos are similar in high density environments and in large scale voids. HOD models naturally explain observed features of the galaxy correlation function, pairwise velocity dispersion, and void probability distribution. They also allow new cosmological tests by providing a flexible model of non-linear galaxy bias whose parameters can be marginalized over when fitting observations. These approaches provided early evidence for a downward revision of Ω_m and σ_8 relative to WMAP1 values, and they are now enabling precise new constraints on these parameters. Frontiers of the subject include accurate modeling of redshift-space distortions and galaxy-galaxy lensing and probing the environmental dependence of halo occupations. Environmental dependence is a source of systematic uncertainty for cosmological analyses, but it is also a source of potentially powerful insights into galaxy formation physics.

Notes

Supermassive black holes and mechanical feedback

Prof Brian McNamara | University of Waterloo
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Abstract

Recent X-ray and radio observations have shown that cooling hot atmospheres in clusters and giant elliptical galaxies are being quenched by mechanical heating by outflows associated with nuclear radio jets. This so-called "radio mode" feedback was discovered when high resolution X-ray observations revealed giant cavities in the central cooling regions of the hot atmospheres of dozens of galaxy clusters. While largely devoid of thermal gas, the cavities are filled with radio synchrotron emission emanating from the nuclei of BCGs. The mechanical power released by radio AGN, estimated through the pV work required to inflate them against the surrounding atmospheric pressure, is generally a few hundred times larger than the radio synchrotron power. This is enough power to suppress radiative cooling and to regulate star formation, apparently through a finely-tuned feedback loop. I will present evidence from the far UV to the far IR for star formation in brightest cluster galaxies. I will show that star formation is triggered when the central cooling time of the hot atmosphere falls below $\sim$0.5 Gyr, directly linking cooling atmospheres to star formation. Furthermore, the molecular gas masses in many BCGs exceed 10^{10} solar masses. No known population of galaxies exists in clusters that could have donated molecular gas at these levels. I will discuss the evidence favouring and against fuelling AGN though cold molecular accretion and Bondi accretion from the hot atmosphere, and I will briefly touch on the role of black hole spin in powering AGN. I will present new evidence showing AGN outflows dispersing metal-enriched gas throughout the ICM.

Notes

The intracluster/intragroup medium

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Abstract

Traditionally, studies of galaxy formation have focused on the observable stellar properties of galaxies. However, a large fraction of the baryonic mass of normal and massive galaxies is believed to be in a hot diffuse form and many of the processes that regulate the formation of stars do so by influencing the properties of this hot gas. Thus, a complete view of galaxy formation necessarily incorporates both the stars and the hot gas and an understanding of the processes by which these phases interact. At present, galaxy groups and clusters represent the only systems in the universe for which it is possible to measure the properties of both the stellar and gaseous baryonic (i.e., the intragroup/intracluster medium) components out to a significant fraction of the halo viral radius.

In this talk I will review what has been (and potentially can be) learnt about galaxy formation from detailed studies of the thermodynamic and chemical properties of the intracluster medium. In particular, I will discuss what the overall content and distribution of the hot gas as a function of system mass tells us about the efficiency of feedback processes in normal and massive galaxies at the present-day and in the past. I will also discuss what the metallicity and abundance patterns of the gas can tell us about feedback and the efficiency of environmental processes such as tidal stripping and strangulation.

Notes

Structure, dynamics and stellar populations in early-type galaxies

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Abstract

The Fundamental Plane relates dynamical and structural properties of early-type galaxies, but differences in age and metallicity cause scatter about the plane. However such stellar population variation also reveal information about the way that early-type galaxies form and evolve. We obtained the Fundamental Plane for a sample of 10,000 galaxies from the 6dF Galaxy Survey, and for 7,000 of these galaxies we also derived age, metallicity and alpha-element over-abundance from a Lick index analysis. We then measured the trends of these stellar population parameters with size, surface brightness and velocity dispersion, and also with the principal components of the Fundamental Plane. In contrast to previous work, we find stellar population trends not just with velocity dispersion and the residuals about the Fundamental Plane, but also with radius and surface brightness. The most remarkable finding is that, although the stellar population parameters vary through and across the plane, they show no variation at all along the long axis of the plane, roughly corresponding to luminosity density. A galaxy's position along this axis is closely related to its merger history, with early-type galaxies with lower luminosity density more likely to have undergone major mergers.

Notes

The stellar angular momentum of nearby early-type galaxies: a paradigm shift

Prof Eric Emsellem | ESO
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Abstract

We provide a census of the apparent stellar angular momentum of all 260 early-type galaxies (ETGs) within the volume-limited Atlas3D sample, thus revealing the distributions and properties of the Fast and Slow Rotators. We show that the vast majority (86%) of ETGs are Fast Rotators with regular rotation, and spread over a large range of flattening, while Slow Rotators only represent about 14% of these ETGs, are rather round (E4 or rounder) with most of them having Kinematically Distinct Cores. In this context, we probe various parameters. including the mass trend within the red sequence of galaxies associated with these two families of galaxies. We further show how the E and S0 classification may be misleading. We propose a revision of the tuning-fork diagram to better represent the large variation in bulge sizes of fast rotators. We then find that such a classification leads to a log-linear clean morphology-density relation holding for nearly four orders of magnitude in surface density. We discuss the impact of such results on our understanding of the processes involved in the shaping of galactic systems.

Notes

A new look at galaxy scaling relations

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Abstract

Galaxies satisfy tight scaling relations (e.g. Faber-Jackson, Tully-Fisher, Kormendy relation, Fundamental Plane) between global observables like luminosity, size and kinematics. The physical interpretation of the relations, and their comparison to models of galaxy formation, has for long been complicated by the fact that (i) either only luminosities and not masses are observed or (ii) the samples are too small and biased for statistical studies. Here we illustrate the power of removing both complications, by deriving masses for the volume-limited Atlas3D sample of 260 nearby early-type galaxies. We discuss the consequences of our findings for the interpretation of local and high-redshift galaxy scaling relations and for galaxy formation models.

Notes

Quantifying mass substructure in early-type galaxies

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Abstract

The cold dark matter (CDM) paradigm predicts that a significant number of substructures, with a steeply rising mass function towards lower masses, populates the dark halo of galaxies. In the Milky Way, however, of order 10^4 substructures are predicted inside the virial radius, whereas only few tens have been so far observed. This poses a major challenge to the CDM paradigm. New and independent methods are, therefore, required to assess the level of mass substructure in galaxies in the Local Universe and beyond. One such method will be discussed in this talk, which consists of three parts. First, I will discuss a novel method, based on strong gravitational lensing, to uniquely address this problem, allowing us to probe substructure beyond the local Universe and in massive early-type galaxies. I will briefly present a fully Bayesian adaptive-grid method, that uses all the information contained in the surface brightness distribution of highly magnified Einstein rings and arcs, to detect and precisely quantify mass substructure in single lens galaxies, even in case of very high mass-to-light ratios. Second, I will discuss how to combine, in a statistical sense, the detections of mass substructures from multiple lens galaxies to constrain the substructure mass fraction and the slope of the mass function. Third, I will present new results on the level of mass substructure in the sample of SLACS lenses, as well a several other systems, and discuss possible implications for galaxy formation models. If time is left, I will discuss possible future applications of the method.

Notes

The rise and fall of disks in cosmological simulations

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Abstract

Understanding the origin of galaxy morphologies is one of the leading challenges of galaxy formation studies. Although the main morphological components (disks, spheroids) of galaxies seem to be present at all redshifts surveyed so far by observation, it has become apparent over the past decade that the available data point to a scenario where the morphology of individual galaxies evolves continuously. We use the suite of high resolution hydrodynamical simulations GIMIC to study the assembly of disks at high redshifts and their posterior evolution onto $z = 0$ galaxies. We find that the existance of extended disks galaxies as early as redshift $z \sim 3 - 2$ is naturally reproduced in the LCDM, albeit not the norm. The representative volumes simulated in GIMIC provide then an avenue to track down the properties of the present day descendants of such early disks in the Local Universe. Our results suggest that low to moderate mass groups are the current habitat of the extended disk population at $z \sim 2$ and characterize the morphological changes undergone by these extreme objects.

Notes

Spiral Galaxy Formation based on Detailed Spectroscopic Studies

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Abstract

I discuss current notions of spiral galaxy formation based on detailed studies of the stellar populations (SPs) and kinematics of galaxy bulges and disks. Current studies show that the SPs of spiral galaxies are not well matched by single episodes of star formation, thus representative SPs must involve average SP values integrated over the star formation history of the galaxy. Spiral bulges follow the same correlations of increasing light-weighted age and metallicity with central velocity dispersion as those of elliptical galaxies. In a mass-weighted context, bulges are predominantly composed of old and metal-rich SPs. Bulge formation appears to be dominated by early processes that are common to all spheroids, whether they currently reside in disks or not. While monolithic collapse cannot be ruled out in some cases, merging must be invoked to explain the SP gradients in most bulges. Further bulge growth via secular processes, or "rejuvenated" star formation, generally contributes minimally to the stellar mass budget. I also demonstrate how the combination of full population synthesis modeling of high-quality optical spectra of integrated SPs along with optical-NIR imaging can single out model weaknesses and help determine the reliability of the inferred SFHs.

Notes

The Assembly History of Disk Galaxies: Evolution in the Tully-Fisher Relation to $z \sim 1.3$

Ms Sarah Miller | University of Oxford/Caltech
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Abstract

We present new measures of the evolving scaling relations between stellar mass, rotational velocity, magnitude, and baryonic mass estimates for a morphologically inclusive sample of 129 disk-like galaxies ($0.2 < z < 1.3$), based on Keck DEIMOS spectra, multi-color HST ACS imaging, and ground-based Ks-band photometry. A unique feature of our survey is the extended spectroscopic integration times, which has led to significant improvements in determining characteristic rotational velocities for each galaxy and a rigorous appraisal of their accuracy. Rotation curves are reliably traced to the radius where they flatten for $\sim$90% of our sample, and we model the HST resolved bulge and disk components of each galaxy in order to de-project measured velocities while accounting for emission asymmetry, seeing, dispersion and slit effects. We demonstrate the merit of these advances by recovering an intrinsic scatter on the Tully-Fisher relations of a factor 2 - 3 less than in previous studies at intermediate redshift, comparable to that of locally determined relations. With this increased precision, we show evidence for modest evolution in the stellar mass Tully-Fisher relation at a growth rate in agreement with recent hydrodynamical and semi-analytic predictions. Greater evolution is seen in the B-band magnitude Tully-Fisher relation consistent with a decline in disk luminosity of at fixed velocity over the same redshift interval. We use our data to evaluate the likely contributions of baryons and dark matter within various disk radii to gain a better understanding of the observed evolution. When accounting for the resolved bulge and disk components of each galaxy, we observe a striking maturation trend within our sample and the likely driving force behind our tightly constrained evolution of the Tully-Fisher relation and assembly history of disk galaxies.

Notes

The Majority of Compact Massive Galaxies at $z \sim 2$ are Disk Dominated

Dr Arjen van der Wel | Max Planck Institute for Astronomy
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Abstract

Over the past few years, it has become clear that massive, quiescent galaxies at $z \sim 2$ are generally much smaller and denser than they are today. Based on HST/WFC3 imaging we now present strong evidence that such galaxies are mostly disk-dominated. This result is foremost based on the simple observation that a significant fraction (about $1/3$) is flat in projection. Viewing angle statistics immediately imply that it is likely that the majority is disk-like, which is further corroborated by two-dimensional surface-brightness fits. The immediate implication is that the majority of stars formed from gas that had time to settle into a disk. These dense, disk-like systems are the progenitors of massive, bulge-dominated galaxies today. Hence, it is likely that all massive galaxies, including their present-day bulges, first form as disks. Subsequent evolution, driven by relatively gas-poor merging, can destroy thin disks and cause the galaxies to gradually grow in size and, to lesser extent, in mass.

Notes

Oral Programme Abstracts

Thursday, 21st July 2011

Gas Outflow and Inflow in $z < 1.5$ Galaxies

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Abstract

Using new, deep spectra, we measure the near-ultraviolet spectral features of of ∼250 galaxies. Analysis of the interstellar absorption lines quantifies the fraction of galaxies over the redshift range $0.6 < z < 1.5$ with outflows (and inflows) of low-ionization gas. And we discuss the correlation of outflow speed and strength with galaxy properties. We also describe the prevalence of both scattered emission and fluorescent emission from these galaxies and discuss the physical conditions that give rise to it. If time permits, I will also discuss nebular emission-line diagnostics of galactic outflows – a technique that could enable large surveys for outflows across much of cosmic time with JWST.

Notes

Gas-phase Outflows and Accretion During the Peak Epoch of Galaxy Formation

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Abstract

During the peak epoch of galaxy formation, the intergalactic medium is both the source of gas responsible for fueling star formation, as well as the waste dump for the products of star formation and black hole accretion that are not retained by galaxies. The exchange of baryons between forming galaxies and their "Circum-Galactic Medium" (regions within $\sim$1 co-moving Mpc ($\sim$300 physical kpc at z $\sim$2–3)) is a crucial, but poorly understood, aspect of the galaxy formation process. By applying a combination of faint galaxy surveys and absorption line studies (using background galaxies in addition to the more traditional QSO sightlines) to the same survey volumes, a picture of the galaxy/IGM system is emerging. I will present an overview of recent observations and their implications for understanding the influence of baryonic flows (both in- and -out) on forming galaxies and and on the physics and chemistry of the CGM/IGM at $z > 2$. At present, there exist puzzling discrepancies between observations and theoretical expectations whose resolution may be key to advancing our understanding of the behavior and distribution of baryonic material over cosmic time.

Notes

The IGM-galaxy connection

Prof Xavier Prochaska | UCO/Lick Observatory
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Abstract

I will review observations on the relationship between the intergalactic medium (IGM) and galaxies, with particular emphasis on low redshift. This includes new results from the Cosmic Origins Spectrometer on the HST. I will also explore the evolution (or lack thereof) of the galaxy-IGM connection with redshift.

Notes

The metal enrichment of the intergalactic medium

Prof Rameel Davé | University of Arizona
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Abstract

I will discuss observations and theoretical insights into the chemical enrichment of diffuse intergalactic gas across cosmic time. Observations of CIV and other metal absorption at high redshifts suggest that strong and ubiquitous galactic outflows have distributed metals over a significant volume of the universe at early epochs. Outflows that eject more material from small, early galaxies are generally more successful at matching observations. Outflows observed in redshifts 2–4 galaxies are capable of providing sufficient IGM enrichment without any contribution from very early non-standard sources. Evolution to lower redshifts is characterized by a general migration of metals back towards galaxies. New HST/COS observations show that star-forming galaxy halos have an oxygen content exceeding that of the galaxy's ISM, with velocities below the halo escape velocity, suggesting that "halo fountains" are common today. Such reaccretion of ejected material may represent a substantial component of infall into star-forming galaxies today.

Notes

A unified model of galaxy evolution in the IR and UV

Dr Cedric Lacey | Durham University
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Abstract

A key goal of theoretical models of galaxy formation is to understand the history of star formation in the universe. This requires models that, as well as incorporating all of the physics of dark matter halo assembly, gas cooling, star formation, feedback etc, can also be compared directly to observational data on different star formation tracers (UV, optical, IR/sub-mm, radio). Since each star formation tracer offers only a partial view and has important uncertainties, it is essential to have a theoretical approach that allows a unified comparison with all of these tracers. I will describe results from such a unified approach, which combines a sophisticated model of galaxy formation in the framework of structure formation of CDM with a radiative transfer model for the emission from stars and dust in galaxies, and predicts SEDs spanning UV, optical, IR, sub-mm and radio wavelengths. I will focus in this talk on what we have learned about galaxy evolution from detailed comparisons of the combined model with far-IR data from Herschel at redshifts $z = 0$–3, and from observations of Lyman-break galaxies in the rest-frame UV at $z = 3$–10. I will discuss how these new comparisons test our ideas about star formation and feedback, and whether they support the idea of a top-heavy IMF in starbursts, which was previously proposed in order to explain the observed sub-mm galaxy population.

Notes

What's causing the drop in the cosmic star formation rate below redshift 2?

Ms Freeke van de Voort | Leiden Observatory
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Abstract

The cosmic star formation rate is observed to drop sharply after redshift $z = 2$. Using large, cosmological simulations, I will discuss how this decline is related to the evolution of gas accretion and to outflows driven by active galactic nuclei (AGN). When gas accretes along filaments of the cosmic web, it is generally relatively dense, cold, metal-poor, and flowing towards the central galaxy quickly (cold mode). More diffuse gas shock heats at the virial radius to the virial temperature and its cooling time is long for massive haloes (hot mode). By the present time, the hot mode strongly dominates the global accretion rate onto haloes. Star formation does not track hot-mode halo accretion, nor does it track total halo accretion, because most of the hot halo gas never reaches the central galaxies. The drop in the star formation rate follows a corresponding decline in the global cold-mode accretion rate density onto haloes, but with a delay. I will show that AGN feedback plays a crucial role by preferentially preventing gas that entered haloes in the hot mode from accreting onto their central galaxies. Consequently, in the absence of AGN feedback, gas accreted in the hot mode would become the dominant source of fuel for star formation and the drop off in the cosmic star formation rate would be much less steep.

Notes

The Millennium Gas Simulation

Prof Peter Thomas | University of Sussex
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Abstract

We present results from a hydrodynamical version of the Millennium Simulation with energy injection from supernovae and AGN. Subgrid physics is handled using the latest version of the L-Galaxies semi-analytic model. This, the largest SPH simulation to-date, is able to resolve halos of virial temperature 1 keV and above with at least 15,000 gas particles within R500, with the largest clusters having in excess of 500,000 paricles. For the first time, we are able to match both the galactic population in clusters, and the entropy and metallicity profiles of the X-ray gas. A physical model for AGN energy injection based on jet heating is crucial for this success. With the addition of radiative cooling, we are able to reproduce both X-ray cool-core and non-cool-core clusters, without over-cooling of gas in cluster cores.

Notes

A detailed study of infrared-luminous galaxies at high redshift

Dr Julie Wardlow | University of California, Irvine
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Abstract

We select a sample of $\sim$ 30 gravitationally lensed infrared galaxies in *Herschel* SPIRE catalogs of three independent wide-area HerMES fields. Thanks to the boost from gravitational lensing, these galaxies have extremely high fluxes, which enables us to perform extensive follow-up observations. Our suite of follow-up data includes spectroscopic CO-line redshifts and high-resolution submillimeter, optical and near-infrared imaging for a significant fraction of the sample. Using these data we present a thorough investigation of the observed and intrinsic properties of the lensed SMGs. Comparisons with other populations of high-redshift galaxies, particularly intrinsically bright submillimeter-selected sources, provides an insight into the physical differences of the populations.

Notes

MAHALO-Subaru: Mapping Star-Formation at the Peak Epoch of Galaxy Formation

Dr Tadayuki Kodama | National Astronomical Observatory of Japan
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Abstract

MAHALO-Subaru (MApping HAlpha and Lines of Oxygen) is an on-going Subaru intensive programme which aims to investigate how the star forming activities in galaxies are propagated as a function of time, mass, and environment (cluster cores, cluster outskirts, groups, and the general field). We are targeting 13 clusters and proto-clusters at $0.4 < z < 2.5$ (of which 8 are located at $z > 1.5$), and two general fields (GOODS-N and SXDF) with Suprime-Cam and MOIRCS and their unique sets of narrow-band filters (many of them are custom-made for this particular purpose). The narrow-band imaging can map out star forming galaxies with the redshifted Hα and [OII] emission lines from our targets. These targets will be (have been) extensively followed-up by NIR spectroscopy with FMOS and MOIRCS to quantify the nature of these emitters such as dust-corrected star formation rates, AGN contribution and gaseous metallicities. This project will serve excellent targets for ALMA as well. In this presentation, I will give an introduction of this programme, and some highlights of our results obtained so far. The individual studies will be presented by Hayashi, Koyama, Tadaki, and I. Tanaka.

Notes

Turbulence and star-formation - chicken or egg?

Prof Karl Glazebrook | Swinburne University
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Abstract

Observations of the high-redshift Universe have suggested a picture of massive star-formation in gas-rich, turbulent disks that are energised and fed by cosmic cold flows. However recent IFS data taken at lower-redshift have raised questions about this picture. We have found turbulent disk galaxies in the SDSS catalog, a population previously thought extinct in the modern Universe. Despite their turbulence they kinematically resemble disks, and fall on a regular Tully-Fisher relation. New Keck AO assisted observations of these galaxies have revealed they also contain giant star-forming clumps up to 1-2 kpc in size strengthening their similarity with their high-redshift counterparts. Across all redshifts the strongest correlations of turbulence is with star-formation rate, and not disk stellar nor gas masses. The detailed mapping of the location of star-formation and turbulent gas within galaxies is very suggestive of a direct feedback of star-formation driving the kinematics of the gas rather than the other way around. More detailed and higher SNR AO mapping at high-redshift is needed to see whether the turbulence is a fundamental driver of disk formation or a natural consequence.

Notes

The growth of galaxies at z $\sim$ 2: Insights from resolved kinematics, morphologies, star formation, and metallicities.

Dr Natascha M. Forster Schreiber | Max-Planck-Institut fur extraterrestrische Physik
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Abstract

Key insights on z$\sim$2 galaxies are gained from studies of the spatially-resolved dynamics, star formation, and physical properties from near-IR integral field spectroscopy, with instruments such as SINFONI at the VLT. Together with morphologies from high-resolution mapping of the stellar component of galaxies, this provides a powerful combination to study in-situ the mechanisms driving the build-up of massive galaxies. I will present recent results from "SINS", the largest survey with full 2D mapping of Halpha kinematics and distribution with SINFONI, for now over 100 galaxies probing the massive star-forming population at z$\sim$2. The survey is complemented with detailed rest-frame optical morphologies and resolved metallicities. I will discuss the implications of key results on some of the most fundamental open issues concerning the formation of massive spheroids and disks, including the role of disk instabilities and minor/major merger events in the formation of bulges.

Notes

3D-HST: a large spectroscopic survey of the z =1-3 Universe with HST

Prof Pieter van Dokkum | Yale
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Abstract

I will describe the 3D-HST survey, a 2484-orbit HST Treasury program. The program uses the WFC3 grism, providing redshifts and stellar population diagnostics for 1000s of galaxies at high redshift. The talk will cover what we have recently learned from ground- and space-based near-IR spectroscopy at z =1-3, what we can expect from 3D-HST, and show some first results from WFC3 spectroscopy and imaging of distant galaxies.

Notes

AMAZE and LSD: Metallicity Evolution of Galaxies in the Early Universe

Dr Giovanni Cresci | INAF
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Abstract

The metal content in galaxies provides important information on the physical processes responsible for galaxy formation, but little was known for galaxies at $z > 3$, when the Universe was less than 15% of its current age. We report on our metallicity survey of galaxies at $z > 3$ using near-IR spectroscopy with SINFONI at VLT and LUCIFER at LBT. We find that at $z > 3$, low-mass galaxies obey the same fundamental relation between metallicity, mass and star formation rate as at $0 < z < 2.5$; however, at $z > 3$ massive galaxies deviate from this relation, being more metal-poor. In some of these massive galaxies we can even map the gas metallicity. We find that three galaxies at $z > 3.3$ have regular rotation, though highly turbulent, and inverted abundance gradients relative to local galaxies, with lower abundances near the centre, close to the most active regions of star formation. Overall the results suggest that prominent inflow of pristine gas is responsible for the strong chemical evolution observed in galaxies at $z > 3$.

Notes

Mapping the circumgalactic medium of high-redshift galaxies

Ms Gwen Rudie | Caltech
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Abstract

We present the analysis of a unique spectroscopic survey of 732 $<z> \sim 2.3$ star-forming galaxies and their accompanying UV absorption seen in high-resolution spectra of 15 ultra-bright $<z> \sim 2.7$ quasars. Through the use of absorption systems, we can determine the impact of star-forming galaxies on their local intergalactic medium (IGM) out to much larger distances than can be probed with direct observations. Our rest-frame UV spectroscopic survey includes galaxies within a few arcminutes ($\sim$2 physical Mpc) of the line of sight to a background quasar. The Lyman alpha forests in the QSO spectra have been carefully analyzed and we will soon begin analysis on metallic lines in the same spectra. Spectral regions of the forest near the redshift of the foreground galaxy are examined to measure the kinematics and column density of neutral hydrogen present around forming galaxies at various transverse distances. We find that the HI column density and the number of associated HI systems increase rapidly with decreasing galactocentric impact parameter and as the systemic velocity of the galaxy is approached. These measurements, combined with an upcoming NIR spectroscopic observing campaign to characterize the rest-frame optical properties of these galaxies will allow for the first glimpses of the co-evolution of galaxies and the IGM, the nature of inflows, galactic outflows, and the effect of star formation on both the IGM and on the future of the galaxy itself.

Notes

Probing galactic winds from DLA/LLS host galaxies with spatially extended Lyman-alpha emission

Dr Martin Haehnelt | University of Cambridge
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Abstract

Deep spectroscopic and narrow-band observations suggest the presence of spatially extended low surface brightness Lyman-alpha emission around most DLA/LLS host galaxies. I will discuss how the spectral shape and spatial distribution of this Lyman-alpha emission can be used as powerful diagnostic of the kinematics of the galactic winds in DLA/LLS host galaxies.

Notes

How Outflows *Feed* Galaxy Growth

Dr Benjamin Oppenheimer | Leiden Observatory
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Abstract

Galactic superwind outflows do many things. Cosmological simulations show they need to be invoked to solve the dual challenges of enriching the intergalactic medium while solving the over-cooling problem where too many baryons form into stars. I will talk about three central ways that outflows determine the growth of galaxies. First, highly mass-loaded outflows can severely suppress galaxy growth by *ejecting* far more gas out of a galaxy than forms into stars. Second, more energetic winds can significantly heat their circum-galactic medium *preventing* more gas from efficiently streaming onto galaxies. Finally, outflow materials ejected above the escape velocity of a halo more often than not re-accrete or *recycle* back onto a galaxy providing a significant and often dominant source of gas for subsequent star formation. Surprisingly, how *recycled wind accretion* grows galaxies is the greatest determinant of how the present-day galactic mass function appears. It also provides a challenge as this efficient channel of accretion needs to be quenched by a mass-dependent feedback mechanism, likely in the form of AGNs, but I will suggest other possibilities to *prevent* recycled winds from re-accreting that could largely solve the problem.

Notes

Caught in the Cosmic Web: Testing Theoretical Models of Giant Lyα Nebulae

Dr Moire Prescott | UC Santa Barbara
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Abstract

With powerful Lyα emission extending out to 100 kpc, overdense environments, and a close association with strong submillimeter and mid-infrared sources, giant Lyα nebulae offer a window into the dominant physical processes at work during episodes of massive galaxy formation and provide a direct probe of the gas within the cosmic web. Leveraging this potential relies first and foremost on understanding what is powering the Lyα emission. In the last few years, substantial progress has been made towards building a theoretical framework for studying Lyα nebulae. In this talk, I will present observations of the morphology, the energetics, and - for the first time - the line polarization of a typical Lyα nebula system and use them to test models of superwind outflows and cold flows. Despite the fact that these two physical phenomena are thought to play an important role in the accretion of gas onto galaxies and in the distribution of metals in the universe, we find robust discrepancies between the observed morphology, energetics, and polarization relative to what is predicted by outflow and cold flow simulations. Thus, while these processes are likely going on, photoionization by AGN or star formation appears to be the only viable mechanism for *powering* the Lyα emission in this system. In addition, using deep rest-frame UV/optical spectroscopy of the first known Lyα+HeII nebula, we are finally able to probe the kinematics of a giant Lyα nebula using the more robust optically thin HeII-1640 line and put meaningful constraints on the physical conditions (ionization state, density, and metallicity) within the line-emitting gas.

Notes

Theoretical and observational insight into the hot side of galaxy formation.

Dr Rob Crain | Swinburne University
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Abstract

I will discuss how developments in the gasdynamical modelling of galaxy formation have reconciled a perceived conflict between X-ray data and theoretical models based on hierarchical cosmogonies. This has motivated a review of the standard intepretation of X-ray observations of 'normal' L* galaxies. I show for the first time that disc and elliptical galaxies follow the same X-ray scaling relations (Lx-Lk, Lx-Tx), a result that is incompatible with the standard interpretation, whereby diffuse emission from disc galaxies is produced by starburst winds and that from ellipticals is assocated with mass loss from evolved stars. I present a simple alternative, in which the hot gas associated with both morphological types has a common origin, namely gas accreted from the IGM.

Notes

The origin of the X-ray halos of early-type galaxies

Dr Marc Sarzi | University of Hertfordshire
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Abstract

For a galaxy, the ability to sustain a corona of hot, X-ray emitting gas can be a key element determining its star-formation history. An halo of hot gas can indeed be an effective shield against the external acquisition of cold gas whereas stellar-mass loss material is quickly absorbed by such an hot medium. Since the discovery of such X-ray halos, the origin of the X-ray emission and the precise amount of hot gas around galaxies have been the matter of long debates, in particular when considering the rather loose correlation between the optical and X-ray luminosity of galaxies. This situation resulted from the limited ability to separate with earlier X-ray data the contribution from an active nucleus, the unresolved population of X-ray binaries and the X-ray emission from the intra-cluster medium, although the use of loosely defined optical data may have also contributed to such an impasse. By combining the homogeneously-derived photometric and kinematic measurements for the 260 early-type galaxies of the Atlas3D integral-field spectroscopic survey with both low- and high-spatial resolution X-ray measurements, we have shown that the ability to retain an halo of hot gas depends crucially on the dynamical structure and intrinsic flattening of a galaxy. Specifically, in the framework of the revised classification for early-type galaxies advanced by the SAURON survey, we found that: 1) Slow Rotators have hot-gas halos with X-ray luminosity and temperature values that are entirely consistent with what expected if the hot gas originates from stellar-mass loss material that is heated up at the kinetic temperature of the stars through shocks and collisions. 2) Fast Rotators have hot-gas halos with X-ray luminosities that always fall short of such a prediction, and the more so the lower their dynamical mass and the larger their intrinsic flattening and degree of rotation support.

Notes

Unravelling the properties of active galaxies in hierarchical cosmologies

Dr Nikolaos Fanidakis | Durham University
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Abstract

I will present a new theoretical model of the formation and evolution of active galactic nuclei (AGN). The calculation is embedded in the GALFORM semi-analytical model which simulates the formation and evolution of galaxies in a Lambda cold dark matter universe. Using this code I calculate the fundamental parameters (mass, spin and accretion rate) that describe the evolution of massive black holes (BHs) hosted at the galactic centres and make predictions for their disc luminosities. The model reproduces the observed optical, X-ray and bolometric luminosity functions of AGN up to $z \sim 6$.

The model also reproduces remarkably well the radio loudness of AGN, suggesting that the jet properties of an active galaxy is a natural consequence of the accretion rate and spin characterising its central BH. Based on this model, I make predictions for the clustering of quasars and radio galaxies and explore the statistical properties of dark matter haloes that host active galaxies.

Notes

Investigating the AGN - Merger Connection at $z \sim 2$ with CANDELS

Dr Dale Kocevski | University of California, Santa Cruz
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Abstract

Using high-resolution HST/WFC3 imaging in the J and H bands, we have examined the rest-frame optical morphologies and colors of X-ray selected AGN hosts at $z \sim 2$ for the first time. This imaging was taken as part of the Cosmic Assembly Near-IR Deep Extragalactic Legacy Survey (CANDELS), which aims to document the evolution of galaxies and black holes at $z > 1.5$. I will show that from visual classifications we have determined that AGN hosts do not exhibit merger or interaction signatures more often than non-active galaxies of similar mass at this redshift. We have also used Galfit to determine the morphological breakup of these galaxies and find that a high fraction of the AGN are located in disk-like systems. Our results suggest that the bulk of the X-ray luminous AGN population at $z \sim 2$ could not have been triggered by a major merger event in the recent past. I will compare the observed properties of the AGN hosts to what is predicted from semi-analytic cosmological models which incorporate a prescription for merger-triggered, self-regulated black hole growth and discuss the implications for AGN feedback models.

Notes

Black Hole Fueling and AGN Feedback

Dr Gregory Novak | Princeton University
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Abstract

We have performed axisymmetric hydrodynamic simulations black hole fueling and feedback in a massive galaxy. The effects of the central black hole on the temperature and momentum of galactic gas resulting from both radiative and mechanical feedback (in the form of a broad-line wind) are treated carefully using a detailed and physically well-motivated prescription. The simulations cover a range of length scales from $\sim$1 pc to $\sim$100 kpc. We carefully treat the forces on the gas due to dust opacity in the UV, optical, and IR bands from photons generated by both stars and the central AGN. We include a prescription for angular momentum transport, allowing us to consider galaxies with large specific angular momenta (disk galaxies) in the axisymmetric code. We consider the case of including steady cosmological infall of cold gas, as well as the case of the rapid removal of the angular momentum of a cold gas disk to mimic the effect of a galaxy merger. We find that the black hole accretion rate depends strongly on the inner radius of the simulation, implying that physical processes that operate on infalling gas between 1 and 100 pc have an important effect on the true black hole accretion rate and the resulting feedback processes.

Notes

Oral Programme Abstracts

Friday, 22nd July 2011

The Galaxy-AGN Connection in the Local Universe

Prof Timothy Heckman | Johns Hopkins University
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Abstract

I will review our understanding of the physical processes that connect supermassive black holes and their host galaxies. I will focus on the present-day universe where we have the most complete set of information. The local AGN population consists of two disjoint families. One is characterized by strong emission-lines and traces the relatively rapid growth of the population of lower-mass black holes in lower mass bulges. It is closely associated with star formation in the central few-kpc-scale region. Stars may be the source of both the fuel for the black hole and of the feedback that limits its growth. Galaxy mergers do not play a significant role. The second AGN family is characterized by radio jets powered by black holes with low radiant output and low growth rates. It comprises the most massive black holes in the most massive bulges. The fuel source is the cooling of the hot X-ray gas, and this process is likely to be limited (at least in part) by feedback from the radio jets and lobes. This feedback may also reduce the amount of star formation that would otherwise occur in such galaxies.

Notes

Active Galactic Nuclei in the Distant Galaxy Population

Prof David Alexander | Durham University
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Abstract

There is now significant evidence that Active Galactic Nuclei (AGNs) have had a significant role in the formation and evolution of galaxies. Theoretical models require energetic AGN outflows to terminate or regulate star formation in the most massive galaxies and the seminal discovery of a tight relationship between the mass of galaxy spheroids and their central black holes suggests that massive black holes grew in concert with the host galaxy. From a combination of deep X-ray, infrared, radio, and optical surveys we now know that the majority of the AGN activity in the Universe has occured at $z > 0.5$.

In this review I will discuss our current understanding of the role and impact of AGNs in the $z > 0.5$ galaxy population. The review will focus on the observational evidence gathered over the last decade from a suite of multi-wavelength facilitiesm with a primary focus on advances made from deep X-ray observations (which provide the most complete census of distant AGN activity to date). I will briefly discuss (1) the connection between AGN activity and star formation, (2) the role of enviroment in the triggering of AGN activity, (3) the growth rates of distant black holes, (4) the evidence for energetic outflows in the distant AGN population, and (5) current searches for the most heavily obscured AGNs and their properties.

Notes

The role of mergers and AGN in the form & evolution of the galaxy population

Dr Philip Hopkins | University of California, Berkeley
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Notes

The discovery of a luminous redshift 7.1 quasar

Dr Daniel Mortlock | Imperial College London
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Abstract

Quasars are powerful probes of the high-redshift Universe, although previously none were known beyond a redshift of $z > 6.5$ because they have been identified primarily in optical surveys. Using data from the UKIRT Infrared Deep Sky Survey (UKIDSS), it has been possible to search beyond this optical limit, resulting in the discovery of a new quasar at a redshift of $z = 7.085$. It hosts a $2 \times 10^9\ M_\odot$ black hole, the formation of which just 0.8 Gyr after the Big Bang places significant restrictions on the possible models of black hole growth. The small visible size of the ionized "near zone" around the quasar, combined with a Ly alpha transmission profile that is consistent with a damping wing, provide strong evidence that the neutral fraction of the inter-galactic medium around the quasar was $f_{\rm HI} > 0.1$.

Notes

The first stars and black holes

Prof Tom Abel | Stanford University
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Notes

The first galaxies

Dr Rychard Bouwens | Leiden University
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Abstract

One of the most exciting frontiers in cosmology today are the observations of very high-redshift galaxies. Such observations allow us to directly trace galaxy growth from early times and explore the likely role of galaxies in the reionization of the universe. Fortunately, this whole field has advanced very rapidly in the last few years. Not only have we been able to push galaxy searches out to redshifts as high as $z \sim 10$, but we have also been able to quantify galaxy growth from $z \sim 10$ to $z \sim 4$ through studies of the luminosity function, stellar masses, and specific star formation rate. Studies of faint $z \sim 7$ galaxies in fields like the Hubble Ultra Deep Field have allowed us to estimate the contribution of galaxies to reionization. In this presentation, I provide a brief overview of some of the most exciting new observational results.

Notes

From the First Stars to Dwarf Galaxies

Dr John Wise | Princeton University
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Abstract

The first stars and galaxies had a profound impact on the universe, leading to reionization and the chemical enrichment of the intergalactic medium. Here I present results from adaptive mesh refinement radiation hydrodynamics simulations that focus on the formation of the first galaxies with a self-consistent transition from massive metal-free stars to metal-enriched stars that populate the first galaxies. These results provide invaluable insight for interpreting the latest and future galaxy observations prior to reionization.

Notes

Galaxies at z = 6 - 10, and cosmic reionization

Prof James Dunlop | University of Edinburgh
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Abstract

I will present the latest results on the number density, star-formation histories, stellar masses and likely UV escape fractions from galaxies at z = 6 - 10, based the on the HST WFC3 imaging of both the Ultra Deep Fields, and the first CANDELS fields (UDS and GOODS-South). The presentation will include our latest results on stellar masses and specific star-fromation rates from McLure et al. (2011), an update on the controversy over the UV slopes of faint high-redshift galaxies (Dunlop et al. 2011), and new measurements of the galaxy UV luminosity function at z= 7 and z = 8, incorporating the first results from CANDELS and, possibly, from UltraVISTA at the very bright end. I will briefly discuss the implications of these results for models of galaxy formation, and for answering the question of whether the growing population of galaxies seen in the redshift range z = 10 - 6 reionized the Universe.

Notes

The Star Formation Histories of Distant Galaxies and Implications for Gas Accretion

Dr Casey Papovich | Texas A&M University
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Abstract

Distant galaxies show correlations between their current star-formation rates (SFRs) and stellar masses, implying that their star-formation histories (SFHs) are highly similar. Moreover, observations show that the UV luminosities and stellar masses grow from $z = 8$ to $z = 3$, implying that the SFRs increase with time. I will present an empirical study of the cosmologically averaged evolution in galaxies at $3 < z < 8$ selected at constant comoving number density, $n = 2 \times 10^{-4}$ Mpc^{-3}. This allows the study of the evolution of galaxies not possible using galaxies selected at constant stellar mass or SFR, quantities that evolve strongly in time. This analysis shows that the cosmologically averaged SFRs of these galaxies increase smoothly from $z = 8$ to 3 as $\Psi(t) \sim t^{\alpha}$ with $\alpha = 1.7 \pm 0.2$. This conflicts with assumptions that the SFR is either constant or declines exponentially in time. Furthermore, the stellar mass growth in these galaxies is consistent with this derived SFH. This provides evidence that the slope of the high-mass end of the IMF is approximately Salpeter unless the duty cycle of star formation is much less than unity. Assuming that these relations follow from gas accretion (or mergers) coupled with galaxy disk growth under the assumption that the SFR depends on the local gas surface density, then this predicts that gas fractions decrease from $z = 8$ to 3 as $f_{\rm gas} \sim (1+z)^{0.9}$ for galaxies with $n = 2 \times 10^{-4}$ Mpc^{-3}. At $z > 4$ the gas accretion rates are as fast and may even exceed the SFR: this is the "gas accretion epoch". At $z < 4$ the SFR overtakes the gas accretion rate, and at $z < 3$, galaxies with this number density depart from these relations implying that star formation and gas accretion are slowed.

Notes

The Herschel-GOODS View of the Build Up of SMBH and Galaxy Mass Since $z \sim 3$.

Dr James Mullaney | CEA-Saclay
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Abstract

There is now substantial evidence that the growth of supermassive black holes (BH) coincides with star-formation (SF) within their host galaxies. However, when and how the tight links between these processes were forged is still a matter of continued debate perpetuated by our lack of observational constraints in this field. Now, however, deep X-ray and infrared observations from e.g. Chandra, XMM, Spitzer and Herschel, are providing the first glimpses of the joint build up of BH and galaxy mass to $z \sim 3$. Recent results from these facilities are painting a picture of differential BH and galaxy growth, in which these links were predominantly forged in short periods of intense SF and AGN activity with more common, moderate levels of activity being largely unconnected. In light of this, I will present the latest results from the Herschel-GOODS survey which provide the clearest view of how AGN and SF activity have co-evolved since $z \sim 3$.

Notes

The Black-Hole Mass Scaling Relations of Active Galaxies: From the Local Universe out to a Lookback Time of 10 Gyrs

Dr Vardha Nicola Bennert | University of California Santa Barbara
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Abstract

Supermassive Black Holes (BHs) seem to be ubiquitous in the center of spheroids - elliptical galaxies and bulges of spirals. The tight empirical relations between the mass of the BH and the properties of the host-galaxy spheroid (stellar velocity dispersion sigma, luminosity L, and stellar mass M) discovered in the local Universe indicate a close connection between the growth of BHs and the formation and evolution of galaxies. To understand the origin of these scaling relations, I will present results from a unique three-fold approach. (i) From a sample of 100 Active Galactic Nuclei (AGNs) in the local Universe, we build a robust baseline of the BH mass scaling relations (MBH-sigma, MBH-L, MBH-M), combining spatially-resolved Keck spectroscopy with SDSS imaging. (ii) We study the evolution of the MBH-sigma and MBH-L relations out to a look-back time of 4-6 Gyrs using Keck spectra and HST images. (iii) We extend this study out to the pivotal cosmic time between the peak of AGN activity and the establishment of the present-day Hubble sequence, a look-back time of 8-10 Gyrs. We measure spheroid stellar masses using deep multi-color HST images from GOODS and determine the MBH-M relation. Our results from (i) indicate that AGNs follow the same scaling relations as inactive galaxies. From (ii-iii) we conclude that BH growth precedes bulge assembly. Combining results from (i-iii) allows us to test the hypothesis that evolution is driven by disks being transformed into bulges.

Notes

HST-WFC3/IR Reveals the $z \sim 2$ Universe: secular black hole growth and first glimpses of seed black holes

Dr Kevin Schawinski | Yale University
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Abstract

The peak epoch of both star formation and black hole accretion at $z \sim 2$ is now accessible in great detail due to the infrared capabilities of the Wide Field Camera 3. I will present recent results and describe ongoing efforts to characterize the rest-frame optical properties of AGN host galaxies in deep fields (CDF-N/S, COSMOS) with imaging and slitless spectroscopic data. Early results from WFC3/IR imaging data indicate that the morphological mix of $z \sim 2$ moderate-luminosity AGN host galaxies is very similar to that of the population at $z \sim 0$, while quasar-luminosity AGN reside on major, gas-rich mergers. Slitless spectroscopy of obscured AGN host galaxies reveal a diversity of recent star formation histories including indications of very recent quenching. I will discuss implications for co-evolution scenarios and the origin of the M-sigma relation.

Notes

Poster Programme Abstracts

Sunday, 17th July to Friday, 22nd July 2011

1.1 Understanding the Evolution of the Magellanic System: A Survey of the Ionized Gas in the Magellanic Bridge using WHAM

Mrs Kathleen Barger | University of Wisconsin-Madison
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Abstract

The Magellanic System exhibits some of the nearest examples of interactions affecting galaxy evolution with extended gaseous structures strewn throughout the halos of the Milky Way and the Magellanic Clouds. Models shown that tidal forces can partly - if not dominantly - produce this stripped material as the Clouds encounter each other and the Milky Way. Interaction with halo gas and exposure to radiation from all three galaxies shapes their extended structures, their evolution, and their ability to form stars. In this work, we use the Wisconsin H-alpha Mapper to study the faint, warm ionized gas in the Magellanic Bridge, a structure between the Clouds. H I studies have extensively mapped the neutral gas in this region, but the amount and extent of the ionized gas remains uncertain. A census of the material allows us to ask questions addressing the evolution of this system: How much gas have the galaxies lost to this structure? How does the gas loss affect future star formation? Is this environment conducive to star formation?

1.2 Chemodynamical Simulations of the Milky Way Galaxy

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Abstract

We present chemodynamical simulations of a Milky Way-type galaxy using a self-consistent hydrodynamical code that includes supernova feedback and chemical enrichment, and predict the spatial distribution of elements from Oxygen to Zinc. In the simulated galaxy, the kinematical and chemical properties of the bulge, disk, and halo are consistent with the observations. The bulge formed from the assembly of subgalaxies at $z \gtrsim 3$, and has higher [α/Fe] ratios because of the small contribution from Type Ia Supernovae. The disk formed with a constant star formation over 13 Gyr, and shows a decreasing trend of [α/Fe] and increasing trends of [(Na,Al,Cu,Mn)/Fe] against [Fe/H]. However, the thick disk stars tend to have higher [α/Fe] and lower [Mn/Fe] than thin disk stars. We also predict the frequency distribution of elemental abundance ratios as functions of time and location, which can be directly compared with galactic archeology projects such as HERMES.

1.3 Local dwarf galaxies and their links to galaxy formation

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Abstract

Theories of galaxy formation are typically tested on large scales with sets of thousands of galaxies. However, the proximity of the satellites of our own Milky Way yield a unique data set with which we can test galaxy formation models down to very small scales. For example, comparing the orbits of the dwarf galaxies around the Milky Way with orbits of subsets of satellites in LCDM simulations can yield important constraints on the missing satellites problem. We use the high resolution simulation Via Lactea to address the question of how well the orbits of the local dwarf galaxies can be determined while accounting for typical model and measurement errors. We then apply these results to the 'classical' dwarf galaxies around the Milky Way and evaluate their agreement with subsets of subhaloes in the Via Lactea simulation. We find that their mean apocenter distribution is consistent with the most massive subhaloes that formed before z=10. This agrees with the notion that dwarf galaxies formed before reionisation.

1.4 Star Formation History of the UGCA 92 and IC 342 Group Structure

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Abstract

We present a quantitative star formation history of the nearby dwarf galaxy UGCA 92. This irregular dwarf is situated in the vicinity of the Local Group of galaxies in the zone of strong Galactic extinction (IC 342 group of galaxies). The galaxy was observed within our HST/ACS project number 9771 (PI I. Karachentsev) and resolved into stars including old red giant branch. We have constructed models of the resolved stellar populations and measured star formation rate and metallicity dependence on time. According to our measurements, the main star formation activity period occured about 8 - 14 Gyr ago. There stars looks mostly metal-poor, with the mean metallicity [Fe/H] of about -1.5 to -2.0 dex. There are indications of recent star formation starting about 2 Gyr ago and enhanced moderately till to our time. It is very likely that the ongoing star formation period has higher metallicity of about -0.6 to -0.3 dex. In our study we also have analysed the spatial structure of the IC 342 group and its possible influence on the star formation activity.

1.5 The mid-life crisis of the Milky Way and M31

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Abstract

Upcoming next generation galactic surveys, such as GAIA and HERMES, will deliver unprecedented detail about the structure and make-up of our Galaxy, the Milky Way, and promise to radically improve our understanding of it. However, to benefit our broader knowledge of galaxy formation and evolution we first need to quantify how typical the Galaxy is with respect to other galaxies of its type. Through modeling and comparison with a large sample of galaxies drawn from the Sloan Digital Sky Survey and Galaxy Zoo, we provide tentative yet tantalizing evidence to show that both the Milky Way and nearby M31 are undergoing a critical transformation of their global properties. Both appear to possess attributes that are consistent with galaxies midway between the distinct blue and red bimodal color populations. In extragalactic surveys, such 'green valley' galaxies are transition objects whose star formation typically will have all but extinguished in less than 5 Gyrs. This finding reveals the possible future of our own galactic home, and opens a new window of opportunity to study such galactic transformations up close.

1.6 Stellar feedback and redistribution of gas in the Magellanic Clouds

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Abstract

We studied star formation and associated supernova–induced gas blowout in the Magellanic Clouds. Their role in feeding the extended gaseous tails associated with the Clouds (the Magellanic Stream and the Leading Arm) with matter was investigated.

1.7 The old- and intermediate-age population of the isolated Local Group dwarf galaxy NGC 6822: an IR study of AGB stars

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Abstract

NGC 6822 is a small Irregular dwarf that forms part of the Local Group. Its close proximity and apparent isolation provide a unique opportunity to study galactic evolution within the Local Group without the influence of strong dynamical factors. The metallicity gradient and the distribution of the stellar population have been studied using the asymptotic branch (AGB) component of the population in NGC 6822. Using deep high quality near-infrared photometry, taken with UKIRT, the carbon- and oxygen-rich intermediate-age AGB stars have been isolated. The tip of the red giant branch has been located at $K = 17.41 \pm 0.11$ and the colour separation for C- and M-type stars falls at $(J-K) = 1.20 \pm 0.01$. The ratio between these populations - the C/M ratio - has then been used to derive the [Fe/H] abundance across the galaxy. The [Fe/H] abundance and the distribution of the AGB population were then analysed as a function of radial distance and azimuthal angle about the galaxy centre. Our analysis indicates an overall C/M number ratio of 0.29 and a mean [Fe/H] value of 1.14 ± 0.08 dex, with noticeable variations when examined as a function of galactocentric distance. A variation has also been detected in the magnitude of the tip of the red giant branch which is believed to be due to either a composite population or overlapping structures within the galaxy relative to our line of sight.

Summarizing, I will present an investigation of the resolved AGB population across the NGC 6822; discuss how regions of varying metallicity and AGB stellar density have been identified and how they may be interpreted to further our understanding of the evolutionary history of this galaxy.

2.1 Passive and Star-forming Galaxies at z∼2 from the CFHT Legacy Survey.

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Abstract

We present results from the four CFHT Legacy Survey Deep fields with an effective area of $\sim$0.8 deg^2 and a magnitude limit of K $<$ 24 (AB magnitudes). The combination of depth, area, and four independent sightlines give us an excellent way to probe the galaxy population at high redshift. We use the BzK selection criteria (adapted to a gzK selection criteria to match the CFHTLS filters) to select galaxies with redshifts 1.4 $<$ z $<$ 2.5 and distinguish between star-forming and passive galaxies. We obtain galaxy number counts and luminosity functions. From the luminosity functions we infer the stellar mass function at this epoch and the stellar mass density of the Universe. An important characteristic of our results is that they go past the peak of the passive galaxy luminosity function, and the large area and four independent sightlines give us excellent statistics and a handle on cosmic variance.

2.2 The Buildup of the Massive Red Sequence Since z∼2

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Abstract

We use the NEWFIRM Medium-Band Survey to study the buildup of massive galaxies since z∼2.2. Galaxies with log M > 10.5 Msun are nearly all red in rest-frame U−V over the full range 0 < z < 2.2; however, the nature of massive red galaxies changes remarkably with redshift. We find an increasing fraction of dusty star-forming galaxies and a decreasing fraction of quiescent, "red and dead" galaxies with redshift. The mass density of quiescent galaxies increases by ∼1 dex from z = 2.2 to the present day, whereas the mass density in star-forming galaxies is roughly flat over the same time period. Modest mass growth (i.e., a factor of two) of individual galaxies at M > 10^{11} Msun can explain much of the strong density evolution of quiescent galaxies, due largely to the steepness of the exponential end of the mass function. This is not true for less massive galaxies, which show a similarly steep increase in their number densities. We propose that mergers are primary mechanism for building up the massive (quiescent) galaxy population, while less massive quiescent galaxies are continuously formed by transforming galaxies from the star-forming population. Finally, we present promising early results from the 3D-HST WFC3 grism survey that confirm the bimodal population of truly quiescent and dusty star-forming massive galaxies at z∼2 found by the NMBS.

2.3 The properties of the interstellar medium in a star-forming galaxy at $z = 2.3$

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Abstract

We present an analysis of the molecular and atomic gas emission in the rest-frame far-infrared and submillimetre from the lensed $z = 2.3$ submillimetre galaxy SMM J2135−0102. We obtain very high signal-to-noise ratio detections of 11 transitions from three species and limits on a further 20 transitions from nine species. We use the 12CO, [C I] and HCN line strengths to investigate the gas mass, kinematic structure and interstellar medium (ISM) chemistry and find strong evidence for a two-phase medium within this high-redshift starburst galaxy, comprising a hot, dense, luminous component and an underlying extended cool, low-excitation massive component. Employing a suite of photodissociation region models, we show that on average the molecular gas is exposed to an ultraviolet (UV) radiation field that is ∼1000 times more intense than the Milky Way, with star-forming regions having a characteristic density of $n \sim 10^4$ cm^{-3}. Thus, the average ISM density and far-UV radiation field intensity are similar to those found in local ultraluminous infrared galaxies (ULIRGs) and to those found in the central regions of typical starburst galaxies, even though the star formation rate is far higher in this system. The 12CO spectral line energy distribution and line profiles give strong evidence that the system comprises multiple kinematic components with different conditions, including temperature, and line ratios suggestive of high cosmic-ray flux within clouds, likely as a result of high star formation density. By virtue of the lens amplification, these observations uncover a wealth of information on the star formation and ISM at $z \sim 2.3$ at a level of detail that has only recently become possible at $z < 0.1$.

2.4 The Evolution of Quiescent Galaxies at High Redshifts

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Abstract

The goal of this work is to study the evolution of high redshift (z $\geq$ 1.4) quiescent galaxies over an effective area of $\sim 1.7 deg^2$ in the COSMOS field. Galaxies have been divided according to their star-formation activity and the evolution of the different populations, in particular of the quiescent galaxies, has been investigated in detail. We have studied an IRAC ($mag_{3.6\mu m}$ <22.0) selected sample of $\sim$ 18000 galaxies at z $\geq$ 1.4 in the COSMOS field with multi-wavelength coverage extending from the U band to the *Spitzer* 24 μm one. We have derived accurate photometric redshifts ($\sigma_{\Delta z/(1+z_s)} = 0.059$) through a SED-fitting procedure. Other important physical parameters (masses, ages and star formation rates (SFR)) of the galaxies have been obtained using Maraston (2005) models. We have divided our sample into actively star-forming, intermediate and quiescent galaxies depending on their specific star formation rate (SSFR=SFR/M). We have computed the galaxy stellar mass function (GSMF) of the total sample and the different populations at $z = 1.4$–3.0. We have studied the properties of high redshift quiescent galaxies finding that they are old (1–4 Gyr), massive ($\langle M \rangle \sim 10^{10.65} M\odot$), weakly star forming stellar populations with low dust extinction (E(B-V) $\leq$ 0.15) and small e-folding time scales ($\tau \sim 0.1-0.3 Gyr$). We observe a continous evolution of the quiescent stellar mass function from $z \sim 2.7$ to $z \sim 1.5$, $\sim$ 1 dex for $logM \sim 11.0$). We find that $z \sim 1.5$ is an epoch of transition of the GSMF: while the MF at $z \gtrsim 1.5$ is dominated by the star-forming galaxies at all stellar masses, at $z \lesssim 1.5$ the contribution to the total MF of the quiescent galaxies is significant and becomes higher than that of the star-forming population for $M \geq 10^{10.8} M_\odot$. The fraction of star-forming galaxies decreases from 60% to 20% from $z \sim$2.5–3.0 to $z \sim$ 1.4–1.6 for $M \sim 10^{11.0} M_\odot$, while the quiescent population increases from 10% to 50% at the same redshift and mass intervals. We compare the fraction of quiescent galaxies derived with that predicted by theoretical models and find significant discrepancie with some of them and a good agreement with the Millenium-based mode. Finally, we calculate the stellar mass density of the star-forming and quiescent populations as a function of redshift and find that the stellar mass density of the quiescent galaxies decreases by $\sim 1 dex$ in the redshift bins considered, being $\rho \sim$ 6.0 $M_\odot Mpc^{-3}$) at $z \sim 2.7$.

2.5 The e-MERGE Survey: e-MERlin Galaxy Evolution Survey

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Abstract

This Legacy survey exploits e-MERLIN's unique combination of sensitivity and spatial resolution to study the formation and evolution of star-forming galaxies and AGN out to redshifts of $z > 5$. These observations will provide a powerful, obscuration-independent tool for measuring the massive star formation and AGN activity in high-redshift galaxies, hence tracing the development of the stellar populations and the black hole growth in the first massive galaxies. With a resolution of 50–200 mas in C- and L-Bands, corresponding to <0.5–1.5 kpc at $z > 1$, e-MERLIN gives us our first truly reliable view of the distribution of star-formation within typical galaxies at the epoch where the bulk of the stars in the present-day Universe were being formed. e-MERLIN will disentangle the relative contributions of AGN and star-formation, an essential step given the apparently simultaneous growth of the black holes and stellar populations in galaxies. To achieve these goals, we have developed a strategy comprising of nested tiers, which together provide a single, coherent survey addressing fundamental questions about the formation and joint evolution of AGN and galaxies. The completed survey will provide a homogeneous data product with lasting legacy value for the whole astronomical community.

2.6 Extreme Gas Kinematics in Starburst-AGN Composite Galaxies

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Abstract

Leading models of galaxy formation require large-scale energetic outflows to regulate the growth of distant galaxies and their central black holes. However, current observational support for this hypothesis at high redshift is mostly limited to rare $z > 2$ radio galaxies. I present some of the results from our Gemini-North Near-Infrared Field Spectrometer (NIFS) programmes. We have taken observations of the [O iii]λ5007 emission from a small sample of sub-mm bright galaxies hosting active galactic nuclei (AGN). There is a wide variety in their [O iii] properties; with multiple components and turbulent dynamics. High velocity, broad and in some cases extended (≥ 4 kpc) [O iii] emission indicates the presence of large-scale energetic outflows. Winds radiatively driven by the AGN and/or supernovae winds from intense star formation are likely to be responsible.

2.7 New Constraints on the Faint Population of Lyman Alpha Emitting Galaxies at z=5.7

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Abstract

Faint star-forming galaxies that are beyond current observational limits are often said to contribute a large fraction of the ionizing background at $z \gtrsim 6$. Extending observations to ever fainter populations is therefore critical in order to quantify the ionizing output of galaxies and definitively determine that the intergalactic medium was reionized by star-formation. *Spectroscopic* searches for Lyα emission at $z \sim 6$ can find the faintest galaxies by maximizing the contrast with the sky background. I present results from a Multislit Narrowband Spectroscopic search for Lyα emitting galaxies (LAEs) at $z = 5.7$. LAEs are now confirmed with luminosities that have only been achieved for a few strongly lensed galaxies at similar redshifts. I present the Lyα luminosity function of these galaxies, giving the first constraints on the faint-end slope at $z = 5.7$. This unprecedented measurement allows a comparison to the steep faint-end slope of the $i-$dropout luminosity function measured by Bouwens et al. (2007). Additionally, the faint LAE contribution to the hydrogen-ionizing background will be discussed.

2.8 Galaxy Evolution Through the Cosmic Time

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Abstract

Galaxies are the beacons that light up distant regions and also the building-blocks that chart the Universe. Modern cosmological models are very successful at explaining the largest structures in the Universe, but a coherent picture of how galaxies are able to form their stars and their evolution through cosmic time is still missing. Among the different morphological types, elliptical (E) galaxies seem to be the simplest ones, with mass indicators presenting robust correlations with many observed properties. Usually we search in these observable properties an imprint of their previous formation history, which is essentially related to their stellar population formation history. Particularly, spectroscopy and color indices are powerful tools for deriving mean ages and chemical abundances of a given stellar population distribution. Here we presented an analytical model of E galaxy formation and evolution, including the possibility of proto-galaxy formation by accretion of intergalactic gas continuously or during merger episodes. The feedback is governed mainly by supernova (SN) explosions, driving the progressive enrichment of the interstellar medium (ISM) by metals and the energy injection into the ISM, eventually producing galactic winds. Two phases of ISM are considered: a hot and ionized phase in which the star formation is quenched and a cold and neutral phase where stars are formed. The ionization rate is estimated by the hot gas generated by SN explosions and those returned to the ISM by stars. The onset of galactic wind removes hot gas from the system and the radiative cooling followed by recombination processes transform part of the hot gas into the cold phase. The resulting mean ages and metallicities for a sample of early type galaxies are presented and the apparent down-sizing effect, opposite to the hierarchical model, is discussed. A comparison is made with the results of cosmological simulations of galaxy formation and evolution.

2.9 Resolved spectroscopy of gravitationally lensed $z = 2 - 3$ galaxies

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Abstract

The detailed study of high-redshift galaxies is hampered by their small angular sizes and faint apparent magnitudes. Both of these limitations can be overcome by observing gravitationally lensed galaxies, where the apparent size and luminosity are highly magnified by massive clusters. We have identified a large number of strongly lensed galaxies from HST imaging of galaxy clusters and extensive spectroscopic followup. I will describe these surveys and focus on observations of the brightest high-redshift sources with the OSIRIS integral field unit and adaptive optics system on the Keck II telescope. The combination of strong lensing and adaptive optics provides a source plane resolution as fine as 100 parsec in these galaxies. The data reveal coherent velocity fields, multiple giant star-forming regions, and steep metallicity gradients, which suggest that we are witnessing inside-out growth of turbulent rotating galaxies. These observations provide a uniquely detailed view of high-redshift galaxies which will only become routine with the next generation of telescopes such as ALMA, JWST, and ELTs.

2.10 Evolution of Galaxy Stellar Mass Function since $z \sim 3$

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Abstract

We present results on the evolution of the galaxy stellar mass function (SMF) at $1 \lesssim z \lesssim 3$ from MOIRCS Deep Survey, which is a deep NIR imaging survey with Subaru/MOIRCS in the GOODS-North region. The data reach 5σ depth of J=24.2, H=23.1, and Ks=23.1 (Vega magnitude, 2×PSF FWHM diameter aperture) over 103 arcmin^2, and J=25.1, H=23.7, Ks=24.1 in 28 arcmin^2 of the survey area. We used the deep NIR data to construct a nearly stellar-mass-limited sample down to $\sim 10^{9.5}$-10^{10} $M_\odot$ even at $z \sim 3$. We found that the low-mass slope of the SMF becomes steeper with redshift from $\alpha \sim -1.3$ at $z \sim 1$ to $\alpha \sim -1.6$ at $z \sim 3$ as well as the gradual decrease of the normalization of the SMF. The evolution of the number density of $\sim M^*$ ($\sim 10^{11}$ $M_\odot$) galaxies is stronger than low-mass (10^9-10^{10} $M_\odot$) galaxies at $z \gtrsim 1$. We also investigated the SMF for quiescent galaxies and star-forming galaxies separately. The low-mass slope of the SMF for quiescent galaxies is significantly flatter than that of star-forming galaxies at $0.5 < z < 2.5$, and the evolution of the normalization for quiescent galaxies more strongly evolves than star-forming ones in the redshift range. The results suggest that the strong evolution of the number density of quiescent galaxies causes the rapid increase of $\sim M^*$ galaxies relative to low-mass galaxies at $z \gtrsim 1$.

2.11 A Model Prediction to the Nature of High-z Lyman-Alpha Emitters

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Abstract

We have been constructed a theoretical model for high-z Lyman-Alpha emitters (LAEs) based on a semi-analytical model for galaxy formation (Nagashima & Yoshii 2004). Our model phenomenologically incorporates the effects of interstellar dust extinction and galactic-wind into the escape probability of LyA photons from their host galaxy. It is found that our model reproduces all of the available observational statistical quantities (LyA and UV-continuum luminosity functions and Lya EW distribution) of the LAEs at z=3-7 (Kobayashi et al. 2007, 2010). Our model predicts the dust geometry in the ISM of LAEs is clumpy so that LyA photons can escape even if large amount of dust exists in them. Here we present a prediction to the physical quantities of high-z LAEs based on our theoretical model and discuss what type of galaxies can be observationally selected as LAEs.

2.12 The Prevalence and Properties of Outflowing Winds at z = 1

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Abstract

Outflowing winds have been observed in galaxies at a variety of redshifts and are thought to play an important role in both the quenching of star formation and the enrichment of the intergalactic medium. We present the results of a study at z = 1 tracing the prevalence and properties of outflows in a sample of DEEP2 objects with rest-frame UV spectroscopy and HST optical imaging. We investigate if a critical star formation rate surface density is required to drive outflows, using a new technique for estimating galaxy area based on a physically motivated luminosity threshold. Previous work has suggested that the star formation rate surface density may be most strongly correlated with outflows (as opposed to the star formation rate); our method of estimating the area over which star formation is occuring represents an improvement over the simple adoption of a Petrosian or half-light radius. We discuss fine structure FeII emission in light of galaxy properties and investigate the likely origin of these features (which are not commonly observed in local starbursts). By conducting analyses on a per-object basis at z = 1, we are able to examine the relationship between outflow properties and individual galaxy morphology, stellar populations, and star formation surface density, at the epoch when the global star formation rate is beginning its decline to the present day.

2.13 Rest-Frame Optical Imaging of $z \sim 2 - 3$ Star-Forming Galaxies with HST/WFC3

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Abstract

I will describe some results from our recent HST/WFC3 rest-frame optical imaging survey of star-forming galaxies in the redshift range $1.5 < z < 3.5$. With 42 orbits of F160W imaging distributed amongst 10 fields, our survey covers ~ 65 square arcmin to a depth of 27.9 AB and contains > 300 spectroscopically confirmed galaxies with stellar masses in the range $M = 10^9 - 10^{11} M_\odot$. I will discuss the typical morphological properties of these galaxies and the evidence for a growth in galaxy structures at fixed stellar mass of the form $r \sim (1+z)^{-1}$, whereby star forming galaxies appear to evolve onto the local late-type mass-radius relation by $z \sim 1$. In addition, I will discuss the apparent relation between galaxy morphology and the characteristics of galactic-scale gasesous outflows.

2.14 The Effect and Influence of Star Formation and Gas Accretion on the Turbulence in the ISM, on Self-regulation and on the IMF.

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Abstract

I will present results from observations of more than 50 galaxies as seen as they were 9 to 12 Gyrs ago with integral-field spectroscopy. Taking advantage of this large sample, I will first paint a brief picture of the very particular physical nature of these galaxies. These observations reveal a surprisingly high amount of random motions in the gas inside these galaxies. I will explain why this effect is real (not due to observational limitations) and why it is probably a consequence of the intense star formation in these objects, outlining why we conclude that star formation is self-regulated. Using additional rest-frame UV observations in a subsample of these objects, we also suggest that their Initial Mass Function is flatter than Salpeter at the high mass end, an effect that may be due to the high turbulence, as has been suggested by some theories of star-formation. I will also discuss our conclusions within the context of cosmological (quasi-)adiabatic gas accretion: is there a phase in galactic evolution where we could detect the effects and rate of gas accretion in our studies of the rest-frame optical emission lines?

2.15 Star-Forming Galaxies at $z \sim 8 - 9$ from HST/WFC3: Implications for Reionization

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Abstract

I will present a selection of robust galaxy candidates at redshift $z \sim 8-9$ with recent data from WFC3 on HST, including the Hubble Ultra Deep Field and the Early Release Science images of the GOODS-South field. We now have enough candidates to fit the characteristic number density and the characteristic luminosity for the UV Schechter function at that redshift. We found fewer Lyman-break galaxy at $z \sim 8 - 9$ than expected from lower redshift data ($z \sim 3 - 7$), and that suggests a significant evolution. Implications for the reionization of the universe will be discussed.

2.16 Constraining the Main Drivers of Galaxy Evolution with Near-Infrared Spectroscopy

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Abstract

The bimodal nature of the galaxy population is apparent to $z \sim 1$ and beyond, and the emerging picture of many studies is one in which, beginning at the highest masses, galaxies transform from blue, star-forming, disk-dominated systems into red, bulge-dominated spheroidals in which star formation has been quenched. A recent simple empirically based model has established a powerful galaxy evolution framework describing how galaxies are born, live and die (are quenched). The model makes clear predictions and identifies the main drivers of galaxy evolution, although some actual physical processes associated with these drivers have still to be identified. Using recent VLT and SUBARU near-infrared spectroscopy for a sample of $0.5 < z < 2.5$ zCOSMOS galaxies, I have been able to study the physical conditions (e.g., gas metallicities, gas fraction, AGN contribution, star formation rates) of these galaxies, by analysing their emission line fluxes. I will present results of this near-infrared spectroscopy, and discuss how these and future observations can constrain the main drivers of galaxy evolution. Specifically, the near-infrared observations, in combination with the wealth of additional COSMOS information (e.g., morphologies, environment), can give insights in the origin of the SFR-mass relation and metallicity-mass relation, and their evolution with time, and shed light on the physical mechanism(s) that quenches galaxies.

2.17 Lyα and Hα surveys for proto-clusters and giant gaseous nebulae at $z = 2$–5

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Abstract

We present our on-going Lyα and Hα surveys for proto-clusters and giant gaseous nebulae at $z = 2$–5. The formation and evolution of galaxies in clusters are thought to be accelerated relative to that in low-density regions. Characteristic objects often discovered in the proto-clusters are giant gaseous nebulae (Lyα blobs), which are likely to be the formation sites of massive galaxies and indicative of the accelerated galaxy formation in the over-dense environments through frequent interactions between galaxy and the surrounding galaxy/IGM. In order to study the galaxy formation in the proto-clusters, we have carried out Lyα and Hα imaging surveys around several potential signposts of over-dense regions (QSOs, HzRGs, SMGs, and an HI over-density) and known proto-clusters at $z = 2$–5 with UKIRT/WFCAM and Subaru/S-Cam. We detect >100 Hα emitter, >2000 Lyα emitter, and >200 Lyα blob candidates, and identify several new proto-clusters. At $z = 2$, we find the first candidate for giant Hα emission-line nebula (or Hα blob) with a spatial extent to 7.5-arcsec (60 kpc), which is 34-arcsec (280 kpc) away from a bright QSO at the same redshift. At $z = 3$, we find a possible "morphology-density relation" for Lyα blobs: filamentary blobs tend to reside in lower density regions while circular blobs tend to reside in higher density regions. At $z = 5$, we find a new proto-cluster associated with the HI over-dense region. Narrow-band surveys are efficient routes to map over-dense regions at high-z and to understand the relation between the growth of galaxies and their surrounding large-scale galaxy/IGM structures.

2.18 The Growth of Massive Quiescent Galaxies since $z \sim 2.5$

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Abstract

Using high-resolution imaging data from the Cosmic Assembly Near-Infrared Deep Extragalactic Legacy Survey (CANDELS), we examine the growth of spheroids from $z \sim 2.5$ to the present. Evidence that massive quiescent galaxies undergo dramatic size evolution from $z > 1$ to the present has been steadily increasing. The compact sizes of high-redshift quiescent galaxies imply densities that are up to two orders of magnitude greater than galaxies in the local Universe of similar mass. However, it is unclear whether measurements to-date, many of which have relied on rest-frame near-UV imaging, have been underestimated due to effects such as signal-to-noise and age or metallicity gradients. Recently it has been suggested that these compact galaxies could survive as the cores of massive ellipticals in the local Universe, growing low-surface-brightness halos through dry mergers, thus preserving the central mass density while increasing the effective radii. The depth of CANDELS imaging at both rest-frame near-UV and optical wavelengths allows us to reliably measure sizes and color gradients of passive galaxies for the first time over a large region of the sky, enabling us to determine when early-type galaxies start to grow their halos and how they evolve onto the local size-mass relation.

2.19 The Evolution of the Mass-Size relation to z=3.5 in the GOODS-North Field

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Abstract

We study the evolution of the size - stellar mass relation for a large spectroscopic sample of galaxies in the GOODs North field up to $z \sim 3.5$. The sizes of the galaxies are measured from K_s-band images (corresponding to rest-frame optical/NIR) from the Subaru 8m telescope. We reproduce earlier results based on photometric redshifts that the sizes of galaxies at a given mass evolve with redshift. Specifically, we compare sizes of UV-bright galaxies at a range of redshifts: Lyman break galaxies (LBGs) selected through the U-drop technique ($z \sim 2.5 - 3.5$), BM/BX galaxies at $z \sim 1.5 - 2.5$, and GALEX LBGs at low redshift ($z \sim 0.6 - 1.5$). The median sizes of these UV-bright galaxies evolve as $(1+z)^{-1.11 \pm 0.13}$ between $z \sim 0.5 - 3.5$. The UV-bright galaxies are significantly larger than quiescent galaxies at the same mass and redshift by 0.45 ± 0.09 dex. We also verify the correlation between color and stellar mass density of galaxies to high redshifts. The sizes of sub-mm galaxies in the same field are measured and compared with BM/BX galaxies. We find that median half-light radii of SMGs is 2.90 ± 0.45 kpc and there is little difference in their size distribution to the UV-bright star forming galaxies.

2.20 Outflows From Massive Star-Forming Clumps in $z \sim 2$ Galaxies

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Abstract

Using SINFONI/VLT integral field spectroscopy with adaptive optics, we have observed large-scale galactic outflows from resolved giant star-forming clumps in several $z \sim 2$ galaxies. We are able to characterize properties of the wind using Hα, [NII] and [SII] line emission. These massive winds have very large outflow rates, often in excess of the star-formation rates of the clumps. We study the structure of the wind using emission line ratios and relate this to observations of local starburst galaxies, to understand how star-formation varies at different redshifts. Examining the properties of these winds is also important for constraining the recycling of heavy elements into the IGM and the effects of star-formation feedback on galaxy evolution.

2.21 Investigating the Rapid Growth of Compact Massive Galaxies Between Redshifts 1 and 2

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Abstract

Many recent observations have established the presence of a substantial population of quiescent galaxies at $z \sim 2$. These early, massive systems are far from being fully-formed ellipticals. Rather, they appear extremely compact and may be up to 5 times smaller in size than their likely descendants on the $z = 0$ red sequence. Comprehensive studies at $z < 1$ have shown relatively little change in the massive galaxy population. Thus, if the $z \sim 2$ results are correct, they imply enormous structural evolution over the interval $1 < z < 2$. Until recently, there were very few high-quality spectra of red galaxies in this interval with which to dynamically calibrate the stellar mass scale. Using new red-sensitive CCDs in LRIS at the Keck telescope, we have assembled the largest library of spectra of spheroids at $1.1 < z < 1.6$ to date, comprising 17 high-S/N examples. Using accurate dynamical mass measures, we confirm a growth in size by a factor of $\sim$2 over $0 < z < 1.5$ at fixed mass. To maintain continuity with the $z \sim 2$ results seemingly requires dramatic size expansion by another factor of 2 over less than 2 Gyr. I will also discuss results from a high-resolution imaging campaign using laser guide star adapative optics to quantitatively assess the role that accretion of low-mass systems may have in driving this rapid growth.

2.22 Star forming galaxies at high redshift: news from Herschel

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Abstract

I will discuss the UV-to-IR properties of galaxies at redshift between 1 and 4, i.e. over the main epoch of galaxy assembly. I use a sample, selected from highly accurate photometric redshifts, drawn from the GOODS North field, and perform a stacking analysis across their full multiwavelength spectrum, spanning from the optical Subaru imaging, through the ultradeep GOODS Herschel IR dataset and all the way to the VLA 20cm continuum. I will present first results on the star formation of these galaxies and UV dust attenuation and on how these properties all ultimately depend on their stellar mass.

2.23 The build-up of mass in faint UV-selected galaxies at high redshift

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Abstract

We probe deep ($R_{lim} = 28$) into the UV-selected $z \sim 2$ galaxy population to study how galaxies build up their masses. First, we find that star formation rates in galaxies below the luminosity function knee at L^* show a strong correlation with galaxy stellar mass. This correlation suggests that star formation in these low-mass objects is fueled by ongoing accretion of material into their dark halos. Next, the low-mass end of the stellar mass function is steeper than extrapolations from shallower surveys would suggest, resulting in a stellar mass density at $z \sim 2.3$ that's $\sim$ 1.4–2 times higher than that given by extrapolations of most of the shallower surveys: apparently the build-up of stellar mass in the universe has proceeded somewhat more rapidly than was previously thought. We also find that sub- L^* galaxies at $z \sim 2$ carry very small amounts of dust compared to their more luminous cousins, so that while only $\sim$ 20% of UV photons escape from a typical M^* galaxy, more than half make it out of an M^*+3 one; this paucity of dust means that sub-L^* are important contributors to keeping the Universe ionized at $z \sim 2$. Turning to clustering measurements, we find that the star formation rates in the most massive haloes decline with redshift, so that while $\sim 10^{12} M_\odot$ halos at $z \sim 3$ and 4 are host to $>$50 $M_\odot$/yr of star formation, at $z \sim 2.2$ they produce $\sim$20 $M_\odot$/yr, and at $z \sim$1.7 only $\sim$2 $M_\odot$/yr. We interpret this as shut-down of star formation in the most massive halos and evidence that galaxy downsizing is related not just to galaxy stellar masses, but to the masses of the dark matter halos that host them.

2.24 The Distribution of Star Formation in High Redshift Galaxies

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Abstract

The ongoing Hubble legacy treasury program 3D-HST is taking near infrared (WFC3) grism spectra of ∼9000 galaxies with $1 < z < 3.5$ across the COSMOS, GOODS, Hubble UDF, UKIDSS/UDS and AEGIS fields. This redshift range probes the epoch where ∼60% of all star formation took place. Here we present first results on the spatial extent of the star formation in some of these galaxies. By extracting the Hα emission-line images from the grism spectra of the individual galaxies, we show how this can be mapped back to the (continuum) near infrared image of the sources, yielding the spatial distribution of star forming regions.

2.25 Extending Pure Luminosity Evolution Models to Herschel Wavelengths

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Abstract

We show that optically defined PLE models, where dust reradiates absorbed optical light into infrared spectra composed of local galaxy templates, fit galaxy counts and colours out to 8 μm and to at least $z = 2.5$. At wavelengths, 24–70 μm, the model is able to reproduce the observed source counts with reasonable success if ∼15% of spiral galaxies show an excess in mid-IR flux due to a warmer dust component and a higher SFR, in line with observations of local starburst galaxies. At 160 μm and longer Herschel wavelengths, the model fails, with our model of normal galaxies accounting for only a few percent of sources in these bands. However, we show that a PLE model of obscured AGN, which we have previously shown to give a good fit to X-ray and 850 μm observations, also fits the Herschel/BLAST number counts and redshift distributions at 250–500 μm. A significant AGN contribution would also immediately improve the prospects for fitting the Herschel/SCUBA source counts in the context of the LCDM cosmology.

2.26 Near-IR Integral Field Unit spectroscopic study of the 8 o'clock arc

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Abstract

We present the results from NIR IFU spectroscopic study of the 8 o'clock arc, a gravitationally lensed Lyman Break Galaxy at z= 2.73, using SINFONI on VLT. We study the physical properties of its interstellar medium, its chemical make-up, its dynamical status and recent and on-going star formation activity.

2.27 Modelling the stellar populations of high redshift galaxies

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Abstract

How galaxies build up and evolve at early times is one of the most fundamental questions in extragalactic astronomy. While well-established constraints exist on how this build-up occurs from rest-frame UV studies, an equally important part of the story - the build-up of stellar mass - is far less well understood. Although a few notable results on the stellar mass have already emerged for high redshift galaxies (like the non-evolution of specific SFR), the stellar masses of lower luminosity galaxies remain essentially unknown. This is a major gap in our knowledge since lower luminosity galaxies dominate the SFR density, UV density, and likely provide the photons that reionize the universe. The only way of obtaining data on these faint sources at high redshift is with Spitzer, but with Spitzer one is faced with serious S/N limitations. To surmount these challenges, we take advantage of gravitational lensing from galaxy clusters to magnify the light seen with Spitzer and with HST – allowing for detailed stellar population modelling. Here we apply such a technique to study a sample of lensed $z \sim 7$ galaxies behind Abell 1703. This sample is a particularly large one – and includes one $z \sim 7$ source with a H-band magnitude of $\sim$24. To put our results in context, we compare our findings with those for other highly magnified $z \sim$6–7 galaxies in the literature.

2.28 The Hubble sequence at $z \sim 2$

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Abstract

We use ultradeep HST WFC3/IR imaging of the HUDF to investigate the rest-frame optical morphologies of a mass-selected sample of galaxies at $z \sim 2$. We find a large variety of galaxy morphologies, ranging from large, blue, disk-like galaxies to compact, red, early-type galaxies. We derive rest-frame $u - g$ color profiles for these galaxies and show that most $z \sim 2$ galaxies in our sample have negative color gradients such that their cores are red. Although these color gradients may partly be caused by radial variations in dust content, they point to the existence of older stellar populations in the centers of $z \sim 2$ galaxies. This result is consistent with an "inside-out" scenario of galaxy growth. We find that the median color gradient is fairly constant with redshift: $(\Delta(u - g_{\rm rest})/\Delta(\log r))_{\rm median} = -0.47$, -0.33 and -0.46 for $z \sim 2$, $z \sim 1$ and $z = 0$, respectively. Using structural parameters derived from surface brightness profiles we confirm that at $z \sim 2$ galaxy morphology correlates well with specific star formation rate. At the same mass, star forming galaxies have larger effective radii, bluer rest-frame $u - g$ colors and lower Sérsic indices than quiescent galaxies. These correlations are very similar to those at lower redshift, suggesting that the relations that give rise to the Hubble sequence at $z = 0$ are already in place for massive galaxies at this early epoch.

2.29 A precise stellar velocity dispersion of a compact massive galaxy at z=1.80 using X-Shooter

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Abstract

The remarkable compactness of massive quiescent galaxies at $z \sim 2$ remains a highly debated issue, and can only be solved using kinematic measurements. Dynamical masses are less uncertain compared to stellar masses, and do not rely on assumptions regarding the initial mass function, metallicity and photometric redshifts. With 2 hours of integration time using X-Shooter on the VLT, we obtained a high signal to noise, high resolution, Ultra-Violet to Near-Infrared spectrum of a massive ($\sim 2 \times 10^{11}$ M$_\odot$) quiescent galaxy at a redshift of $z = 1.80$. With our high S/N, we determine accurate stellar population properties and a stellar velocity dispersion. The stellar and dynamical mass are in good agreement, and consistent with the relation found for low-redshift galaxies in the Sloan Digital Sky Survey. However, for galaxies with similar dynamical masses in SDSS, our galaxy has a higher velocity dispersions (factor ~ 1.5) and smaller effective radius (factor ~ 2.5). Our results confirm the existence of massive quiescent galaxies with high stellar mass densities, and that evolution in both size and velocity dispersion is required if these galaxies are to become local early-type galaxies.

2.30 The changing relationship between galaxy stellar mass and dark matter halo mass since $z = 2$

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Abstract

Using measurements of the stellar mass dependent clustering from the NEWFIRM medium band surveys I and II at $1 < z < 2$ and the SDSS at $z = 0.1$ I will show how the relationship between galaxy stellar mass and dark matter halo mass has changed over the last 10Gyrs. By combing these measurements with the halo model of galaxy clustering I will demonstrate that the halos that are most efficient at forming stars move to lower halo mass in more recent times. I will also show that such clustering measurements and the halo model may be used to directly link galaxies at different epochs. Using this method, I find that the stellar mass assembly rate of galaxies depends strongly on their stellar mass (or halo mass), with the most massive galaxies increasing their mass at the slowest rate over this period.

2.31 Measuring star formation and stellar populations at $z = 1$-2 with infrared spectroscopy from HST

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Abstract

As astronomers' focus on galaxy evolution moves to higher redshift, faint galaxy spectra in the near-IR become important, but are made difficult by the atmosphere. Slitless spectroscopy with HST's WFC3-IR provides spectra that are low resolution but very sensitive and with high multiplex advantage. I will discuss results from WFC3-IR grism surveys, including: i) Comparison of star formation indicators between H-alpha, far-IR, and [O II] at $z = 1$, biases in SFR indicators, and the implications for obscuration in star forming galaxies. ii) Measurements of diameters of the star forming region in $z \sim 1$ galaxies, using the spatial resolution of HST, and the nature of IR-luminous galaxies at $z \sim 1$ – is star formation in IR-luminous galaxies centrally concentrated or spread out in a disk? iii) Continuum spectroscopy of passive and reddened galaxies at $z \sim 2$ and results from modeling their stellar populations.

2.32 On the puzzling plateau in the specific star formation rate at $z = 2$-7

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Abstract

The indications for a constant specific star-formation rate (sSFR) at a given stellar mass throughout the redshift range $z = 2$-7, as found by Gonzalez et al. (2010), Stark et al. (2009) and others, are puzzling in the context of current galaxy-formation models. Since the predicted specific dark matter accretion rate increases steeply towards earlier time, and the dynamical timescale for star formation decreases, current semi-analytical models and SPH simulations predict that the sSFR increases significantly with redshift. Despite the tentative nature of the observational data, this marked conflict with theory motivates a study of their implications. Using the simplified semi-analytical model presented by Neistein & Weinmann (2010) we show that the sSFR plateau can be reproduced by non-trivial modifications to the standard models. These modifications include a time-dependence of the star formation efficiency and/or feedback, which makes star formation at high redshift inefficient, followed by a period around $z = 2$ where gas accreted earlier is consumed. We find that it is difficult to simulateously reproduce both the plateau and the presence of massive galaxies by $z = 2$, unless the assembly of galaxies by mergers, or the strength of merger-induced bursts, is increased compared to standard models.

2.33 Substructure and stellar populations in $z \sim 1$-3 galaxies using a pixel colour approach: systematics

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Abstract

Spatially resolved studies of stellar populations and substructure in $z \sim 1$-3 galaxies provide important insights into the formation history of these objects. While this can be approached using spatially resolved spectroscopy using integral field units (as has been done in a number of studies), the colors of subcomponents of galaxies also provide a way to unveil the underlying stellar populations, potentially for large samples of these high-redshift objects. I use approximately 500 galaxies in the GOODS-VIMOS survey which have multi-band ACS imaging and spectroscopic redshifts, in order to study the systematic effects in extracting properties of resolved stellar populations (such as their age, dust, metallicity and star formation rate) in individual pixels, from their colors using the 'pixel-z' method (Welikala et al. 2008, 2009). I analyse systematics in the technique, including those that arise from differences in input stellar population synthesis models whose SEDs are fit to the pixel colors. The systematic uncertainties in the derived stellar population properties are compared to the statistical ones, pixel-by-pixel, and their distribution over the galaxy sample is characterised. I show that systematic uncertainties arising from model differences can be well constrained with the available optical data. I also examine the systematic effects of combining the optical data with near-infrared colors.

2.34 Quiescent galaxies through cosmic time from (ultra-) low resolution NIR spectroscopy

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Abstract

We have performed a unique near-IR medium bandwidth survey of the AEGIS and COSMOS fields. The NEWFIRM Medium-Band Survey (NMBS) gives redshifts accurate to 1-2% for 4000 galaxies at $z = 0.5$–3. We show evidence for a clear bimodal color distribution between quiescent and star-forming galaxies that persists to $z \sim 3$, a higher redshift than has been probed so far. Additionally, we measure an increase in the intrinsic scatter of the rest-frame U–V colors of massive, quiescent galaxies in the NMBS out to $z \sim 2$. This scatter in color arises from the spread in ages of the quiescent galaxies, where we see both quiescent red, old galaxies and quiescent blue, younger (post-starburst) galaxies toward higher redshift.Finally, we confirm the quality of the NMBS redshifts and stellar population parameters of a sub-sample of these massive, quiescent galaxies using HST/WFC3 grism data from the 3D-HST survey.

2.35 Probing the Dust Obscuration of Star Forming Galaxies Over Cosmic History

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Abstract

The ultraviolet luminosity can be used as a robust diagnostic of the ongoing star formation activity in galaxies. This is particularly useful at very-high redshift where the rest-frame UV is shifted into the observed optical/Near-IR. However, some fraction of the UV continuum light is reprocessed by dust. Star formation rates inferred from the observed UV luminosity then only represent lower limits on the intrinsic star formation rate. While several techniques exist for obtaining the intrinsic star formation rates of galaxies (e.g. combining UV measurements with Far-IR, H-alpha luminosities corrected using the Balmer decrement, etc.), these are typically only accessible to moderate redshifts for large samples of galaxies. One alternative is to correct the observed UV luminosity using observations of the UV continuum slope which is both theoretically and empirically found to be sensitive to the degree of dust extinction. In this work I'll present the results of a collection of studies aimed at measuring the redshift evolution and luminosity dependence of the rest-frame UV continuum colours. Further, I'll discuss in detail the interpretation of these colours utilising galaxy formation models. In addition, I'll briefly discuss an alternative strategy for constraining the fraction of obscured star formation using the ocally observed Cosmic spectral energy distribition (CSED) combined with the observed UV luminosity density history. Combining these two observations allow us to place strong constraints on the average fraction of obscured star formation over Cosmic history.

2.36 Clumpy Star-formation at $z = 1.5$ in the WiggleZ Dark Energy Survey

Ms Emily Wisnioski | Swinburne University of Technology
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Abstract

I will present the results from a new sample of Hα galaxy kinematics revealing that even the most extreme SFRs at $z = 1.5$ appear to take place in disks rather than mergers. The sample consists of 13 star-forming galaxies from the WiggleZ Dark Energy Survey with $z = 1.2 - 1.5$ and stellar mass $9.8 < \log(M_*[M_\odot]) < 11.6$ observed with LGS-AO on Keck to obtain spatially resolved Hα emission. With comparable intrinsic luminosities to IFU samples at $z > 2$ we achieve higher spatial resolution and comparable signal-to-noise in a much shorter exposure time. We detect multiple emission, 1–2 kpc size sub-components, or 'clumps' within the Hα spatial emission which extends over 6–10 kpc in 4 of the galaxies. We find evidence of ordered orbital motion in the majority of galaxies as would be found in unstable gaseous disks. This unique data set is indicative that a different mode of star formation could be feeding gas to galaxies at $z > 1$ and lends support to theories of cold dense gas flows from the IGM.

2.37 A resolved view on the SFR-mass diagram at $1 < z < 3$

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Abstract

The existence of a fairly tight relation between star formation rate and stellar mass out to $z \sim 3$ is one of the key results from extragalactic surveys in recent years. This relation has profound implications on our understanding of the dominant mechanisms driving star formation. In particular, the scatter and zeropoint evolution of this main sequence of star formation provides important clues on star formation histories, which proceed predominantly in a fairly continuous fashion. Here, we refine the measurement of the SFR-mass relation and add a new, resolved dimension. We first establish a set of carefully cross-calibrated SFR indicators including Herschel/PACS photometry from the PEP survey, and use it to construct the SFR-mass diagram. We then exploit high-resolution ACS and WFC3 data from the COSMOS, GOODS, ERS2, and CANDELS surveys to quantify variations in galaxy structure along and across the main sequence, revealing a link between the level and mode of star formation. We present resolved stellar mass, stellar age and SFR maps of $z \sim 2$ galaxies based on stellar population modeling on a pixel-by-pixel basis of the 7-band ACS + WFC3 imaging in GOODS-South. We describe how the resolved stellar populations vary as a function of position in the SFR-mass diagram, and demonstrate how resolved SED modeling also improves estimates of integrated stellar population properties, such as the galaxy-averaged stellar age.

3.1 The Evolution of the Velocity Dispersion Function

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Abstract

The distribution of the stellar velocity dispersions of galaxies, or the Velocity Dispersion Function (VDF) has been measured locally using dynamical measurements from the Sloan Digital Sky Survey. The evolution of the VDF places constraints on models for galaxy formation and even cosmology. Direct studies of the VDF are difficult at high redshift as they require velocity dispersion measurements of many thousands of galaxies. In this paper we present a study of the evolution of the VDF using photometric data from the UDS and NMBS COSMOS Surveys. We begin by calibrating the relation between measured central velocity dispersion and the velocity dispersion inferred by the stellar mass, effective radius and Sersic index of galaxies in the SDSS. We apply this relation to galaxies in the photometric surveys and examine the inferred VDF as a function of redshift. The VDF at $z \sim 0.5$ is very similar to the VDF at $z = 0$. At higher redshift, we find that the number density of galaxies with dispersions < 200 km/s decreases, but the number of high dispersion galaxies is constant or even increases. At fixed cumulative number density, the velocity dispersions of galaxies with $N > 5 \times 10^{-6}$ Mpc^{-3} decrease with redshift by a factor of ~ 1.7 from $z \sim 0 - 1.5$, whereas the dispersions of galaxies $> 5 \times 10^{-5}$ Mpc^{-3} are approximately constant. Above 5×10^{-4} Mpc^{-3}, velocity dispersions appear to have been even at high redshift. The analysis encompasses a number of sources of uncertainty and we suggest several avenues for further calibration of inferred velocity dispersion.

3.2 Random Galaxy catalogues

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Abstract

We present a Maximum Likelihood method of jointly determining, from a galaxy redshift catalogue, both the luminosity function (LF) and the overdensity as a function of redshift. One utility of this approach, which we focus on in this paper, is to develop a simple algorithm to produce random (unclustered) versions of the original galaxy catalogue. The algorithm works by cloning each galaxy in the original catalogue with the number of clones determined by the Maximum Likelihood solution. Each of these cloned galaxies is then assigned a random redshift uniformly distributed over the accessible survey volume, taking account of the survey magnitude limit(s) and optionally both luminosity and number density evolution. The resulting random catalogues, which can be employed in traditional estimates of galaxy clustering, make fuller use of the information available in the original catalogue and hence are superior to simply fitting a functional form to the observed redshift distribution. They are particular suited to studies of the dependence of galaxy clustering on galaxy properties as each galaxy in the random catalogue has the same list of properties as were measured for the galaxies in the genuine catalogue. The derivation of the joint overdensity and LF estimator reveals the limit in which the Maximum Likelihood estimate reduces to the standard 1/Vmax LF estimate. Namely when one makes the prior assumption that the are no fluctuations in the radial overdensity. The new ML estimator can be viewed as a generalization of the 1/Vmax estimate in which Vmax is replaced by a density corrected Vdc,max.

3.3 Evolution of the Elliptical Galaxy Luminosity Function Since z = 1

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Abstract

We have visually classified galaxies in existing *Hubble Space Telescope* images of the Extended Groth Strip. The classifications are directly comparable to those used for nearby galaxies and are not based on colors or other proxies. Ground-based spectroscopic and photometric redshifts allow us to define complete samples of galaxies of various morphological types at z $\sim$ 1. Complementary imaging with the *Spitzer Space Telescope* gives magnitudes at rest-frame 2.2-μm a wavelength that closely reflects stellar mass. The combined data allow the luminosity function to be computed for each morphological type and compared to local ones. Some morphological types show evidence for significant evolution whereas others do not. We compare the observed evolution with that predicted by the GALFORM semi-analytic galaxy evolution model, the results of which will be presented at the meeting.

3.4 First results from the VIMOS Public Extragalactic Redshift Survey

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Abstract

The VIMOS Public Extragalactic Redshift Survey (VIPERS) is an ongoing ESO Large Program to map in detail the spatial distribution of galaxies and to measure its statistical properties and related cosmological parameters over an unprecedented volume of the Universe at $0.5 < z < 1.2$ (Guzzo et al. 2011). Based on 5-band accurate photometry from the CFHTLS, VIPERS is using VIMOS at the VLT to measure 100,000 redshifts for galaxies down to $I_{AB} < 22.5$ over an area of $\sim$24 deg^2. This is the largest galaxy redshift survey ever performed at ESO and is comparable to the 2dF Galaxy Redshift Survey in the local Universe. There is a great synergy with other surveys at various wavelengths, such as e.g. GALEX, UKIDSS, VISTA, SWIRE, VLA, XMM-LSS.

We will give an update on the current status of the project and will present the first results based on the VIPERS EDR. We construct the redshift space two-point correlation function and give constraints on the bias parameter. Further, we show the first detailed spatial clustering of galaxies between 0.5<z<1 and give results on our search for overdense structures within the observed fields.

3.5 The Satellite Luminosity Functions of Galaxies in SDSS

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Abstract

We study the luminosity function of satellite galaxies around isolated primaries using the Sloan Digital Sky Survey (SDSS) spectroscopic and photometric galaxy samples. We select isolated primaries from the spectroscopic sample and search for potential satellites in the much deeper photometric sample. For primaries of similar luminosity to the Milky Way and M31, we are able to stack as many as $\sim$ 20, 000 galaxy systems to obtain robust statistical results. We derive the satellite luminosity function extending almost 8 magnitudes fainter than the primary galaxy. We also determine how the satellite luminosity function varies with the luminosity, colour and concentration of the primary. We find that, in the mean, isolated primaries of comparable luminosity to the Milky Way and M31 contain about a factor of two fewer satellites brighter than MV = -14 than the average of the Milky Way and M31.

3.6 Halo Gas and Galaxy Disk Kinematics of MgII Absorption Selected

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Abstract

MgII absorption lines detected in the spectra of background quasars allow us to probe the cool metal-enriched halo gas associated with foreground galaxies. This technique allows us to directly study the complex nature of halo gas which consists of the fuel for star-forming disks and is likely dynamically driven by gas ejected by supernovae and stellar winds, minor mergers, and inflow via filaments. In an effort to gain an understanding of how halos are built and evolve in a cosmological context, We perform the first detailed comparison of the properties (i.e. colour, SFR, morphology, kinematics) of galaxies hosted by MgII absorption systems at z=0.1. We find MgII host galaxies have little-to-no star formation and reside in isolated environments, making them ideal test cases for differentiating between models of gas accretion and extended, dynamically-stable disks. We find that even at 100 kpc from the host galaxy, halo gas retains a clear signature of co-rotation with the host galaxy disk. However many systems exhibit distinct velocity components that are inconsistent with simple lagging halo models, and may be a signature of the gas accretion which is fueling low levels of host galaxy star formation.

3.7 Hα Dots

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Abstract

Hα dots are extragalactic emission-line sources recently discovered in images taken as part of a narrow-band Hα survey, which is a follow-up optical survey based on the HI ALFALFA radio survey (Giovenelli et al. 2005). In order to investigate the nature of these Hα dots, we wrote a software package in IRAF to systematically search all of our Hα images and obtain a complete sample of the Hα dots. To date, we have detected 158 Hα dots. Based on follow-up spectra, we determined that the Hα dots are a combination of (1) low-luminosity star-forming galaxies ($z = 0.006$ to $z = 0.02$), (2) isolated extra-galactic HII regions, and (3) background objects ($z = 0.3$–3.3) where another strong emission-line, such as [OIII]5007, has redshifted into the Hα filter. The background objects are a combination of star-forming regions and AGN. Some of the low-redshift star-forming Hα dots are metal poor (with metallicities as low as log(O/H) $+12 = 7.62$). It is possible that these low-redshift Hα dots are unable to retain their metals because they are low mass. The Hα dots can add to our understanding of the formation and evolution of low-luminosity galaxies.

3.8 Probing Galactic Outflows and Infall with Lyman Limit Systems at $z < 1$

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Abstract

Lyman limit systems are clearly seen to trace phenomena associated with the circulation of matter into and out of galaxies. They therefore provide a path for studying the metallicity distribution of circumgalactic gas in an "unbiased" manner. This can yield a measure of the covering factor for infalling streams vs. outflowing winds as a function of redshift. Here we show and discuss the distribution of the metallicity of LLS at $z < 1$ based on recent observations from the Cosmic Origins Spectrograph.

3.9 Tracing the Assembly of Present-Day Star Forming Galaxies

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Abstract

We attempt to compile a concordant picture of the assembly and evolution of actively star forming galaxies (SFGs) today. We first constrain the star formation history of these galaxies by adopting a simple, data-driven framework, which traces the evolution of SFGs as they evolve in mass and redshift, and applying that framework to recent multi-epoch star formation rate observations from Herschel and VLA-COSMOS analysis. We then confront these constraints with VESPA's archaeological analysis of the fossil record of SDSS Data Release 7. Finally, we will highlight and parse outstanding differences between the two methods for understanding the growth of SFGs, which are now systematic in nature and persist down to $z \sim 1$.

3.10 A Search for Young Metal-poor Galaxies at Intermediate Redshifts

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Abstract

Identifying and studying galaxies in their earliest stages of formation is an important step towards testing cosmological models of galaxy formation. Future facilities and observatories aim to search at $z > 7$ for these extremely young galaxies that are thought to be responsible for cosmic reionization. These young galaxies are often characterized by extremely metal poor metallicities (less than 0.1 solar, for example) and high star formation. While it is important to find the earliest galaxies that formed, searching for lower redshift analogs will permit detailed studies of their morphologies, gas metallicities and the states of their ISM, and kinematics. I will present a new survey that we are conducting to search for metal-poor galaxies at $z \sim 0.8$. We use narrow-band imaging to identify galaxies with extremely high emission-line equivalent widths. These emission lines fall outside the narrow-band filter and produce a significant excess in the broad-band imaging. Due to the rarity of such galaxies, we cover a wide volume by probing a large redshift range ($dz \sim 0.3$) and surveying three independent fields, COSMOS, Subaru Deep Field, and Subaru-XMM Deep Survey. This survey is a couple of orders of magnitude larger than past surveys (Hu et al.). I will also discuss future follow-up spectroscopy with Keck, which is crucial to confirm their low metallicities by detecting [O III] 4363.

3.11 Velocity Dispersions and Stellar Populations of the $z = 1$ Most Compact and Massive ETG's

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Abstract

We present GTC/OSIRIS spectra of 4 of the most compact and massive early-type galaxies at redshift $z \sim 1$, with effective radii $R_e = 0.5 - 2.4$ kpc and photometric stellar masses $M_\star = 1.2 - 4 \cdot 10^{11} M_\odot$. The spectra are best fitted by SSP models with approximately 1 Gyr of age and solar metallicity. We find these galaxies have velocity dispersions $\sigma_e \sim 143 - 221$ km/s, yielding dynamical masses up to 10 times smaller than their stellar mass estimates. We model the passive luminosity evolution of these galaxies and find that this mechanism by itself is inconsistent with the local mass-size and Fundamental Plane relations. When dynamical masses are considered, we show that a combination of fading and size/mass evolution via minor mergers is consistent with both local relations. We conclude that: i) the stellar masses of these galaxies are likely being overestimated by a factor of ~ 7. If confirmed for other similar galaxies, this result would argue against the strong mass-size evolution proposed for these extreme objects since $z = 1$; ii) passive luminosity fading combined with mass/size growth due to minor mergers can plausibly evolve our objects to match the properties of the local population of early-type galaxies.

3.12 The Morphology of Galaxies in the Baryon Oscillation Spectroscopic Survey

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Abstract

We study the morphology and size of the luminous and massive galaxies at $0.3 < z < 0.7$ targeted in the Baryon Oscillation Spectroscopic Survey (BOSS) using publicly available Hubble Space Telescope (HST) imaging, and catalogues, from the COSMic Origins Survey (COSMOS). Our sample (240 objects) provides a unique opportunity to check the visual morphology of these galaxies which were targeted based solely on stellar population modelling. We find that the majority of BOSS galaxies ($74 \pm 6\%$) possess an early-type morphology (elliptical or lenticular), while the remainder have a late-type (spiral disc) morphology. This is as expected from the goals of the BOSS target selection criteria which aimed to predominantly select slowly evolving galaxies, for use as cosmological probes, while still obtaining a fair fraction of actively star forming galaxies for galaxy evolution studies. We show that a colour cut of (g-i)> 2.35 is able to select a sub-sample of BOSS galaxies with $>$90% early-type morphology and thus more comparable to the earlier Luminous Red Galaxy (LRG) samples of SDSS-I/II. The remaining 10% of galaxies above this (g-i) cut have a late-type morphology and may be analogous to the "passive spirals" found at lower redshift. We find that $23 \pm 4\%$ of the early-type BOSS galaxies are unresolved multiple systems in the SDSS imaging. We estimate that at least 50% of these multiples are likely real associations and not projection effects and may represent a significant "dry merger" fraction, most likely dominated by minor mergers. We compare the SDSS pipeline sizes of BOSS galaxies which we find to be systematically larger (by 40%) than those measured from HST images, and provide a statistical correction for the difference. These details of the BOSS galaxies will help users of the BOSS data fine-tune their selection criteria, dependent on their science applications. For example, the main goal of BOSS is to measure the cosmic distance scale and expansion rate of the Universe to percent-level precision – a point where systematic effects due to the details of target selection may become important.

3.13 Paschen Star Formation History of the Universe

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Abstract

The study of the star formation history of the Universe and of the star formation rate as a function of epoch is crucial for the understanding of galaxy formation and evolution, however the star formation (SF) indicators are numerous. H-alpha is a well calibrated SF tracer in the nearby Universe, although, like all Balmer lines, is dust obscured. HiZELS (High-z Emission Line Survey) has found, in its narrow-band K filter, a wide-range of line emitters, of which about half are potential non-H-alpha emitting galaxies and among those some are likely Paschen (Pa) line emitters at redshifts 0.13 (Paα), 0.66 (Pa-beta) and 0.95 (Paγ). Because the lines in the Pa series are essentially unaffected by dust, these could become an alternative to H-alpha and be used as SF tracers. Hence, we aim at obtaining the first-ever derived SF rate history from Pa emitters and compare with the existing luminosity functions derived from H-alpha within HiZELS. Moreover, these Pa emitting galaxies are expected to yield some constraints on the low z ($0 < z < 1$) end of the H-alpha luminosity function. We present the early results from a spectroscopic campaign using the AAOmega instrument to confirm the identifications of these non-H-alpha emitters, and Paschen luminosity functions derived using these and photometric redshifts.

3.14 Chain galaxies in the COSMOS field

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Abstract

Galaxies with unusual morphological structures have been discovered by recent deep and high resolution observations. Chain galaxies are one of such examples with unusual morphology. They are characterized by elongated knotty structures without bulges. They are first discovered by the Hubble space telescope (HST) thanks to its high resolution (Cowie et al. 1995). Since then, approximately 200 chain galaxies have been discovered with the HST at high redshift universe (van den Bergh et al. 1996, Elmegreen et al. 2004, 2005, 2006, Miley et al. 2006). Although some models to explain their structures and formation have been proposed (Noguchi 1998, Taniguchi & Shioya 2001, Immeli et al. 2004, Dekel et al. 2009), their origin is still controversial and remains mysterious. This is partly because of the small sample size used in previous studies. Hence it is crucial to examine much larger sample of chain galaxies for further understanding. For this purpose, we searched chain galaxies based on the HST ACS i-band data in the COSMOS field, which is nearly 10 times larger than those of previous studies. We selected geometrically thin galaxies in appearance with I $<$ 23 AB magnitude from the COSMOS/ACS catalog (Leauthaud et al. 2006).Then, we checked their morphology by eyeball inspection. Consequently, we found almost 100 chain galaxy candidates in the COSMOS field. We would like to show you some examples of the candidates and discuss their properties.

3.15 Secular Evolution of Galaxies

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Abstract

The role of bars in driving secular evolution of galaxies is still highly debated. Studies on the fraction of barred galaxies in the local universe, their evolution with redshift, and their role in building bulges and triggering AGN have not yielded consistent results. Recently, Nair & Abraham (2010) using their sample of $\sim$14,000 visually classified galaxies were able to reconcile the disparity in local bar fractions. In this work, I will extend the analysis to high-redshift, using a sample of $\sim$20,000 equally detailed visual classifications from the zCOSMOS survey (Lilly et. al. 2007). In addition, I will present results on the impact of bars on the metallicity evolution of galaxies and their correlations with AGN activity.

3.16 Studying Galaxy Evolution with DEEP2 and DEEP3

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Abstract

The recently completed DEEP2 and DEEP3 Galaxy Redshift Surveys provide unique datasets for studying the evolution of galaxies within the context of their underlying dark matter halos. These datasets will soon be strengthened via deep CANDELS imaging in the Extended Groth Strip. In this talk, I will summarize the current status of the surveys and present recent results on the relationships between star formation history, AGN activity, and the environments in which galaxies are found.

3.17 The Star Formation Rate-Density Relation at $0.6 < z < 0.9$ and the Role of Star Forming Galaxies

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Abstract

We study the star formation rates (SFRs) of galaxies as a function of local galaxy density at $0.6 < z < 0.9$. We used a low-dispersion prism in IMACS on the 6.5 m Baade (Magellan I) telescope to obtain spectra and measured redshifts to a precision of $\sigma_z/(1+z) \sim 0.01$ for galaxies with $z_{\rm AB} < 23.3$ mag. We utilized a stellar mass-limited sample of 986 galaxies above $M > 1.8 \times 10^{10}\ M_{\odot}$ to conduct our main analysis. With three different SFR indicators, (1) Spitzer MIPS 24 μm imaging, (2) SED fitting, and (3) [OII]3727 emission, we find the median specific SFR (SSFR) and SFR to decline from the low-density field to the cores of groups and a rich cluster. This result holds even when looking at galaxies at a fixed stellar mass. For the SED and [OII] based SFRs, the decline in SSFR is roughly an order of magnitude while for the MIPS based SFRs, the decline is a factor of ~ 4. We find approximately the same magnitude of decline in SSFR even after removing the sample of galaxies near the cluster. Galaxies in groups and a cluster at these redshifts therefore have lower star formation (SF) activity than galaxies in the field, as is the case at $z \sim 0$. We find that the decline in the SSFR-density relation at $0.6 < z < 0.9$ is driven by both a combination of declining SFRs of star forming galaxies (SFGs) as well as a changing mix of SFGs and quiescent galaxies.

3.18 Connecting the galaxy stellar/baryon mass function and galaxy scaling laws

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Abstract

The baryon mass-to-halo mass ratio (baryon fraction) required to match the observed baryon mass function encloses all the key ingredients of the galaxy formation and evolution processes. We infer this baryon fraction for late- and early-type galaxies by matching the corresponding cumulative observed galaxy baryon mass function to their corresponding cumulative halo mass function (HMF). For halos hosting late-type galaxies, we subtract from the total HMF the observed group/cluster mass function as well as those halos with a central major merger since redshift $<$0.8. For halos hosting early-type galaxies, we used the complement of this function to the total. Finally, the resulting baryon fractions were used as an input in galaxy population models in order to study its consistency with structural and dynamical scaling relations for disk and bulge dominated galaxies.

3.19 Rejuvenated Early-type Galaxies at $z \sim 0.1$

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Abstract

In recent years a significant fraction of early-type galaxies (ETGs) in the local universe was found to exhibit low levels (< 1 $M_\odot$/yr) of star formation that causes strong excess in the UV flux, yet leaves the optical colors red. Many of these studies were based on GALEX imaging of SDSS galaxies ($z \sim 0.1$), and were thus limited by its 5" FWHM. Poor UV resolution left other possibilities for UV excess open, such as the old populations or an AGN. We present high-resolution far-ultraviolet HST/ACS images of optically quiescent early-type galaxies with strong UV excess. The new images show that three-quarters of these moderately massive ($\sim 5 \times 10^{10}$ $M_\odot$) ETGs shows clear evidence of extended SF, usually in the form of wide or concentric UV rings. UV-excess ETGs have on average less dust and larger UV sizes ($D > 40$ kpc) than other green-valley galaxies, which argues for an external origin for the gas that is driving the SF. Thus, most of these galaxies appear "rejuvenated" Possible rejuvenation mechanisms include minor gas-rich mergers and intergalactic medium ("cosmic web") accretion. Further details are given in Salim & Rich (2011).

3.20 Size Does Matter: the SFI++ Size-Luminosity Relation and the Spins of Halos Hosting Sc Galaxies

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Abstract

We derive scaling relations between the sizes, luminosities, and rotation velocities of ∼4000 late-type disk galaxies from the SFI++ catalogue, in order to constrain models of galaxy formation and evolution. We focus on the size-luminosity (RL) and size-rotation velocity (RV) relations, and show that using homogeneously derived, inclination-corrected isophotal radii instead of disk scale lengths produces significantly tighter relations than previously reported. In particular, the scatter in the SFI++ RL relation is 2.5–4 times smaller than found for other large galaxy samples: we demonstrate that this improvement stems from the reliability of measured isophotal radii relative to disk scale lengths. Detailed error budgets that account for correlated measurement errors suggest that the intrinsic scatter in the RL relation is independent of luminosity. Combining the small intrinsic scatter of the SFI++ RL relation with a simple model for disk galaxy formation, we find that the range of disk spin parameters allowed by the data is at least ~ 7 times smaller than that of the halo spin parameters produced in cosmological simulations. Unless angular momentum redistribution in late-type disks is more effective than current models suggest, this discrepancy implies that the halos hosting Sc galaxies have a much narrower distribution of spin parameters than cosmology predicts.

3.21 The evolution of brightest cluster galaxies

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Abstract

Brightest Cluster Galaxies (BCGs) are the most luminous and massive galaxies observed from $z \sim 1.5$ to $z = 0$. The general consensus for these objects, mainly based on SED-fitting techniques, is that they are old and passively evolving, and very massive. Recently, Collins et al. (Nature, 2009) claimed that hierarchical models cannot reproduce the observables of these galaxies, the main cause residing in their early fast assembly and late passive evolution. We studied the properties of BCGs in the Croton et al. (2006) model, based on the Millennium simulation, equipped with a photometric model based on Maraston (2005). While it is true that model BCGs are not passively evolving and form most of theirs stars over a wide range of epochs, nonetheless the evolution of colors and luminosity correctly reproduces the data. This suggests that the interpretation of these objects as "red & dead" is not the only viable option, and that our understanding of these systems is far from being complete.

3.22 The hierarchical origins of observed galaxy morphology

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Abstract

The history of a galaxy is encoded in its morphology: the angular momentum and dissipative properties of gas leads to the formation of a disk, within which stars form; mergers of galaxies and tidal interactions randomize stellar orbits, forming a bulge; and the presence or lack of a gas disk drives the level of disk star formation and (apparently) spiral features. The history of a galaxy is also encoded in its environment: sub-halos and their galaxies rarely merge, except at the bottom of the potential well (the centre of the main halo) in which they live; and gas disks and the hot gas which feeds them can only be stripped in a dense surrounding medium, found only in massive haloes. To distinguish the mechanisms driving galaxy evolution, we examine the halo and stellar mass dependence of morphology separately for central and satellite galaxies at $z \sim 0$. We place constraints on evolution utilizing a variety of physical prescriptions applied to two different semi-analytic models and compared to a local SDSS-RC3 matched sample. We find ellipticals primarily in massive galaxies, and at the centre of $\geq 10^{13}$ solar mass haloes, compatible with expectations of bulge growth in mergers; S0s and passive disk galaxies are created via two independent channels: as central galaxies, with star formation suppressed possibly as a result of AGN feedback, and as satellite galaxies in $\geq 10^{13}$ solar mass haloes in which stripping of the hot gas associated to a galaxy is probably responsible for the suppression.

3.23 The Cosmic Web and galaxy evolution around the most X-ray luminous cluster

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Abstract

We present results of our ongoing photometric and spectroscopic campaign centered on the most X-ray luminous cluster: RXJ1347.5-1145 at z=0.45. We use photometric redshifts derived from ugriz CFHT MEGACAM photometry together with VIMOS VLT spectroscopy to identify and characterize structures around this cluster on a scale of 20x20 Mpc. We use GALEX 9ks imaging to study the star-formation status of cluster members. We find that the blue and star-forming fractions decline towards higher densities, but the star-forming galaxies are a constant fraction of the blue population. Furthermore, the GALEX selected star-forming galaxies have similar properties at all environments, suggesting a fast transformation. Investigating the environmental effects within the cluster, optically selected groups and the field, we find little or no correlation of the blue fraction with galaxy density for the first two types of environment. Most of the environmental signal is carried by the cluster galaxy population.

4.1 Lensing twins: probing the physics of galaxy formation with SLACS & OWLS

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Abstract

I compare the weak lensing signal, scaling relations and dark-matter fractions of 22 SLACS strong lenses with halos taken from OWLS hydrodynamical simulations that have the same einstein mass and effective radius as the observed strong lenses. We do the comparison for different galaxy formation scenarios, and find a similar weak lensing signal to the observed one for the different scenarios. We complement this with the study of their scaling relations and inner dark-matter mass fractions for which observational limits are now becoming available. Our study is the first detailed comparison between physically motivated galaxy-formation models (OWLS) and a well-selected sample of observed strong lensing galaxies (SLACS). I discuss the implications of our study on galaxy formation theories (i.e. cooling, feedback, etc) of massive early-type galaxies and in particular on studies of their stellar and dark-matter mass distributions.

4.2 Kinematic Signatures of Two-Phase Galaxy Formation

Mr Jacob Arnold | University of California, Santa Cruz
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Abstract

We present the wide-field kinematic and metallicity structure of nearby early-type galaxy bulges and stellar halos, and discuss these results in the context of inside-out/two-phase galaxy formation models. A key success of the hierarchical mass assembly paradigm is the ability of idealized merger simulations to broadly reproduce the kinematic properties of observed early-type galaxies. While these comparisons have generally been relegated to within the central half-light radius, recent advances in technology and observing methods are now extending this baseline by nearly an order of magnitude in some cases. Here, we use an extensive dataset that includes deep spectroscopy of integrated stellar-light, globular clusters, planetary nebulae and wide-field multi-band photometry. We find that some rotational profiles sharply decrease beyond a couple effective radii, contrary to general expectations for major merger remnants, as well as large scale metallicity gradients. We argue that these observations are well explained by a two-phase formation scenario where the inner regions of early-type galaxies form early in a violent dissipative phase followed by the gradual assembly of the outer parts via minor mergers.

4.3 Utilizing nature's telescope to resolve intermediate and high redshift galaxies

Ms Kaushala Bandara | University of Victoria
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Abstract

We utilize the advantages of gravitational lensing to analyze detailed properties of 62 strongly lensed galaxies in the Sloan Lens ACS (SLACS) Survey that span a redshift range of $0.1965 \leq z \leq 1.1924$ with a median redshift of $z = 0.6053$. Lensing magnification allows us to probe the properties of a galaxy population that is typically $\sim$2 magnitudes fainter in comparison to direct galaxy imaging surveys. The SLACS lens systems were initially selected based on the presence of multiple emission lines in the SDSS spectra and these systems have been imaged with HST-ACS in the broad I-band, which allows us to reliably measure the rest-frame B-band luminosities, sizes and Sersic indices of the lensed galaxies. The derived properties of the SLACS lensed galaxies show a primarily compact, "disk"-like population with the peaks of the size and Sersic index distributions corresponding to $\sim$1.0 kpc and $n \sim 1$ respectively. We compare the luminosity-size relation of the SLACS disk galaxy sample ($n \leq 2.5$) to an unprecedented local galaxy sample, which consists of 670,131 SDSS galaxies at $z \sim 0.1$. From this comparison, we find evidence that the evolution of the luminosity-size relation since $z\sim1$ cannot be explained fully by pure size evolution but must be caused by a size-dependent luminosity evolution or a combination of luminosity evolution and moderate size-growth. Our observations are consistent with previous observational and theoretical studies of the evolution of disk galaxy luminosity-size relation since $z\sim1$.

4.4 Kinematics, structure and stellar populations of disks since z=1

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Abstract

We have constructed a data set of >250 disk galaxies at redshifts up to z=1 with Very Large Telescope spectroscopy and Hubble Space Telescope imaging. We use spatially resolved rotation curves to derive maximum rotation velocities Vmax and total masses; we also investigate disk sizes, stellar population properties etc. The ratio between stellar and total mass is constant over the past 8 Gyr, favoring 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. In a recent observational campaign, we took very deep spectra of disks at the extremes of the galaxy mass function: sub-M* and super-M* spirals at a mean redshift $<z> \sim 0.5$. We will present first results of this project which aims at a better understanding of the interplay between galaxy mass and i) the evolution of scaling relations like the Tully-Fisher ii) star formation history. We will also utilize the correlation between Vmax and central velocity dispersion to study bulge growth in spirals since z=1.

4.5 Thick disks: the lair of missing baryons?

Dr Sebastien Comeron | Kasi Astronomy and Space Science Institute (KASI)
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Abstract

The ongoing Spitzer Survey of Stellar Structure in Galaxies (S^4G; Sheth et al. 2010, PASP, 122, 1397) aims to obtain space-based deep 3.6μm and 4.5μm imaging of 2331 galaxies located at a distance smaller than 40 Mpc. As the mid-infrared traces well stellar mass distribution and is not much affected by dust, the S^4G can be used to study the structure of galaxy disks in edge-on galaxies in a more accurate way than in previous studies. Most, if not all, disk galaxies have a thin (classical) disk and a thick disk. In most models thick disks are thought to be a necessary consequence of the disc formation and/or evolution of the galaxy. We will present the results of a study of the thick disk properties in a large sample of carefully selected edge-on galaxies. In this study we have fitted one-dimensional luminosity profiles with physically motivated functions, which are likely to yield more accurate results than the rather ad-hoc functions used in previous studies. We find that thick disks are on average more massive than previously reported, and that, typically, the thin and the thick disk have a similar mass amount. We will discuss the implications this result has on galaxy formation models and on the missing baryon problem.

4.6 Young Ages and other intriguing properties of Compact Massive Galaxies in the Local Universe

Miss Anna Ferre-Mateu | Instituto Astrofisica de Canarias
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Abstract

The discovery that massive galaxies in the early universe were more compact than present day counterparts has revolutionized our understanding of the assembly of these objects. Some model renditions predict the presence of a non-negligible fraction of these compact massive objects in the nearby universe. Following such expectations, several works have been conducted in order to find such relics from the early universe in our vicinity. So far, only a tiny fraction of nearby galaxies which masses and sizes similar to those found at high redshifts has been detected. Preliminary analysis of the stellar population of these objects revealed that they were surprisingly younger than expected. In this talk I will present a detailed analysis of the stellar populations, the kinematical and the morphological properties of seven of these nearby compact massive galaxies with high quality spectra (S/N$>$50) (Ferre-Mateu et al. in prep). This data allowed us to explore the star formation histories of these galaxies with accuracy, finding that all the galaxies in our sample have very tiny or none fraction of old stellar populations (having at least a contribution of 70% of young populations in light). This is unseen in all previous known normal-sized massive galaxies which are found to be typically old, while we find that for 4 of our galaxies there is no contribution either in mass or in light of old stars. We think that nearby compact massive galaxies are almost perfect counterparts in terms of mass, size and age of the massive compact galaxies found at high-z. These closer objects could open the possibility to explore the early mechanisms of the formation of massive galaxies in unprecedented detailed.

4.7 Massive Galaxy Formation as Revealed by their Globular Cluster Systems

Prof Duncan Forbes | Swinburne University
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Abstract

I review the results of 'near-field cosmology' studies using the globular cluster (GCs) systems of nearby massive galaxies. GCs trace major star formation events over all epochs, are relatively robust and offer a unique probe of the outer halos of galaxies. Starting with the Milky Way, I discuss the relative contributions of in-situ vs accreted GCs and the growth of the stellar halo. From our survey of early-type galaxies with the Subaru and Keck telescopes, I present metallicities which probe halos out to $\sim$15 effective radii. From such data we have detected the transition radius from a dissipative to accretive-dominated halo. Our data support a picture in which galaxies grow from a compact 'seed' at high redshift (akin to 'red nuggets') via the hierarchical accretion of low mass galaxies into the massive red sequence galaxies we see today.

4.8 Measuring the physical properties of galaxy components in modern multi-wavelength surveys

Dr Boris Haeussler | Univ. of Nottingham
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Abstract

Most galaxies are fundamentally multi-component systems, often comprising a spheroidal bulge and a thin disk. As these components have largely independent origins, separating their properties provides important information with which to constrain models of galaxy formation and evolution. However, current automated methods are not sufficiently developed to allow the routine use of this technique on large samples of galaxies. In this talk we introduce the MegaMorph project, in which we are developing an accurate, robust tool for measuring the key physical quantities of the individual structural components of galaxies imaged by large multi-band surveys. The primary focus of our work is the extension of current tried-and-tested galaxy fitting/decomposition techniques (e.g. GALAPAGOS & GALFIT) to fully utilise multi-band imaging, as routinely produced by modern surveys, both ground-based (e.g. GAMA/SDSS) and space-based (e.g. CANDELS/HST). Using all the available multi-colour information in the galaxy fitting process enables much more robust decompositions in terms of physically-meaningful parameters. We will also present further improvements, such as the inclusion of non-parametric components to naturally account for non-smooth galaxy features, quantifying the evidence for including each model component, and ensuring the optimisation is both robust and computationally efficient. We will demonstrate how these enhancements allows us to examine the properties and evolution of galaxy components in previously unattainable detail.

4.9 Surface Brightness Profile Breaks in Dwarf Galaxies

Dr Kimberly Herrmann | Lowell Observatory
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Abstract

Recently it has been well shown that there are three different surface brightness profile types in spiral galaxies: (I) the minority, where the light falls off with a single exponential; (II) truncated, the majority, where the light falls off with one exponential to a break radius and then falls off more steeply; and (III) anti-truncated, where the light falls off with a more shallow exponential beyond the break radius. Additionally, Bakos, Trujillo, & Pohlen (2008) showed that each type has a characteristic color trend with respect to the break location. In dwarf disk galaxies, however, there is a fourth type which is perhaps a special Type II case: the light profile is flat on the inside and then falls off exponentially beyond the break radius. We will show the different color trends for these four profile types from a large multi-wavelength photometric study of dwarf disk galaxies and explore the ramifications of the differences between spirals and dwarfs. We gratefully acknowledge funding for this research from the National Science Foundation (AST-0707563).

4.10 Dynamical bulge-disk decomposition of spiral galaxies

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Abstract

The mass of a galaxy is the most important parameter to understand its structure and evolution. The total mass we can infer by constructing dynamical models that fit the motion of the stars and gas in the galaxy. The dark matter content then follows after subtracting the luminous matter inferred from colors and/or spectra. Here, we focus on measuring the mass distribution of a sample of 18 spiral galaxies, using two-dimensional stellar and gas kinematics obtained with the integral-field spectrograph SAURON (Ganda et al. 2006). We dynamically decompose these Sb/c/d galaxies into bulge and disk components, and compare them with structural and stellar population properties. The developed techniques will be applied to PMAS/PPAK integral-field spectroscopic data of 600 nearby galaxies being obtained as part of the Calar Alto Legacy Integral Field Area survey (CALIFA). The results on the kinematic mass distribution will be connected with properties of the stars and gas to help understand the evolution of galaxies from the blue cloud to the red sequence.

4.11 The effects of the interaction on the kinematics, stellar population and metallicity of AM2322-821 with Gemini/GMOS

Dr Angela Krabbe | Universidade do Vale do Paraíba
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Abstract

We present an observational study about the impacts of the interactions in the kinematics, stellar populations, and oxygen abundances of the components of the galaxy pair AM2322-821. A fairly symmetric rotation curve for the companion (AM2322B) galaxy with a deprojected velocity amplitude of 110 km s^{-1} was obtained, and a dynamical mass of $1.1 - 1.3 \times 10^{10} M_{\odot}$ within a radius of 4 kpc was estimated using this deprojected velocity. Asymmetries in the radial velocity field were detected for the companion, very likely due the interaction between the galaxies. The interaction between the main and companion galaxies was modelled using numerical N-body/hydrodynamical simulations, with the result indicating that the current stage of the system would be about 90 Myr after perigalacticum. The spatial variation in the distribution of the stellar-population components in both galaxies was analysed using the stellar population synthesis code STARLIGHT. The companion galaxy is dominated by a very young (t $\leq 1 \times 10^8$ yr) population, with the fraction of this population to the total flux at $\lambda\,5\,870$, increasing outwards in the galaxy disc. On the other hand, the stellar population of AM 2322A is heterogeneous along the slit positions observed. Spatial profiles of oxygen abundance in the gaseous phase were obtained using two diagnostic diagrams (R_{23}=([OII]$\lambda\,3727$+[OIII] $\lambda\,4959$+[OIII] $\lambda\,5007)/\mathrm{H}\beta$ vs. [OIII]$\lambda\,5007$/[OII]$\lambda\,3727$ and [OIII]$\lambda\,5007$/[OII]$\lambda\,3727$ vs.[NII]$\lambda\,6584$/[OII]$\lambda\,3727$), where we compared the observed values with the ones obtained from photoionization models. Such gradients of oxygen abundance are significantly flatter for this pair of galaxies than in typical isolated spiral galaxies. This metallicity distribution is interpreted as the gradients having been destroyed by interaction-induced gas flows from the outer parts to the centre of the galaxy.

4.12 Spatially resolved star-formation in nearby early-type galaxies

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Abstract

I will present the spatially resolved stellar population analysis of the absorption line strength maps for 48 nearby early-type galaxies from the SAURON survey (Kuntschner et al. 2010, MNRAS, 408, 97). Remarkably, ∼40% of the galaxies show signs of a contribution from a young stellar population. The most extreme cases of post-starburst galaxies, with SSP-equivalent ages of ≤ 3 Gyr observed over the full field-of-view covering about the half light radius are restricted to low mass systems (∼2 $\times 10^{10} M_{\odot}$). Spatially restricted cases of young stellar populations in circumnuclear regions can almost exclusively be linked to the presence of star-formation in a thin, dusty disk/ring, also seen in the near-UV or mid-IR on top of an older underlying stellar population. The flattened components with disk-like kinematics previously identified in all fast rotators are shown to be connected to regions of distinct stellar populations. These range from the young, still star-forming circumnuclear disks and rings with increased metallicity preferentially found in intermediate-mass fast rotators, to apparently old and more massive structures with extended disk-like kinematics, which are observed to have an increased metallicity and mildly depressed [α/Fe] ratio compared to the main body of the galaxy.

Using radially averaged stellar population gradients we find a mass - metallicity-gradient relation where the most massive systems, being slow-rotators, exhibit the shallowest metallicity gradients. This is interpreted as a consequence of the competition between different star-formation and assembly scenarios following a general trend of diminishing gas fractions and more equal mass mergers with increasing mass, leading to the most massive systems being devoid of ordered motion and signs of recent star-formation.

4.13 The impact of bars on axisymmetric modelling of galaxies

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Abstract

A large fraction of disk galaxies (spirals, lenticulars) harbour tumbling bars, which significantly affect their dynamics and evolution. The Atlas3D volume-limited sample provides a unique benchmark on which to test the impact of bars, specifically on the dynamical modelling of such systems and the influence of a bar on the star formation and metals re-distribution. We have therefore built a library of N-body models for various mass distribution, kinematics, gas fraction and metallicity distributions. These simulations allowed us to investigate the recovery accuracy of basic stellar dynamical parameters determined from anisotropic Jeans axisymmetric models. We uncover some systematic biases in the recovered values for M/L and the velocity dispersion anisotropy due to the presence of the bar. We then show how this applies to the high quality Atlas3D dataset, and how such high resolution numerical simulations allow us to better understand the dynamical and stellar population evolutions in barred early-type systems.

4.14 Total magnitude superior to bulge magnitude as Black Hole mass predictor

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Abstract

The correlation between masses (M_{BH}) of central Supermassive Black Holes (SMBH) and the bulge luminosities (L_{bul}) of their host galaxies has been widely used as a SMBH mass predictor in black hole demographic studies and as a constraint in galaxy evolution models. It has been claimed that its intrinsic scatter even matches that of the $M_{BH} - \sigma$ relation, in both optical and near-infrared (NIR) bands. These relations were based on either poorly resolved and relatively shallow data (2MASS), or on inhomogeneous data sets with mixed techniques of measuring L_{bul}. By means of new, deep and highly resolved wide-field NIR imaging, a dedicated NIR-sky substraction procedure, and detailed 2D image decomposition, we extract bulge and total magnitudes from a galaxy sample spanning all morphological types. We show that: - the intrinsic scatter of the $M_{BH} - L_{bul}$ relation is at least as high as that from relating M_{BH} to the *total* luminosity - bulge magnitudes often differ considerably from published values - the low intrinsic scatters given in the literature are a result of cropped samples - bulges cannot be reliably extracted via a 'standard' bulge+disk decomposition in most cases - even with high-quality data and detailed decompositions provided, ambiguity in determining L_{bul} often remains. In conclusion, usage of bulge magnitudes as SMBH mass indicator is practically inferior to total magnitudes, and questionable as a "fundamental" relation of galaxy-SMBH co-evolution.

4.15 HST Pixel Analysis of the interacting galaxy system M51

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Abstract

A pixel analysis is carried out on the interacting galaxy system M51 (NGC 5194 + 5195), using the HST/ACS images in the F435W, F555W and F814W (BVI) bands. After 4 by 4 binning of the HST/ACS images to secure sufficient signal-to-noise ratio for each pixel, we derive several quantities describing the pixel color-magnitude diagram (pCMD) of M51, such as blue/red color cut, red pixel sequence parameters, blue pixel sequence parameters and blue-to-red pixel ratio. Those parameters reflect the internal properties of M51 such as age, metallicity, dust content and galaxy morphology, and are expected to be useful for quantitative comparisons of the pCMD features between different galaxies. To investigate the spatial distributions of stellar populations, we divide pixel stellar populations using the pixel color-color diagram and population synthesis models. As a result, we find that the spiral arm pattern and the tidal interaction significantly affect the stellar populations in their dust content and mean stellar age. In addition, we find that the pixels corresponding to the central active galactic nucleus (AGN) area of NGC 5194 show a tight sequence at the bright-end of the pCMD, of which spatial extent is R$\sim$100 pc, which may be a photometric indicator of AGN properties.

4.16 Radial Gradients and Disc Formation in Spiral Galaxies

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Abstract

Radial abundance gradients are a common feature of spiral galaxies, including the Milky Way, Andromeda and other objects in the Local Group and beyond. These gradients can be observed in several objects, such as HII regions, planetary nebulae and stars, and are very probably linked to the formation process of the galactic disc. Recent determinations of the gradients for elements such as Fe, O, Ne, Ar and S suggest that there are differences between the gradients derived from younger objects, e.g. HII regions and young stars, and those determined from intermediate and older objects, such as planetary nebulae and open clusters. In this work, we present new determinations of the gradients from intermediate age planetary nebulae and compare the results with those derived from other objects. Individual ages are estimated for the planetary nebula central stars on the basis of age-metallicity relations as well as using their kinematic properties, so that a detailed comparison can be made with objects of different ages. Some conclusions can be obtained regarding the formation of the discs of spiral galaxies, especially concerning the star formation rate as a function of the galactocentric distance.

4.17 The Disk-Mass Survey: Breaking the disk-halo degeneracy

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Abstract

The observed relative mass fractions of dark and luminous matter in galaxies provide a strong test for galaxy formation models. A major roadblock for this measurement is the disk-halo degeneracy; derived density profiles of dark matter halos as inferred from rotation curve decompositions depend critically on the adopted M/L of the luminous components. A direct and absolute measurement of the M/L of the disk can be derived from the vertical stellar velocity dispersion. One of the main goals of the Disk-Mass Survey is to use the two custom-built integral-field units (IFUs) SparsePak and PPak to measure the kinematics of the gas and stars in nearly face-on spiral galaxies. The total mass surface densities of the disks are calculated from the measured stellar velocity dispersions and thus the disk-halo degeneracy can be broken. In this talk, I will present the first robust results from the Disk-Mass Survey, based or IFU and 21-cm radio synthesis observations. In most galaxies the radial stellar velocity dispersion profiles follow in detail the radial light distributions. A very tight relation exists between the maximum rotation speed and the velocity dispersion of the stars, with a clear indication for all galaxies having a sub-maximal disk. Measurements of the asymmetric drift allow for deriving the stellar velocity dispersion from observations of stellar and gas rotation curves, useful for estimating disk mass surface densities at larger redshifts. Finally, the combined HI+Halpha rotation curves are decomposed into contributions from the various dynamical constituents of the galaxies, providing unambiguous density profiles of the dark matter halos.

4.18 Momentum Driven Feedback from Galaxy Nuclei

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Abstract

In the last decade observations with the Hubble Space Telescope (HST) have revealed the presence of massive star clusters at the centres of the majority of low and intermediate mass galaxies. An unexpected observational result is that nuclear cluster mass scales with the velocity dispersion of the host galaxy bulge, sigma. This M–σ relation is parallel to that which holds for central supermassive black holes (SMBHs) in massive galaxies. Several authors have shown previously that both of these observed $M-\sigma$ relations can be understood as a consequence of momentum-conserving feedback from the nucleus which sweeps the ambient medium into a shell that expands into the galaxy. If the shell escapes, the growth of the nucleus is cut off and the $M-\sigma$ dependence is locked in. Previous treatments of this problem have assumed outflows into galaxies modelled as singular isothermal spheres, and have focussed on the behaviour of the shell only very near or very far from the nucleus. We present a consolidated analysis of the problem in the isothermal sphere case, and we extend this work to include more realistic cases in which the dark matter halo need not be a singular isothermal sphere, and the gas in the galaxy need not trace the dark matter distribution. With these considerations, we explore a more detailed parameter space influencing the M-sigma and related scalings for both SMBHs and nuclear clusters.

4.19 Deep $UBVRIHK_s$ Surface Photometry of 45 BCGs

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Abstract

We present new and previously unpublished observations of 45 Blue Compact Galaxies (BCGs) in seven optical and near-infrared broadband filters ($UBVRIHK_s$), obtained in the span of six years from ESO NTT and NOT. The majority of the observations are the deepest to date, with exposure times in some cases as long as 5.6 hours in K_s. The depth of the observations allows us to carry out detailed analysis not only on the central starburst usually present in BCGs, but we are also able to separately examine the properties and structural parameters of the underlying old stellar host with reasonable errorbars for each target and each filter.

4.20 Two-Dimensional Kinematics of Hydrodynamic Galaxy Merger Simulations Compared to Observation

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Abstract

Rich two-dimensional integral field unit spectrographs such as SAURON and large multi-object spectrographs such as DEIMOS are producing rich observational data sets yielding insights into galaxy formation. We create mock kinematic profiles of the stellar components of hydrodynamic simulations sampling galaxy merger formation scenarios including minor and major binary mergers and a program of cosmologically-motivated mergers. Emsellem et. al (2007) use a proxy quantifying the projected stellar angular momentum per unit mass ($\lambda_R =< R|V| > / < R\sqrt{V^2+\sigma^2} >$) as a basis for kinematic classification of slow and fast rotators. We construct λ_R profiles and draw correlations with varying formation scenarios, triaxiality, kinematically decoupled cores, and $V/\sigma - \epsilon$. We find that fast rotators are nearly oblate, and slow rotators are triaxial. Except in a single instance, where the total initial angular momentum is zero, we find that viewing a merger-produced galaxy as a slow rotator is rare.

4.21 Much More Than Just The "Fuel of Star-Formation"

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Abstract

Baryons matter, even in a Universe forming hierarchically under the gravitational forces of dark matter. Most of the "unknowable unknowns" of current galaxy evolution models are closely linked to the hydrodynamics of baryons, from gas accretion to galaxy merging and feedback from star formation and AGN. All of these processes inject mechanical energy into the ISM, energy that must be dissipated before stars can form. I will report on our on-going efforts of quantifying the role of molecular gas as an agent (and tracer) of the dissipation of mechanical energy, by measuring bulk and turbulent velocities, gas masses, and dissipation timescales in the multiphase warm and cold gas. It is well known that shocks can heat molecular gas, but we are only starting to understand the potential consequences for galaxy evolution. Turbulent cascades in the shocked gas trigger a cycle of molecule destruction and (re-)formation, which boosts the luminosity of molecular emission lines, and makes molecular gas an important (and so far largely ignored) coolant of the ISM. I will discuss two archetypal examples to illustrate that this could be significant in shaping galaxies during astrophysically very different evolutionary phases. In the overlap region of the Antennae, we find that recent star formation appears directly related to the local dissipation rate of kinetic energy injected by the merger. In nearby, gas-rich radio galaxies like 3C326N and 3C293, we find several $10^9 M_\odot$ of dense molecular gas, which appears at least a factor 10 less efficient in forming stars than expected from the Schmidt-Kennicutt relationship, a consequence of the injection of mechanical energy by the radio-loud AGN. For both examples, I will discuss how these results may contribute to solving some of the outstanding open questions of our hierarchical paradigm of galaxy evolution.

4.22 The Outer Halos of Elliptical Galaxies

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Abstract

Observations of the velocity dispersions of Planetary Nebulae in the outer halos of elliptical galaxies have revealed a huge variety of velocity dispersion profiles, some flattening to nearly constant values, some increasing again in the outer part and some decreasing fast, showing nearly no evidence for a dark matter halo. In this work we address the questions of the nature of the Dark Matter halos ellipticals are embedded in, and what we can learn about the formation mechanisms and histories of elliptical galaxies by measuring velocity dispersions in the outer halos. Furthermore, we are interested in how important projection effects and the number of observed Planetary Nebulae are for these measurements. Therefore, we study a sample of simulated elliptical galaxies with different evolution scenarios, covering a wide range of galaxy masses: High resolution mayor merger events, in which we collide two galaxies with mass ratios between 3:1 to 1:1, to study the dynamical values of the resulting ellipticals in detail, and cosmological simulations with gas and star particles, to study the effects of the multiple minor merger evolution scenario and the influence of the environment. We are able to reproduce the full range of observed outer halo profiles, and we show that star formation, gas content and environment play an important role for probing these range, while there is no significant difference between the outer halo profiles resulting from the different elliptical formation mechanisms.

4.23 CALIFA: Calar Alto Legacy Integral Field spectroscopy Area Survey, Early Report

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Abstract

We report on the current status of the CALIFA survey. CALIFA is an IFS survey with the main aims of (1) characterizing the spatial resolved spectroscopic properties of the galaxies in the Local Universe, (2) understand the nature of the dichotomy in the color-magnitude diagram, and (3) trace the chemodynamical and starformation history evolution of galaxies on the basis of their fosil records. To achieve these goals CALIFA is obtaining IFS data covering the complete optical extension of a sample of ∼600 galaxies at $0.005 < z < 0.03$, to a depth of ∼23 mag/arc^2 (3 sigma), using PPAK/PMAS@3.5m CAHA with two instrumental setups (low and high spectral resolution). The project has been granted with 210 dark nights along 2010-2013. We present here the current status of the survey.

4.24 XLENS: The X-shooter Lens Survey □ dark matter, IMF, and internal structure of 'The Cosmic Horseshoe'

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Abstract

I present first results from the X-shooter Lens Survey (XLENS),which aims to study the dark matter and stellar content of the high-mass end (sigmaETG $>$ 250km/s) of the early-type galaxies, by combining stellar kinematics,stellar population studies and strong gravitational lensing. We observe a sample of lens galaxies with X-Shooter,a powerful broad-band spectrograph and thanks to the huge wavelength coverage, we are able to obtain high-resolution spectra from the UVB to the near-IR for detailed stellar-population and kinematics studies of the most massive ETGs up to redshift 1. We combine these data with high-precision strong gravitational lensing estimates of the total masses to obtain their precise dark-matter mass fraction inside Reff, and to test a possible correlation between internal dark matter fraction and galaxy mass and size. In this talk, I present results from the pilot program of the project: The Comic Horseshoe (SDSSJ1148+1930),a very massive galaxy at redshift z = 0.444(Spiniello et al 2011, in prep).In particular, by combining constraints from X-shooter spatially resolved stellar kinematics and strong gravitational lensing, we measured the logarithmic slope of the total mass density profile of the lens. We find that dark matter is unambiguously present and accounts for more than 50% (99% CL) of the mass within the effective radius. By computing the spectral evolution of the galaxy with several star formation histories from SSP models, we calculated a second independent estimate of the stellar mass fraction inside the same aperture for Salpeter and Chabrier IMFs. We find that a Salpeter IMF is preferred, providing a fraction in perfect agreement with the one inferred by lensing. We have also tested IMFs with steeper profiles in the lower mass range (0.1 - 0.7 Msol)following a suggestion by van Dokkum & Conroy(2010). We infer that dwarf-rich IMFs steeper than Salpeter (slope of 3 or even 3.5) are unlikely,at least for this very massive ETG, as they result in a stellar mass fraction that disagrees with the lensing result at a confidence level of 95%.

4.25 Feedback from circumnuclear star formation in normal barred galaxies

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Abstract

We report on our study of how feedback, implied by the presence of hot X-ray-emitting gas, operates in the central regions of normal barred galaxies. Bar-induced inflow often forms a circumnuclear ring of intense star-formation some 0.5−1.0 kpc in diameter. Massive-star feedback from this starburst activity may ultimately affect the growth of galactic pseudo-bulges and hence evolution along the Hubble sequence, the formation and fueling of central SMBHs, and the physics behind the $M_{\rm BH} - \sigma_\star$ relation. We have been studying this phenomena using deep, high-resolution, X-ray observations of several nearby galaxies hosting circumnuclear rings. We report on determinations of the physical parameters of the hot gas in the circumnuclear regions, correlations of hot gas with other signatures of local star formation, and estimates of the role of feedback on gas inflow onto any central object and gas outflow into galactic halos.

4.26 An Investigation of the Apparent Counter-Winding Bar-Spiral Hybrid of NGC 3124

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Abstract

NGC 3124 is an unusual SB(r)bc galaxy in that the bar seems to be a very open spiral pattern winding in the opposite sense of the outer spiral arms. We will show some preliminary results of our photometric analysis of high resolution B, V, R, and I-band images from the Carnegie-Irvine Nearby Galaxy Survey. We will also show some preliminary results from our attempts to recreate the observed morphology through inelastically colliding test particle simulations.

4.27 Lopsidedness in nearby galaxies

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Abstract

Both the stellar and the gas distribution of galaxies are often characterised by asymmetries. The origin of this so-called lopsidedness is still poorly understood. Possible scenarios include tidal interactions, minor mergers, asymmetric gas accretion, but also an offset of the stellar disc in a halo potential. We investigated a large sample of nearby disc galaxies, observed within the Westerbork HI Survey of Irregular and Spiral Galaxies. Both the morphological and kinematic lopsidedness of the neutral hydrogen are measured, in most cases far beyond the optical radius. We compare the degree of lopsidedness with several galaxy properties, e.g., the morphological type, star formation rate, and the environment. We find a strong correlation of morphological and kinematic lopsidedness. Early-type galaxies seem to be more lopsided than late-type galaxies. We do not find a correlation between lopsidedness and the environment or the star formation activity.

4.28 Bulgeless galaxies with big bulges: the stellar kinematics and populations of peanuts

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Abstract

Williams, Zamojski, Bureau, Kuntschner, Merrifield, de Zeeuw and Kuijken Boxy and peanut-shaped bulges are seen in about half of edge-on disk galaxies. If these bulges are nothing more and nothing less than bars viewed in projection, then this may imply that their hosts are pure disk galaxies with no classical bulge. But classical bulges are a ubiquitous feature of giant disk galaxies formed in a hierarchical universe with our current understanding of galaxy formation physics. Since there is nothing special about edge-on galaxies, this raises the possibility that a demographically significant population of real disk galaxies are irreconcilable with our understanding of galaxy formation. It is therefore crucial to better understand these bulges. A handful of them, including that in the Milky Way, have been observed to rotate cylindrically, i.e. with velocity independent of height above the disc. In order to assess whether such behaviour is ubiquitous in boxy bulges, and whether a pure disk interpretation is consistent with their stellar populations, we have analysed the stellar kinematics and populations of a targeted sample of five boxy bulges.

4.29 X-raying the Circumnuclear Star Formation in NGC 2903

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Abstract

NGC 2903 is a nearby SBc galaxy with intense circumnuclear star formation induced by a young stellar bar. We present deep Chandra observations of this central star forming region. The data reveal high surface brightness diffuse emission within the central 15" (650 pc) of the nucleus along with eleven point-like sources. None of the point sources ($Lx < 6 \times 10^{38}$ erg/s) coincide with the galactic center of mass, and we place stringent upper limits on the X-ray emission from any accreting compact central object. Lower surface brightness emission extends to the north and west of the nucleus. X-ray temperature and column density maps indicate a possible hot gas outflow from the circumnuclear region to the northwest; however, the rest of the hot gas is probably confined to the disk.

5.1 Clusters as a Galaxy Evolution Laboratory: A Multi-Wavelength Approach

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Abstract

Due to their high densities, galaxy clusters are an excellent location to study the impact of environment on galaxy evolution. We use optical and mid-infrared imaging to construct spectral energydistributions (SEDs) for galaxy cluster members, which we fit using model templates. These fits yield K-corrections to the observed galaxy luminosities, which we also use to measure stellar masses and star-formation rates (SFRs). We identify AGN from the shapes of their SEDs and from their X-ray luminosities. The two AGN populations are largely disjoint. The difference is due to varying sensitivities and at least partially to obscuration in their host galaxies. The duty cycle of AGN relative to star formation in galaxy clusters shows no significant difference compared to the field, but we do see variation in $SFR/\dot{M}_{BH}$ with radius within the cluster. This suggests that AGN fueling in cluster members is most closely related to stellar mass. Therefore, low luminosity AGN like the ones in our sample are a poor tracer of cold gas. Furthermore, we find a substantial transition population of galaxies with unusually low SFRs for their stellar mass. This indicates that star formation must slowly decline in cluster members rather than being rapidly truncated. Thus, we favor slow processes such as strangulation over rapid processes like ram-pressure stripping to create the SFR-density relation.

5.2 Group Environment Evolution Collaboration (GEEC)

Dr Michael Balogh | University of Waterloo
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Abstract

I present preliminary results from a new survey of galaxy groups at $0.85 < z < 1$, using Gemini (GMOS) nod-and-shuffle spectroscopy. When complete, the survey will consist of sixteen groups selected from spectroscopically confirmed, extended *XMM* detections in COSMOS. From completed observations of the first seven groups, we find the dynamical mass estimates are in good agreement with the masses estimated from the X–ray luminosity, with most of the groups having $13 < \log M_{\rm dyn}/M_\odot < 14$. We compute stellar masses by template-fitting the spectral energy distributions; our spectroscopic sample is statistically complete for all galaxies with $M_{\rm star} > 10^{10.1} M_\odot$, and for blue galaxies we sample masses as low as $M_{\rm star} \sim 10^{8.8} M_\odot$. The fraction of total mass in galaxy starlight spans a range of 0.25–3 per cent. Like lower-redshift groups, these systems are dominated by red galaxies, at all stellar masses $M_{\rm star} > 10^{10.1} M_\odot$. Few group galaxies inhabit the "blue cloud" that dominates the surrounding field; instead, we find a large and possibly distinct population of galaxies with intermediate colours. The "green valley" that exists at low redshift is instead well-populated in these groups, containing ~ 30 per cent of the galaxies. We postulate that these are a transient population, migrating from the blue cloud to the red sequence, with a star formation rate that declines with an exponential timescale $0.6{\rm Gyr} < \tau < 2{\rm Gyr}$. Their prominence among the group galaxy population, and the marked lack of blue, star-forming galaxies, provides evidence that the group environment either directly reduces star formation in member galaxies, or at least prevents its rejuvenation during the normal cycle of galaxy evolution.

5.3 Galaxy Cluster Assembly and Environmental Effects on Galaxy Morphology

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Abstract

We study the formation of galaxy cluster-size dark matter halos (M > $10^{14.0}$ $M_{\odot}$) formed within a set of cosmological Λ cold dark matter N-body simulations, and track the accretion histories of cluster subhalos. By comparing the observed morphological fractions in cluster and field populations, we estimate an approximate timescale for morphological transformation within the cluster environments. Galaxy clusters provide a interesting environment for the study of several astrophysical phenomena. They are the largest collapsing objects in the universe, and, as such, they are an observable constraint of hierarchical structure formation. Through understanding the formation of clusters, we probe key parameters in cosmology and such studies allow us to place constraints on several processes in the formation and evolution of galaxies as well as large scale structure. Simulations provide us with tools to interpret the growth and assembly of these objects allowing us to probe the effects that the cluster environment may have on galaxies that have been accreted into the cluster. I examine the formation of galaxy cluster sized dark matter halos in simulations and examine the possible effects on the morphologies of galaxies accreted into the cluster environment as well as the timescales necessary to affect this change. Comparisons with observed samples of galaxy clusters allow simple models to be tested.

5.4 Interacting Void Galaxies

Miss Burcu Beygu | Kapteyn Institute
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Abstract

Voids are unique environments for galaxies to evolve. We are conducting a Void galaxy Survey which is a multi-wavelength observational survey of 60 geometrically selected void galaxies. The aim of the survey is basically to study in detail the gas and stellar content, kinematics and dynamics of these galaxies and their companions. We use a wide range of ground based telescopes and satellite to get deep imaging in different wavebands like H_α, B, J&K and UV and the HI imaging of the gas as well. Within this sample we got very interesting examples of interacting systems such as a system of three galaxies with one companion having a tidal tail and ring like structure suggesting a possible merging event. Another one is also a system of three aligned galaxies with one showing a sign of a major merging event obvious from its extreme morphology. Galaxies undergoing interactions in voids are important prototypes for testing current galaxy formation theories since evolution in these underdense regions is expected to progress slowly. Here we want to present our first results of interacting void galaxies from the Void Galaxy Survey and discuss the possible merging scenarios and the role of low density environments on the galaxy interactions.

5.5 The WIRCam Deep Survey: Mass Selected Clustering to $z \sim 2$

Dr Rich Bielby | Durham University
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Abstract

We present deep near-infrared imaging in the four CFHTLS deep fields, taken as part of the WIRCam Deep Survey (WIRDS). The WIRDS data incorporates J, H and K_s band imaging over a total area of $2.4\,\mathrm{deg}^2$ with (AB) depths of ≈ 24.5. We combine this deep near-infrared data with the deep optical data of the CFHTLS to produce 8-band $ugrizJHK_S$ photometric catalogues in each of the four CFHTLS Deep fields. Taking these catalogues, we use the Le PHARE code to perform SED fitting of the photometry to estimate photometric redshifts, galaxy types, star-formation rates and stellar masses of sources in the $ugrizJHK_s$ catalogues. We analyse the clustering of galaxies as a function of mass, type and redshift using derived quantities from the photometric template fitting. Passive galaxies are seen to be consistently more clustered than star-forming galaxies across our entire redshift range, whilst we see little redshift evolution in the clustering of either sample to $z \approx 2$. For star-forming galaxies we see that clustering strength increases for higher stellar mass systems, however little sign of a mass dependence in passive galaxies is seen observed over the range in stellar mass that is probed.

5.6 The Spitzer Interacting Galaxies Survey: The Behaviour of Cold Gas in Damp Mergers

Dr Nicky Brassington | University of Hertfordshire
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Abstract

It is widely believed that very few galaxies exist today that have not been formed or shaped in some way by an interaction with another galaxy. These interactions play a major role in the evolution of galaxies by triggering star formation and nuclear activity. However the parameters that influence this enhanced activity are poorly understood. The Spitzer Interacting Galaxies Survey (SIGS) is addressing this question by using IR data obtained with the Spitzer Space Telescope to study a large sample of 111 galaxies in different stages of interaction. In this presentation I will provide an overview of the sample and further present radio HI data which allow us to determine the properties of the ISM of these systems. I will specifically focus on the interacting systems that contain one gas-rich and one gas-poor galaxy; the damp mergers. Such systems provide us with the opportunity to study how cold gas from the gas-rich galaxy is affected by its companion and thereby, in conjunction with the Spitzer data, provide constraints on the relationship between the ISM and star-formation in interacting systems.

5.7 Spatial kinematics of Brightest Cluster Galaxies and their close companions from IFU spectroscopy

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Abstract

I will present Integral Field Unit (IFU) spectroscopy of four brightest cluster galaxies (BCGs) at z∼0.1. Three of the BCGs have close companions within 20 kpc and one has no companion within that radius. I will show that while the lowest mass companion (1:4) is not bound, the two nearly equal mass (1:1.45 and 1:1.25) companions are likely to merge with their host BCGs in 0.35 Gyr in major, dry mergers. I conclude that BCGs continue to grow from major merging even at z∼0. I will also present the stellar kinematics of these systems, analysed using the SAURON λ_R parameter which offers a new and unique means to measure the stellar angular momentum of BCGs and make a direct comparison to other early-type galaxies. Not all these massive galaxies have low angular momentum as one might expect. One of the four BCGs and two of the massive companions are found to be fast-rotating galaxies with high angular momentum, thereby providing a new test for models of galaxy evolution and the formation of Intra-Cluster Light.

5.8 Topology of the Halos in the Cosmic Web

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Abstract

Using the Multiscale Morphology Filter we dissect in a scale-free way the structure of the Cosmic Web into its elements: clusters, filaments and walls. We analyze and characterize the topological structure of the resulting halo populations in terms of Betti numbers, following the instruments of alphashapes and persistence. The results show the potential of Betti numbers to discriminate between different cosmological parameters and offer new insights in the topology of the Cosmic Web and that of its environments (clusters, filaments and walls).

5.9 Spatial anti-correlation of Lyman break galaxies based on their spectral features: Quantifying the growth of groups and clusters from $2 < z < 5$

Dr Jeff Cooke | Swinburne University
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Abstract

I will present results of detailed angular correlation function measurements of Lyman break galaxy (LBG) sub-types categorized by their spectral features. The analysis of LBG subsamples that exhibit dominant Lya in absorption and broad/strong ISM features (aLBGs) and those exhibiting dominant Lya in emission and weak/narrow ISM features (eLBGs) is motivated by recent work investigating spectroscopic interacting $z \sim 3$ LBGs. We use broadband color-magnitude criteria, tested using $\sim$400 Keck spectra, that produces large ($> 10^4$) pure samples of $z \sim 3$ aLBGs and eLBGs in 4-year stacked images of the 4 square-degree CFHTLS Deep fields. Analysis of the CFHTLS auto-correlation functions reveals a significant difference in the behavior of the LBG subtypes on small scales (one-halo term regime). We find that aLBGs have a large amplitude and steeper slope indicative of multiple massive halos within the parent dark matter halo whereas eLBGs have a weaker amplitude and a shallower slope which exhibits an upturn at separations of $<$30 kpc, physical. The eLBG behavior suggests the typical presence of a single massive halo, with a fraction of eLBG halos consisting of two closely separated halos. The aLBG-eLBG cross-correlation function shows an anti-correlation signifying the intrinsic difference in mass and spatial distribution of the two subtypes. I will discuss a picture that we are testing using the three-point correlation function in which aLBGs are largely located in dense filamentary knots and filament intersections and eLBGs existing largely within the filaments. I will conclude by discussing preliminary results that follow this analysis from $z \sim 5$ to $z \sim 2$ that can be used to quantify the growth of proto-groups and clusters and the precursor to the red and blue sequence observed today.

5.10 Photometric analysis of Abell 1689

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Abstract

We present a photometric analysis of 44 early type galaxies in Abell 1689, based on observations in the rest-frame V-band with the Advance Camera for Surveys (ACS) on board the Hubble Space Telescope (HST). We performed a two- dimensional photometric decomposition of each galaxy surface-brightness distribution using the GASP2D fitting algorithm. We adopted both a Sérsic law and a de Vaucouleurs law. S0 galaxies were analyzed also taking into account a disc component described by an exponential law. The derived photometric parameters will be used to analyze the fundamental plane of Abell 1689 and quantify how it is affected by the use of different decomposition techniques.

5.11 Witnessing the Formation of a Massive Galaxy Cluster: A Multiwavelength Study of a z$\sim$1 Supercluster

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Abstract

We have identified a spectacular supercluster at z$\sim$1 as part of the Red-Sequence Cluster Survey: a unique and massive high-redshift structure, comprising three bound and merging galaxy clusters spectroscopically confirmed to lie at z = 0.9 and separated by less than 3 Mpc in the plane of the sky. This supercluster is one of the few known examples of the progenitors of present-day massive galaxy clusters (10^{15} M$\odot$ at $z \sim 0.5$) and affords a unique opportunity to study not only the formation of the most massive structures in the local universe, but also the effect that the merging of massive halos has on the galaxy populations within them. We have assembled an extensive multiwavelength data set over the structure including 1925 redshifts with 211 confirmed supercluster members thus far, and deep optical, near-IR, infrared, radio and X-ray imaging. Using these data we identify substructure and dynamically distinct groups within the supercluster and present an analysis of the specific star formation rates of the members galaxies as a function of their local environment.

5.12 Clustering segregation of Lyman Alpha Emitter Galaxies at z=2.1

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Abstract

We present updated results on large scale structure clustering strength of z=2.1 Lyman Alpha Emitters (LAE) in the MUSYC survey. This survey comprises 4 fields of 30x30 arcmin each, which have been imaged both in broadband UBVRIz and narrow-band OII 3727 filters, allowing for the selection of LAEs at this redshift (Guaita 2010). Here we present the joint clustering analysis of the four fields. With the additional samples, we were able to measure the dependence of correlation length r_0 with Lyman-Alpha line luminosity and equivalent width (EW), as estimated from the narrow- and broadband photometry. We found that these LAEs show a significant trend of increasing r_0 with line luminosity, while the subsamples divided by EW showed no statistically significant difference in clustering. Since for star-forming galaxies it has been previously shown that clustering strength scales with continuum luminosity, our result could be a reflection of this effect on Lyα luminosity, modulo some dispersion given by the distribution of EWs of the line and the physics involved therein.

5.13 Probing Halo Mass Distributions through Weak Lensing

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Abstract

Measuring the mass distributions within dark matter halos, and in particular the masses of subhalos, can provide key insights into the timing and extent of tidal stripping of the subhalos. Using halo models to simulate weak lensing signals around simulated halos with various mass distributions, we show that weak lensing provides a sufficiently powerful tool to differentiate between groups which have undergone tidal stripping and those which haven't. In order to have the statistical power to overcome the noise inherent in lensing, it will likely be necessary to have at least $\sim$250 deg^2 of data with spectroscopic redshifts for foreground galaxies and shape measurements for background galaxies. We plan to apply these results to data from the CFHTLS-Wide for an empirical comparison.

5.14 Galaxy groups: a window on galaxy evolution

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Abstract

Galaxy groups are a an ideal laboratory to study the distribution and assembly of visible matter and the interplay between central and satellite galaxies. We studied the distribution of stellar mass in galaxy groups from the COSMOS survey and compared it to different environments, looking for a cross-talk between mechanism regulating satellite and central galaxies. We look for differences in the survival rate of star forming satellite galaxies, and constrain how fast satellite quenching operates in galaxy groups with respect to the field. We constrain the shape of the galaxy stellar mass function and compare it to the prediction from galaxy evolution models. Finally we estimate the contribution of different types of galaxies to the baryonic budget in galaxy groups. Our results give useful guidelines to galaxy evolution models.

5.15 Clustering of massive galaxies and the evolution of clustering with mass, for $z < 2$.

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Abstract

Using the semi-analytical model developed in Durham, GALFORM, we have studied the clustering of Extremely Red Objects and mass selected samples at z < 2. For the first part of this work we find an angular correlation function that agrees with observations from UKIDSS, one of the largest and deepest near-infarred surveys. In the second part we find the surprising result that, although semi-analytical models predict a clustering that does not change with luminosity, the variation of clustering with mass is clear and at odds with observations. Splitting the mass selected sample of galaxies at z < 2 into blue and red, we find that the correlation length of red galaxies stays rather flat with redshift, while that for blue galaxies tend to increase with redshift, a result in qualitative agreement with observations.

5.16 Does environment matter at $z > 2$?

Dr Nina Hatch | University of Nottingham
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Abstract

The effects of environment on galaxy evolution are most obvious when comparing galaxies in highly contrasting environments. To investigate the influence of environment in the early Universe we present a study which compares $z \sim 2$ field galaxies to those in proto-clusters, some of the densest environments at $z > 2$. We use these early progenitors of galaxy clusters to understand how environment affects galaxies during their formative epoch. We select clean samples of $z \sim 2$ proto-cluster and field Hα emitters and compare their properties, including stellar mass, star formation rate, colour and specific star formation rate. I will show that the proto-cluster galaxies are rapidly forming stars in a similar manner to field galaxies. However, the proto-cluster galaxies are already twice as massive, and have lower specific star formation rates than their field counterparts. Thus the proto-cluster galaxies are further evolved than the field galaxies. This study implies that dense environments promotes galaxy growth in the early Universe, and that cluster galaxies differed from field galaxies even before the clusters virialized.

5.17 Star formation activities in a cluster and its surrounding structure at z=1.46

Dr Masao Hayashi | National Astronomical Observatory of Japan
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Abstract

We present a panoramic [OII] emission survey in and around a cluster XMMXCS J2215.9-1738 at z=1.46 with Suprime-Cam/Subaru, and the follow-up NIR spectroscopy of 16 [OII] emitting galaxies in the cluster core with MOIRCS/Subaru. With NB912 narrow-band filter (λ=9139Å, $\Delta\lambda$=134Å), we identify 380 [OII] emitting galaxies down to 1.4×10^{-17} erg s^{-1} cm^{-2} in a 32×23 arcmin^2 area. We find that the [OII] emitting galaxies are distributed even in the cluster core, and further along filamentary large-scale structures around the cluster, which are among the largest structure of star-forming galaxies ever identified at $1.3 < z < 3.0$. The discovery of such structures in this cluster enables us to investigate the dependence of properties of star-forming galaxies on the environment at z=1.46. The star formation activities and mass-matallicity relation for the [OII] emitters indicate that this cluster has experienced active star formation comparable to those in its surrounding regions. On the other hand, a significantly higher fraction of [OII] emitters is seen on the red sequence in the cluster core compared with those in the other environments. These red galaxies are more likely to be nearly passively evolving galaxies which host [OII] emitting AGN, rather than dust-reddened star-forming [OII] emitters. Our results all suggest that there is apparently no longer a strong environmental variation in the galaxy properties at $z \sim 1.5$, except for the excess of the red emitters. AGN feedback may be one of the critical processes to quench star formation in massive galaxies in high density regions.

5.18 Clustering and dark matter halo masses of 870-um selected SMGs

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Abstract

We present a measurement of the spatial clustering of 870 μm-selected submillimeter galaxies (SMGs) at $1 < z < 3$. Using data from the Laboca ECDFS Submm Survey (LESS), we employ a novel technique to measure the cross-correlation between SMGs and galaxies, using full the full probability distributions for photometric redshifts of the galaxies. From the observed projected two-point correlation function we derive the linear bias and characteristic dark matter halo masses for the SMGs. We detect clustering in the cross-correlation between SMGs and galaxies at the $> 4\sigma$ level. We show that SMGs at $1 < z < 3$ are indeed strongly clustered and reside in dark matter halos of mass a few $\times 10^{12} h^{-1} M_{\odot}$, very similar to the typical halos for optical quasars. These results are consistent with measurements for optically-selected quasars, and support evolutionary scenarios in which powerful starburst and quasars are driven by a common mechanism.

5.19 Red star forming galaxies in distant cluster outskirts: a key population for understanding environmental effects at $z < 1$

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Abstract

We present our panoramic H-alpha emitter survey for the two distant clusters of galaxies at $z = 0.4$ (CL0939+4713) and $z = 0.8$ (RXJ1716+6708), with narrow-band filters of Suprime-Cam and MOIRCS on the Subaru Telescope. Taking advantage of the wide-field capability of these facilities, we investigate in detail the star forming activity of galaxies along the large-scale structures at these high redshifts. In particular, we report a discovery of a surprisingly large number of optically red H-alpha emitters in the cluster surrounding environment such as groups and filaments, where the colour-density relation shows an abrupt break (i.e. transitional environment). We revealed that a non-negligible fraction of such red H-alpha emitters are indeed MIR-detected dusty starbursts, based on our wide-field 15-micron imaging with AKARI satellite. Thus, our results demonstrate that properties of galaxies are indeed changing 'before' entering cluster environment accompanying strong dusty starbursts, and that the group-scale environment at $z < 1$ has probably played a key role in shaping at least a fraction of the present-day cluster galaxies.

5.20 The Spitzer Interacting Galaxy Survey: IR-UV Photometry

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Abstract

The evolution of galaxies is greatly influenced by their interactions. The Spitzer Interacting Galaxy Survey (SIGS) sample was designed to probe a range of interaction parameters using infrared data complemented by a range of other observations. It is comprised of the Keel-Kennicutt (Keel et al. 1985) complete sample of interacting galaxies chosen on the basis of association likelihood. The resulting sample contains 111 galaxies in 50 systems, located with $cz < 4000$ km/s. We present the photometric analysis of the complete Spitzer coverage and almost complete GALEX coverage. This atlas will be used to investigate the variation of star formation along the interaction sequence. We describe observed trends and compared to those predicted by numerical simulations.

5.21 A WISE-Chandra view of baryon content evolution in galaxy clusters

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Abstract

We study the relationship between two major baryonic components in galaxy clusters, namely the galaxies and the intra-cluster medium (ICM), using 94 clusters that span the redshift range 0-0.6. Accurately measured total and ICM masses from Chandra observations, and stellar masses derived from Wide-Field Infrared Survey Explorer and Two-Micron All-Sky Survey allow us to trace the evolution of cluster baryon content in a self-consistent fashion. We find that the evolution of the ICM mass-total mass relation is consistent with the expectation of self-similar model, while there is no evidence for redshift evolution in the stellar mass-total mass relation. This suggests that the clusters acquire their gas and galaxy contents in different ways.

5.22 The dwarf galaxy content of present-day clusters: SAM vs reality

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Abstract

The Millennium-II simulation allows semi-analytic models (SAMs) to probe the regime of dwarf galaxies, whose evolution is still not well understood theoretically. We compare the properties and distribution of cluster dwarf galaxies in the Guo et al. (2011) SAM to the nearby clusters Virgo, Fornax, Coma and Perseus. Apart from the systematically higher dwarf-to-giant ratio in the SAM, the dwarf population of the SAM clusters is very similar to the dwarfs in Coma and Perseus, in terms of galaxy colour and distribution. However, there seems to be no Virgo cluster equivalent in the SAM: the Virgo dwarfs are bluer in colour and less dynamically relaxed. This is important, since Virgo is the nearest and most extensively studied cluster, serving as a local universe benchmark. When focusing on the diversity of dwarf galaxy subpopulations, we find that the huge number of elliptical dwarf galaxies in the real universe does not have a counterpart in the SAM clusters, where passive disk-dominated dwarfs are abundant. We interpret this by environmental effects not included in the model, which could transform galaxies morphologically.

5.23 Mg2 gradients as a signature of brightest cluster galaxy evolution

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Abstract

We have fitted the Mg2 absorption index gradients for 21 brightest cluster galaxies (BCGs), in the nearby Universe, for which we have obtained high signal-to-noise ratio, long-slit spectra on the Gemini telescopes. This is a sub-sample of a large optical, spatially-resolved, spectroscopic sample of BCGs which allows possible connections between the kinematical, dynamical and stellar population properties to be studied. We investigate the existence of a correlation between the Mg2 (and therefore metallicity) gradients and mass of the BCGs, and whether such a correlation is the consequence of the special location of these galaxies in the centre of the cluster gravitational well.

5.24 Groups of Dwarfs

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Abstract

We present a project on the study of groups composed of dwarf galaxies only. We selected such structures using the HyperLEDA and NED databases with visual inspection on SDSS images and on digital copy of POSS. The groups are characterized by size of few tens of kpc and line-of-sight velocity dispersion about 18 km/s. Our groups are similar to associations of nearby dwarfs from Tully et al. (2006). This specific population of multiple dwarf galaxies such as I Zw 18 may contain significant amount of dark matter. It is very likely that we see them at the stage just before merging of its components.

5.25 The Bimodality of Compact Groups: Untangling the role of compact groups in galaxy evolution

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Abstract

Compact groups of galaxies represent ideal laboratories for the study of galaxy interactions owing to both their high local densities and low encounter velocities. I will present the results of an ongoing effort to understand galaxy evolution in these dense environment using a large, homogeneously selected catalogue of ∼1100 compact groups from the SDSS DR7. I will show that the canonical photometric selection of CGs results in a bimodal population, where groups can be classified as either substructure in a larger group/cluster or a genuine isolated structure. An investigation of galaxy properties shows that isolated compact groups host a more prominent population of blue, disk-like galaxies than similar (locally) dense galaxy configurations embedded within a larger structure. I will provide a comparison of these results with expectations based on the study of interacting galaxy pairs, and discuss the interpretation of compact groups within the larger framework of hierarchical structure formation.

5.26 Considerations on the Formation Mechanism of Massive BCGs in Low-Density Environments

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Abstract

We report the results of the deepest spectroscopic study of fossil groups to-date. The study shows that many fossil groups can be characterized as relatively massive ($\sim 2 \times 10^{14} M_{\odot}$), with appropriately bright BCGs ($\sim 5 \times 10^{11} L_{\odot}$), but otherwise containing only ∼25% of the non-BCG galaxies of "normal" systems (clusters) of the same mass. The luminosity of the missing 75% of non-BCG galaxies amounts to some 5 times the luminosity of the central BCGs and twice the total luminosity of the whole system. Our results therefore raise a number of interesting questions. Probably, the most important are: where are all the baryons that would, in normal systems, go into making up the missing galaxies?; how did the bright BCGs form in such low richness environments; and what does this mean for the hierarchical merging scenario for BCG formation (cannibalism)? In other words, what process or environmental factor could inhibit the formation of galaxies in general, while still allowing the growth of a massive BCG in the centers of fossil groups?

5.27 Linking ICM Cooling and AGN heating with Star Formation, Cold Gas and Dust

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Abstract

Active galactic nuclei at the center of galaxy clusters with gas cooling times that are much shorter than the Hubble time have emerged as heating agents powerful enough to prevent further cooling of the intracluster medium (ICM). Amidst the emerging hypothesis of self-regulated AGN feedback, infrared, optical and FUV observations of clusters also indicate the presence of large amounts of cold gas in several brightest cluster galaxies (BCGs). We are conducting a project aimed at understanding the detailed processes that govern the fate of the cold gas in and around BCGs in a sample of 11 cooling flow systems. This sample is the basis of a Herschel Key Project, the main goals of which are to determine the location and mass of cooled gas, along with its temperature, ionization state, density and cooling rate. We present the first detections of the strongest atomic cooling lines and dust emission in a subset of our Herschel sample and focus on one of the systems, NGC4696, the BCG of the Centaurus cluster of galaxies.

5.28 LRG clustering evolution to $z = 1.5$ in Stripe 82

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Abstract

We have measured the clustering of Luminous Red Galaxies in Stripe 82 using the angular correlation function. We have selected 130000 LRGs via colour cuts in R-I:I-K with the K band data coming from UKIDSS LAS. We have used the cross-correlation technique of Newman et al (2008) to establish the redshift distribution of the LRGs as a function of colour cut,cross-correlating the LRGs with SDSS QSOs,DEEP2 and VVDS galaxies. We also used the AUS LRg redshift survey to establish the $n(z)$ at $z < 1$. We then compare the $w(\theta)$ results to the results of Sawangwit et al (2010) from 3 samples of SDSS LRGs at lower redshift to measure the dependence of clustering on redshift and LRG luminosity. We have compared the results for luminosity-matched LRG samples with simple evolutionary models, such as those expected from long-lived, passive models for LRGs and for the HOD models of Wake et al (2009) and find that the long-lived model may be a poorer fit than at lower redshifts. We find some evidence for evolution in the LRG correlation function slope in that the 2-halo term appears to flatten in slope at $z > 1$. We present arguments that this is not caused by systematics.

5.29 Infrared galaxies in a rich cluster at $z = 0.871$

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Abstract

It is now well established that galaxies in the past formed stars more rapidly than today, and additionally, that local environment regulates star formation (SF). In particular, SF consistently decreases with increasing galaxy density at $z \lesssim 1$, but reverses in the field at $z \sim 1$. Moreover, star-forming galaxies follow a universal correlation of increasing star formation rate (SFR) with stellar mass. Studies have only begun to unfold similar trends in high-redshift galaxy clusters, specifically with the confirmation of enhanced activity in a $z = 1.62$ galaxy cluster core. This link between SFR and stellar mass, along with the evolution of SFR over cosmic time and density prompts the question: what governs SF in galaxies and how does it vary with environment?

We address this question through an infrared (IR) study of a $z = 0.871$ galaxy cluster (EN1-240) drawn from the Spitzer Adaptation of the Red-sequence Cluster Survey (SpARCS). SpARCS is currently the largest completed $z > 1$ galaxy cluster survey with $\sim$12 $z > 1$ spectroscopically confirmed clusters, and has been carrying out an ambitious spectroscopic and photometric follow-up survey of the richest clusters. Our extensive multi-wavelength data for EN1-240 includes: deep Spitzer IRAC and MIPS imaging; $u'g'r'i'z'$JK imaging from Magellan, CFHT, CTIO, and VLT; and Chandra X-ray data. This cluster has 93 spectroscopically confirmed members, 18 of which are detected at 24μm.

We find differences in the SFR-versus-stellar mass trend for various populations, with the most massive systems displaying the lowest specific SFRs. We discuss how rapidly the SF of massive, IR-luminous members must be quenched in order to avoid overproducing the cluster mass at $z \approx 0$. This study will ultimately provide further insight into the role of local environment on SF through mass assembly and cluster infall, at the pivotal epoch at which the most active sites of SF move toward higher density regions.

5.30 Fingerprints of Merger Events in the Observed Properties of Galaxies in Galaxy Groups

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Abstract

By analyzing a collection galaxy groups with different masses in the Millennium II simulations and comparing their properties to observed galaxy groups in SDSS DR7 data, we study how galaxy properties are linked to their dark halos and the formation history. The spatial distribution of galaxies and the luminosity distributions are compared. We also talk about the formation of galaxy groups and analyze how well we can identify the fingerprints of recent mergers of galaxy groups in the simulations and observations.

5.31 A Dynamical Investigation of Galaxy Evolution in Groups

Dr Laura Parker | McMaster University
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Abstract

Motivated by the mounting evidence that galaxy groups play a significant role in the evolution of galaxies I will present recent dynamical analysis of a sample of optically and X-ray selected groups at intermediate redshifts. The GEEC sample consists of more than 100 groups with multi-wavelength imaging and extensive spectroscopic coverage to identify well-populated group samples. I will discuss the dynamical classification of these systems, the amount of identified substructure and the properties of central galaxies. We've found that the properties of member galaxies depend critically on the dynamics of the host group. By combining these results with studies at high and low redshift we can study the dynamical evolution of groups and uncover the processes driving the transformation of galaxies in this environment.

5.32 Evolution of galaxies in the richest environments up to the highest redshifts

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Abstract

Thanks to the z∼2.2 JKCS041 cluster, we can probe galaxy formation and evolution at ages as young as less than 3 Gyrs and put constraints on the different environmental mechanisms affecting galaxy evolution at the early stages of the cluster ages. Photometric redshifts based on 8 bands photometry (u*grizJHKs) confirm the cluster redshift to be z∼2 and allow us to neatly disentangle cluster members from obvious foreground and background galaxies. We estimate JKCS041 blue fraction of galaxies, inside both half and one cluster virial radius. We show that the obtained values are in agreement with the ones derived for a consistent sample of mass-selected galaxies in clusters at lower redshifts ($0 < z < 1$). These results will be supplemented by the ongoing identical analysis on the second most distant cluster, ClG J0218.3−0510 at$z = 1.62$. JKCS041 star forming galaxies (SFR > 5 Msun/yr) exhibit a strong environmental dependency, being virtually absent inside half the cluster virial radius and aboundant outside it.

5.33 Offsets in Metallicity and SFR as interaction markers in Compact Groups: the importance of large scale environment

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Abstract

Compact groups of galaxies provide a unique galaxy interaction testing ground; their high local densities should provide opportunities for frequent tidal interactions, while their isolation from other structures should, in principle, limit the effects of large-scale environment. Gas-phase metallicities and star formation rates have previously been used as a probe into interaction timescales for both galaxy pairs and galaxies in cluster environments. These two environments show opposite trends: high metallicities for a given mass in clusters and low metallicity for a given mass in galaxy pairs. These differences may be due to both differences in environment and merger history. To disentangle these dependencies, I present sample of 121 compact group galaxies selected from the SDSS which have robustly measured star formation rates and metallicities. I will show that the behaviour of a galaxy in a compact group depends on the large scale environment of the compact group, rather than on the high local densities of the group and I will discuss the implications for merger histories in locally dense regions.

5.34 Differences and similarities of galaxy groups in the Millennium simulation and in the SDSS DR7

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Abstract

The Millennium N-body simulation and SDSS DR7 galaxy and galaxy group catalogs are used to study the structure of the dark matter halos, the distribution of subhaloes inside the main halos and the correspondence between dark matter halos and galaxies. We test hypothesis that galaxy groups are galaxy systems hosted by shared main halo dark matter halo. The comparison also reveals possible differences between widely used semi-analytical galaxy models used for galaxies in the Millennium simulations, and the real galaxy properties in the observations. Four different volume limited samples are derived from the galaxy group catalog SDSS DR7. Specifically, we compare the group richness, virial radius, maximum separation and velocity dispersion distributions and find a rather good agreement between the mock catalog and observations. We always consider the halo group as a system with the main halo and its subhaloes. The halos we find encompass the mass scales from $10^8 M_\odot$ to $10^{15} M_\odot$. We estimate that in our SDSS DR7 galaxy group catalogue more than 90% of the groups are gravitationally bound and the group finding algorithm can find real galaxy groups very well. This work strongly supports the idea that the link between galaxies in galaxy groups and dark matter subhaloes inside main halos is very strong at the used luminosity range $M_r < 18$. This is work is a result of collabraition work from Observatory of Tuorla and Observatory of Tartu.

5.35 AGN and Galaxy Clustering at $z = 0.3$ to 3.0 measured by using the Japanese Virtual Observatory (JVO)

Dr Yuji Shirasaki | National Astronomical Observatory of Japan
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Abstract

We present the result of projected cross correlation analysis of AGNs and galaxies at redshifts from 0.3 to 3.0. The Japanese Virtual Observatory (JVO) was used to obtain the Subaru Suprime-Cam images and UKIDSS catalog data around AGNs. We investigated 1,809 AGNs, which is about ten times larger a sample than that used in previous studies on AGN-galaxy clustering at redshifts larger than 0.6. We found significant excess of galaxies around the AGNs at redshifts from 0.3 to 1.8. For the low redshift samples ($z < 0.9$), we obtained correlation length of r_0 =5–6 h^{-1}Mpc ($\gamma = 1.8$), which indicates that the AGNs at this redshift range reside in a similar environment around typical local galaxies. We also found that AGNs at higher redshift ranges reside in a denser environment than lower redshift AGNs; For $z = 1.3 \sim 1.8$ AGNs, the cross correlation length was measured as 11^{+6}_{-3} h^{-1}Mpc ($\gamma = 1.8$). Considering that our galaxies sample is based on optical observations with Suprime-Cam at the redshift range, it is expected that blue star-forming galaxies comprise the majority of objects that are observed to be clustered around the AGNs. It is successfully demonstrated that the use of the archive through the Virtual Observatory system can provide a powerful tool for investigating the small scale environment of the intermediate redshift AGNs.

5.36 Are Brightest Halo Galaxies Central Galaxies?

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Abstract

It is generally assumed that the central galaxy in a dark matter halo, that is, the galaxy with the lowest specific potential energy, is also the brightest halo galaxy (BHG), and that it resides at rest at the centre of the dark matter potential well. This central galaxy paradigm (CGP) is an essential assumption made in various fields of astronomical research. I test the validity of the CGP using a large galaxy group catalogue constructed from the Sloan Digital Sky Survey and modeled group catalogues. For each group I compute two statistics, R and S, which quantify the offsets of the line-of-sight velocities and projected positions of brightest group galaxies relative to the other group members. By comparing the cumulative distributions of R and S to those obtained from detailed mock catalogues, I rule out the null-hypothesis that the CGP is correct. Rather, the data indicate that in a non-zero fraction of haloes of a given mass the BHG is not the central galaxy, but instead, a satellite galaxy. In particular, I find that the fraction increases from 0.25 in low mass haloes to 0.40 in massive haloes. I show that these values are uncomfortably high compared to predictions from halo occupation statistics and from semi-analytical models of galaxy formation. I end by discussing various implications of our result.

5.37 Stripping and quenching of infalling dwarfs in the Coma cluster

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Abstract

I will present new results from a wide-field spectroscopic and multi-wavelength imaging survey of the Coma cluster. Together, these observations provide a comprehensive view of environment-driven quenching of star-formation in clusters, from the remote past to the present epoch.

Using a spectroscopic sample of ∼400 red sequence galaxies spanning a very wide range in luminosity and mass, I explore the dependence of SSP-equivalent age on mass and location within the cluster environment. The characteristic ages of giant galaxies correlate primarily with their mass, while for dwarfs there is a stronger dependence on projected distance from the cluster centre. Among dwarfs in the core of the cluster, approximately 50 per cent joined the red sequence more recently than $z \sim 0.5$, consistent with the redshift-evolution of the giant-to-dwarf galaxy ratio in distant clusters. In the cluster outskirts by contrast, almost all of the passive dwarfs are young, with their star formation having been quenched only at $z \lesssim 0.2$.

The ongoing build-up of the faint red sequence population can also be probed by observations of galaxies caught in the act of transformation as they encounter the dense cluster environment. Using ultra-violet and narrow-band Hα imaging, I identify a sample of galaxies apparently undergoing gaseous stripping events. The UV and gas morphology of these objects suggest they are being stripped by ram pressure, with star-formation occurring in the tails of expelled gas. Some $\sim$30 per cent of currently star-forming galaxies within 1 Mpc of Coma are undergoing this process; their distribution in radius and orientation shows that stripping is a first-passage phenomenon, with a timescale $\lesssim$500 Myr.

Finally, I will show some first results from a very deep spectroscopic study of faint red-sequence galaxies clusters at $z = 0.3$, which will help to trace the emergence of the passive population over the crucial $z = 0.5$–1.0 epoch.

5.38 The mass and size evolution of the most massive galaxies

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Abstract

Brightest cluster galaxies are the most massive stellar systems in the Universe, residing at the centres of the largest potential wells and are thus ideal objects for studying hierarchical assembly. I present new results from our Subaru MOIRCS and VLT HAWKI imaging surveys of 20 of the most distant X-ray selected clusters, using near-infrared light as a proxy for stellar mass, to investigate their merger activity since redshift 1.5. In a parallel study we exploit deep HST imaging data for a subset of this sample to look for evidence of an evolution in the scale size and light profile shape of BCGs in order to constrain their evolution further.

5.39 Biased galaxy formation and evolution in two frontier clusters at z=1.6?

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Abstract

It is well known that galaxy formation and evolution is closely related to the surrounding environments. In order to investigate the environmental dependence of the properties for star-forming galaxies at the peak epoch of galaxy formation, we have conducted panoramic narrow-band surveys of [OII] emitters in two frontier high-z clusters at $z \sim 1.6$ (Cl0332-2742 and CIGJ0218-0510) with Suprime-Cam on Subaru telescope. Both surveys cover about 800 arcmin^2 area each, and reached a 3-sigma limiting line flux of 2.0×10^{-17}erg s^{-1} cm^{-2}, corresponding to a dust-uncorrected star formation rate of 5 $M_\odot$ yr^{-1}. In CIGJ0218-0510 ($z = 1.62$), we identified more than 300 [OII] emitters on the basis of narrow-band excess and photometric redshifts. We also sampled red-sequence galaxies on the color-magnitude diagram. We find that the star forming activity in the cluster cores ($r < 1$ arcmin) is very high, and that the ratio of the [OII] emitters to the red galaxies increases towards higher density regions. We obtain consistent results for the other cluster Cl0332-2742 at $z = 1.61$. This opposite trend at high-z to the one in the local Universe suggests that galaxy formation and evolution is biased and accelerated in high density regions at high redshift.

5.40 Tracing the galaxy evolution in supercluster-void environment

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Abstract

We study the influence of the large-scale environment on evolution of galaxies, comparing the luminosity functions (LF) of galaxies of different morphological types and colours in various global environments: in voids, filaments, superclusters, and supercluster cores. As additional data, we use galaxy groups and study the importance of environment for group central and satellite galaxies separately. We use the data from the Sloan Digital Sky Survey (SDSS) to construct the LFs for galaxies of different morphology and colours. We have taken special care to correct galaxy luminosities for intrinsic dust attenuation. We use the global large-scale luminosity density field to define different environments. We find a strong environmental dependency for the LF of elliptical galaxies; the environment is more important for red elliptical galaxies than for blue elliptical galaxies. The LF of spiral galaxies is almost independent of environment, both for blue and red spirals, showing that spiral galaxy formation has to be similar in all types of environment (from voids to superclusters). We show that the evolution of group central and satellite galaxies has been different; it also depends strongly on the environment.

5.41 Determination of HI Deficiency in Galaxy Group WBL 368

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Abstract

Most galaxies reside and evolve in galaxy groups and it is important to understand the environment of groups in a quantitative way. We present results from a study of the environment surrounding galaxy group WBL 368 using data from the Arecibo Legacy Fast ALFA Survey (ALFALFA) and Sloan Digital Sky Survey (SDSS). With a determination of group membership, we find the most probable optical counterparts for HI source detections of member galaxies. These are used to calculate the HI deficiency of the group by comparing our results to the field galaxy sample of Solanes.

5.42 Galaxy And Mass Assembly: Galaxy LF on host group properties

Mr J. Antonio Vazquez-Mata | University of Sussex
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Abstract

Using the GAMA-I group catalogue, we estimate the galaxy luminosity function for galaxies in groups in intervals of redshift and halo mass in order to understand the evolutionary processes of these systems. Luminosity functions are estimated in the SDSS optical bands and are fitted with evolutionary power-law Schechter functions. This study will contribute to understanding the connection between galaxies and their distribution in dark matter halos. In this poster, we present our preliminary results.

5.43 Brightest Cluster Galaxies: Analysis of Stellar Populations

Miss Danièl Viljoen | North-West University
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Abstract

The aim of this project is to study the stellar populations, and thereby evolution and star formation histories of brightest cluster galaxies (BCGs). In particular, I will determine if a Single Stellar Populations (SSP) or Composite Stellar Populations (CSP) provides the most significant fit for the BCGs using high signal-to-noise ratio (S/N), long-slit spectra, obtained on the Gemini and WHT telescopes. By using the ULySS software package, the data will be fitted against the Pegase. HR and Vazdekis/Miles stellar population models to simultaneously derive the SSP equivalent ages and metallicities of the BCGs. Furthermore, the stellar populations will be decomposed into two or more components, and the chi square (χ^2) value for each component is used to determine whether a SSP or CSP represents the BCGs most accurately. The obtained results are compared to previously published results, as determined by using Lick indices. We find that both young and old stars are present in the stellar populations of these BCGs, and those BCGs, therefore show surprisingly diverse star formation histories.

5.44 Examining the Role of Environment in a Comprehensive Sample of Compact Groups

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Abstract

Compact groups, with their high number densities, small velocity dispersions, and an ISM that has not been fully processed, provide a local analog to conditions of galaxy interaction in the early universe. The frequent and prolonged gravitational encounters that occur in compact groups affect the evolution of the constituent galaxies in myriad ways. Recent work has shown clear evidence that the compact group environment has a strong impact on galaxy evolution - in particular, a “gap” has been discovered in both the mid-infrared (MIR) IRAC (3.5-8.0 micron) colorspace and specific star formation rates (SSFRs). This gap is not seen in field samples and is an interesting new example of how the compact group environment may affect the evolution of member galaxies. In order to investigate the origin and nature of this gap, we have studied an expanded sample of 35 compact groups in addition to the original 12 groups studied by Johnson et al. (2007) (yielding 171 individual galaxies). We find that an underrepresentation of galaxies in this color range of IRAC colorspace is persistant in the full sample, lending support to the hypothesis that the compact group environment inhibits moderate SSFRs. We have more fully characterized the distribution of galaxies in this colorspace, as the full sample now picks up a few galaxies in this region, allowing us to quantify this lower density region more fully with respect to the MIR bluer and MIR redder colors. This full sample allows us to analyze physical properties of the sample, revealing that neither projected physical diameter or density show a trend in colorspace within the values represented by this sample. We hypothesize that this is due to the variances in these properties being too small.

5.45 The Evolution of Galaxies in Groups and Clusters

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Abstract

Galaxies in groups and clusters exhibit significantly truncated star formation rates and evolved morphologies. Using galaxy group catalogs created from the Sloan Digital Sky Survey Data Release 7, I examine the specific star formation rates and morphologies of satellites galaxies in groups/clusters. I focus on how these galaxy properties depend on satellite mass, group mass, and radius within the group. Using high-resolution cosmological simulations to track satellite galaxy orbits within groups, I test a variety of mechanisms and timescales for satellite galaxy star formation truncation and morphological evolution.

5.46 Galaxy Clustering and Dark Matter Halos

Dr Idit Zehavi | Case Western Reserve University
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Abstract

The recently-completed Sloan Digital Sky Survey (SDSS) has been immensely useful for studies of the large-scale structure of the universe. We present the latest measurements of galaxy clustering from the full SDSS DR7 redshift survey, concentrating on the projected two-point correlation function. The SDSS is particularly suitable for investigating the dependence of clustering on galaxy properties, and we focus on the dependence on color and luminosity. We interpret our measurements using halo occupation distribution modeling, and show that most of the observed trends can be naturally understood in this framework. This provides insight on the relation between galaxies and dark matter halos and informative tests for galaxy formation theories.

6.1 IFU observations of high-z ULIRGs

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Abstract

High-z ULIRGs, identified originally by their emission at submm wavelengths, are found to have some of the highest star formation rates in the Universe. Determining the trigger of the ultraluminous bursts in these galaxies is key to understanding their extreme properties. Local ULIRGs appear to be often formed by mergers and interactions however this may not be the only method of formation at high redshift and there is significant evidence to suggest that the high-z ULIRGs are not purely scaled-up versions of those found locally. I will present the results of integral field spectroscopy observations of a large sample of high-z ULIRGs which allows for the mapping of the gas dynamics and metallicity fields, by tracing the H alpha and NII emission lines, within the galaxies. The sample is compared to the SINS survey of normal z∼2 star forming galaxies in an effort to understand what causes the high star formation rates in the ULIRGs, placing them well above the blue sequence of other star forming galaxies at this redshift. The kinematic information can provide an insight into the trigger of the ULIRG burst since one would expect different morphologies, dynamics and metallicity profiles in a major merger, minor merger or galaxy harassment scenario. Hydrodynamical simulations have been successful at simulating these submm galaxies at z=2 with the ultraluminous activity being triggered in a number of ways. The outputs of the simulations can be directly compared to the observations to identify which ULIRG trigger in the simulations produces galaxies which best match those observed in the real Universe and thus help to understand how these galaxies form and evolve.

6.2 Evidence of Galaxy Interaction from a Study of the Optical Morphologies of a Sample of Type II Quasars.

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Abstract

We present deep GMOS-S Gemini optical broad band images for a sample of 19 type II quasars taken from the SDSS Zakamska et al (2005) sample. The sub-sample comprises quasars in the redshift range $0.3 < z < 0.41$ and [OIII] emission line luminosities $L_{[OIII]} > 10^{35}$ W. As the depth of these images allows the identification of extended features not previously detected, we use the results derived from this sample to discuss the significance of galaxy interactions and/or mergers in the triggering of quasar activity. We find that 15 of our sample of 19 (∼80%) some evidence of interaction in the form of tails, shells, fans, irregular features, amorphous halos and double nuclei. We find a median surface brightness for the features of $\tilde{\mu}_r \simeq 25$ mag arcsec $^{-2}$ and a range of $\Delta\mu_r \simeq [23,27]$. The wide range of features suggest that AGN activity can be triggered before, during or after the coalescence of the black holes with 5 of the 19 objects (∼26%) having double nuclei. This presents a strong case for galaxy interaction playing a significant role in the triggering of quasar activity.

6.3 The Sub-mJy Radio Population in the E-CDFS: star formation and BH accretion

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Abstract

Recent theoretical and observational studies agree on the importance of radio emission from active galactic nuclei (AGN) as feedback mechanism to their host galaxies. Key ingredients to study the co-evolution between central SMBH and galaxies out to high redshift are an unbiased AGN sample as well as large auxiliary data to determine the galaxies physical properties. Radio observations are by far less affected by dust extinction compared to similar surveys performed in the optical and the X-ray band, which allows us to select a more complete AGN sample. We have therefore embarked in a deep VLA survey at 20 cm of the Extended Chandra Deep Field South (E-CDFS) to explore the faint end of the radio population, down to the μJy level. From a sample of ~ 900 radio sources, we use a multi-wavelengths approach to separate AGN from star forming galaxies looking at the ratio between their FIR and radio emission, their flux ratio in the optical and radio bands, the level of X-ray luminosity and morphology. Thanks to the μJy sensitivity of our survey, we are able to detect not only the radio loud AGN, but also significant population of radio quiet objects according to the standard classification. Using the high redshift completeness of our sample, we trace the evolution of the AGN luminosity function up to $z \sim 3$. We finally correlate the accretion level of these radio selected AGN with the overall properties of their host galaxies: star formation rates, stellar masses and morphological appearances.

6.4 The galactic spin of AGN galaxies

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Abstract

Using an extensive sample of galaxies selected from the Sloan Digital Sky Survey Data Release 5, we compare the angular momentum distribution of AGN with non-AGN hosting by late-type galaxies. To this end we characterized the galaxy spin through the dimensionless angular momentum parameter λ, which we estimate approximately through simple dynamical considerations. Using a magnitude limited sample, we find a considerable difference when comparing the empirical distributions of λ for AGNs and non-AGN galaxies, the AGNs showing typically low λ values and associated dispersions, while non-AGNs present higher λ values and a broader distribution. A more striking difference is found when looking at λ distributions in thin $M_{\rm r}$ cuts, while the spin of non-AGN galaxies presents an anti-correlation with $M_{\rm r}$, with bright (massive) galaxies having low spins, AGN host galaxies present uniform values of λ at all magnitudes, a behaviour probably imposed by the fact that most late-type AGN galaxies present a narrow range in coluor with a typical constant λ value. We also find that the fraction of AGN hosting galaxies in our sample strongly depends on the galactic spin, increasing dramatically for decreasing λ. For AGN host galaxies we compute the mass of the supermassive black holes and find that this value tends to be higher for low spin galaxies, even at fixed luminosity, a result that could account, to a certain extent, for the spread on the luminosity - black hole mass relation.

6.5 Local Density of hot- and cold- mode accretors

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Abstract

Feedback models suggest that radio-loud AGN accrete material in two distinct modes, a hot-mode and a cold-mode. These two modes are differ in their feedback mechanism, stellar population, redshift and environment. Using a sample of radio selected galaxies in the Galaxy and Mass Assembly (GAMA) survey, we compare the 5th nearest neighbour densities of hot- and cold- mode accreting radio-loud AGN to test the environmental dependence.

6.6 Mechanical AGN Feedback in Moderately Strong High-Redshift Radio Galaxies: a Common Phenomenon?

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Abstract

There is growing evidence that supermassive black holes may play a crucial role for galaxy evolution, in particular during the formation of massive galaxies at high redshift. Our work focuses on quantifying the effects of radio-loud AGN on the interstellar gas in their host galaxies. To this end, we are studying the kinematics of the ionized gas in 9 moderately powerful radio galaxies at redshifts z∼2-3 with rest-frame optical imaging spectroscopy obtained at the VLT. We search for outflows and other signatures of feedback from the supermassive black holes in the centers of these galaxies to evaluate if the AGN may plausibly quench star formation. AGN-driven outflows have previously been identified in very powerful, but also very rare, radio galaxies at similar redshifts. Do galaxies with less powerful, and more common radio sources exhibit similar signatures? This would suggest that mechanical, jet-driven AGN feedback may well be a fairly common phenomenon during the early evolution of massive galaxies.

6.7 Galaxy activity in Semi-Analytical Models

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Abstract

AGN feedback is believed to play an important role in shaping a variety of observed galaxy properties, as well as the evolution of their stellar masses and star formation rates. In particular, in the current theoretical paradigm of galaxy formation, AGN feedback is believed to play a crucial role in regulating star formation activity in galaxies residing in relatively massive haloes, at low redshift. Only in recent years, however, has detailed statistical information on the dependence of galaxy activity on stellar mass M_*, parent halo $M_{\rm DM}$ mass and hierarchy (i.e. centrals or satellites) become available. In this paper, we compare the fractions of galaxies belonging to different activity classes (star-forming, AGN and radio active) with predictions from four different and independently developed semi-analytical models. We adopt empirical relations to convert physical properties into observables (Hα emission lines, OIII line strength and radio power). We demonstrate that all models used in this study reproduce the observed distributions of galaxies as a function of stellar mass and halo mass: star forming galaxies and the strongest radio sources are preferentially associated with low-mass and high-mass galaxies/haloes, respectively. However, model predictions differ from observational measurements in many respects. All models used in our study predict that almost every $M_{\rm DM} > 10^{12} M_{\odot}$ dark matter halo and/or $M_* > 10^{11} M_{\odot}$ galaxy should host a bright radio source, while only a small (few per cent) fraction of galaxies belong to this class in the data. In addition, radio brightness is expected to depend strongly on the mass of the parent halo mass in the models, while strong and weak radio galaxies are found in similar environments in data. Our results highlight that the distribution of AGN activity as a function of stellar mass provides one of the most promising discriminants between different gas accretion schemes.

6.8 Quasar Absorption Lines as Probes of Quasar-SMBH-Host Galaxy Coevolution

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Abstract

Quasar absorption lines provide valuable information on a range of quasar environments, including powerful outflows from the central source, ambient gas in the host galaxies, and, perhaps, the gaseous remnants of recent galaxy mergers. These are all important pieces to the puzzle of quasar/SMBH/host galaxy evolution. For example, we can address the question of whether quasar outflows carry enough kinetic energy to regulate star formation in the hosts and halt further infall onto the central SMBH, as described by some recent models. We can also measure the amounts and metallicities of gas in the extended environments to further constrain galaxy merger/evolution models. I will describe several studies of quasar absorption line phenomena, including 1) an HST/COS spectroscopy program to estimate the mass loss rates and kinetic energy yields of quasar-driven outflows, 2) an outflow modeling effort to constrain their energetics and acceleration mechanisms, and 3) ground-based spectroscopy to identify and derive physical properties for the particular lines that form in the extended host galaxies and/or merger remnants.

6.9 The hyperluminous X-ray source HLX1 – evidence for an intermediate mass black hole?

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Abstract

The existence of intermediate-mass black holes (IMBHs)– black holes of masses between 10^4 and 10^6 Msun – has important implications for the formation and evolution of star clusters and supermassive black holes. Although IMBHs are predicted by the M-sigma relationship, until recently an unambiguous identification has proved elusive. The hyperluminous X-ray source HLX1 located in the S0 galaxy ESO 243-49 (Soria et al 2010, Farrell et al 2010) represents one of the strongest candidates for their existence. Using the Magellan telescope, we have identified the optical counterpart for HLX1. Furthermore, we have performed deep VLT/VIMOS UBVRI photometry of HLX1 and its host star cluster. I will present the latest analysis on the stellar populations of the host cluster, the constraints on the nature of HLX1, and examine the connection between HLX1 and the host galaxy.

6.10 Merger-driven nuclear activity in galaxies: Close environment of AGN in the VISTA-VIDEO survey

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Abstract

It has long been argued that there might be a causal connection between nuclear activity and merger events, at least for part of the AGN population. Together with possible feedback mechanisms, these effects highlight the importance of active galaxies in the standard paradigm of galactic evolution. Using the new VISTA-VIDEO near-infrared survey data of the XMM-LSS field, we study the close environment of AGN (selected in X-rays, mid-infrared, and radio), looking for indications of over-dense environments around them. Results show radio and mid-infrared selected AGN to have an excess of close companions. On the contrary, X-ray selected AGN appear to populate consistently under-dense environments.

6.11 The Role of Galaxy Mergers in High Redshift ULIRGs

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Abstract

In the local universe, Ultraluminous Infrared Galaxies (ULIRGs, $L_{\rm IR} > 10^{12} L_{\odot}$) are all interacting and merging galaxies. To date, studies of ULIRGs at high redshift have found a variety of results due to their varying selection effects and small sample sizes. Some studies have found that mergers still dominate the galaxy morphology while others have found a high fraction of morphologically normal or clumpy star forming disks. Near-infrared imaging is crucial for interpreting galaxy structure at high redshift since it probes the rest frame optical light of a galaxy and thus we can compare directly to studies in the local universe. Here, we present the results of a morphological analysis of a sample of high redshift ($z \sim 1-3$) ULIRGs. These galaxies are selected based on their infrared luminosities measured using 100 and 160 micron data from the GOODS-Herschel coverage of GOODS-S. We visually classified all of the ULIRGs as well as a comparison sample with the same redshift and H band magnitude range using ACS and WFC3 data from the GOODS and CANDELS surveys. We compare our results to those from other classifiers as well as several automated classification methods. The high resolution and increased sensitivity of WFC3 over NICMOS for this large sample of objects allows us to investigate the role of galaxy mergers among high redshift ULIRGs consistently for the first time.

6.12 AGN and Star Formation Activity in High Redshift (U)LIRGs

Ms Allison Kirkpatrick | University of Massachusetts
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Abstract

(Ultra) Luminous Infrared Galaxies (ULIRGS) are more numerous at high-redshift and thus contribute significantly to the stellar mass buildup in today's massive galaxies. (U)LIRGS show signs of both star formation (SF) and active galactic nuclei (AGN) activity, indicating a link between growth of the stellar mass and the central black hole. Spitzer mid-infrared spectroscopy is unique in that it allows us to simultaneously probe the contribution to the infrared luminosity from both SF and AGN components of a galaxy. We have compiled a rich catalog of multi-wavelength data (HST, Spitzer, Herschel) for a large sample of 150 (U)LIRGS in the GOODS-N and ECDFS fields for which we have Spitzer IRS spectroscopy. For each source, we decomposed the mid-IR spectrum into contributions to mid-IR luminosity from SF and AGN components. A significant portion ($\sim 30\%$) of our sample of (U)LIRGS are dominated by an AGN ($> 50\%$) in the mid-IR. With our large spectroscopic sample and wealth of multi-wavelength data, we are in a unique position to study in detail the nature of these galaxies. We explore infrared color-color diagrams to identify different diagnostics of the SF and AGN activity. We found several useful techniques that cleanly separate the AGN and starburst dominated sources; these diagnostics are useful tools to determine the nature of (U)LIRGs when spectra are not available. We look for evolution in our sample with redshift and luminosity by studying the details of spectral properties (such as relative strength of PAHs, absorption, etc.) and the morphological properties of these galaxies using near-IR imaging from HST. Our goal is to map out how the properties of a galaxy (e.g. morphology, PAH emission, dust temperature) evolve as the AGN becomes more luminous in the mid-IR.

6.13 Estimating SFR from X-ray through radio: Which method works best at $1 < z < 3$?

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Abstract

We determine Star Formation Rates (SFRs) in a sample of color selected, star forming (sBzK) galaxies (K(AB)< 21.8) at $1 < z < 3$ in the Extended Chandra Deep Field - South (ECDF-S). To avoid AGN, we eliminate 12% of the original sample that have X-ray detections in Chandra catalogs. Photometric redshift binned, average flux densities are measured with stacking analyses in Spitzer-MIPS IR, APEX/LABOCA submillimeter, VLA and GMRT radio and Chandra X-ray (including 4 Ms CDF-S) data. We include averages of aperture fluxes in MUSYC UBVRIz'JHK images to determine UV-through-radio Spectral Energy Distributions (SEDs). We determine total IR luminosities, compare SFR calibrations from FIR, 24 micron, UV, radio and X-ray wavebands, and find preferred calibrations for each waveband. We find consistency with our best estimator, SFR(IR+UV), to within errors for dust corrected UV and the preferred radio SFR calibration. Our results show that 24 micron-only and X-ray SFR estimates should be used with caution. Average sBzK IR luminosities are equal to those of Luminous Infrared Galaxies.

6.14 Dynamics of Starbursting Dwarf Galaxies: I Zw 18

Mr Federico Lelli | University of Groningen
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Abstract

Starburst activity plays a key role in the formation and evolution of galaxies. The mechanisms that trigger, sustain and quench intense star formation are still poorly understood. Blue Compact Dwarfs (BCDs) are nearby starbursting low-mass galaxies, characterized by high specific star formation rates, low metallicities and large amount of gas. Therefore, the starburst is occurring under physical and chemical conditions similar to those of high-redshift galaxies. In their central regions, BCDs show strong concentrations of HI with steep velocity gradients. These morphological and kinematic properties of the gas are not observed in more quiescent dwarfs. This points to a close connection between the starburst, the large-scale gas dynamics and the compact distribution of luminous and dark matter. We are performing a HI study of a sample of BCDs by focusing on those galaxies that have been resolved into single stars by HST observations, which provide detailed information on their stellar populations and star formation histories. I will discuss the first results on I Zw 18, one of the most metal-poor galaxies known. I will present evidence for an interaction/merger between two extremely gas-rich dwarfs. Also, the presence of an extended gaseous tail may be interpreted either as a result of the tidal interaction or as a massive cold flow of gas from the IGM.

6.15 Large scale environments of nearby AGN

Ms Heidi Lietzen | University of Turku
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Abstract

Through the morphology-density relation we know that the properties of galaxies depend on their large-scale environments. The role of feedback from an active nucleus may be important in galaxy evolution and the large-scale environments of active galaxies can give support to the different models of evolution. In my talk I will show our latest results on the environments of active galaxies on supercluster scale. In our recently-submitted paper we found that radio galaxies prefer high-density environments, while radio-quiet quasars are usually in emptier regions. It is known that galaxies in the dense cores of superclusters are usually older than galaxies in void regions. This can explain our results: If quasars are activated earlier in galaxy evolution than radio galaxies, the low-redshift quasars are more likely to be in younger galaxies, and therefore, in low-density environments.

6.16 Complete Sample of Millimetre-Selected Galaxies in the SHADES Fields

Dr Michal Michalowski | Institute for Astronomy, University of Edinburgh
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Abstract

Understanding of the redshift distribution and the properties of the dust-enshrouded, highly star-forming galaxies is an important aspect of the galaxy formation and evolution. We address this issue using the JCMT/AzTEC survey of the SHADES fields, the widest (0.7 deg^2) millimetre survey to date at the resolution of $\sim$18 arcsec, which resulted in the detection of $\sim$150 millimetre objects. We identified their counterparts at other wavelengths using the deep radio and 24um data and completed the selection using a novel and successful method based on near-infrared fluxes and optical colors. In this way we reached an unprecedented $\sim$90% completeness of identification, which allows us to construct for the first time the unbiased sample of dusty galaxies. We will present their redshift distributions, star formation rates and stellar masses and discuss the implications of these results on our understanding of the galaxy formation.

6.17 The triggering mechanisms of powerful AGN: evidence for galaxy interactions

Dr Cristina Ramos Almeida | University of Sheffield
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Abstract

Despite speculation that nuclear activity in galaxies may be triggered by mergers and interactions, very little is known about the true nature of the link. I will present deep Gemini/GMOS imaging of powerful radio galaxies and quasars which reveal that 80-85% of their galaxy hosts show signs of interactions at relatively high levels of surface brightness. The galaxy morphologies are consistent the AGN being triggered at any stage of the interaction. By comparing with a control sample of quiescent ellipticals, we find that the percentage of morphological disturbance in PRGs greatly exceeds that found for quiescent ellipticals ($\sim$30%) when similar surface brightnesses are considered. Our results contrast with those found for lower luminosity AGN (as e.g. Seyfert galaxies), where the nuclear activity is more likely triggered by internal secular processes and minor interactions. However, these results can be reconciled on the basis of galaxy evolution: in massive galaxies, powerful AGN are triggered in mergers/interactions, since larger fuel supply is required. On the other hand, low-luminosity AGN, hosted in less massive galaxies, do not require such a major event to be triggered.

6.18 The SDSS-III BOSS Quasar Survey: The Definitive Unobscured Quasar Luminosity Function and its constraining power for AGN Semi-Analytic Models

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Abstract

We present key early results from the SDSS-III:Baryon Oscillation Spectroscopic Survey (BOSS) Quasar Survey; namely the definitive measurement of the luminous optical AGN (Quasar) Luminosity Function, at the height of the quasar epoch (redshifts $z \sim 2-3$). BOSS is assembling an unprecedented sample of high, $z > 2$, QSOs; 50,000 of which will be in hand by summer 2011. As such, it will be the premier spectroscopic dataset at high-z for the remainder of this decade. Here, we give the initial results from the investigations into the observational measurements of the quasar number density and clustering, as measured by the luminosity function and the 2-point correlation function respectively. We relate these results to new measurements of the obscured population by Hickox et al. (2011). We also place them in the context of recent AGN Semi-Analytic Models (e.g. Fanidakis et al. 2011a,b), in order to begin to answer the question of "what *precisely* are the links between central black hole formation, galaxy formation and AGN?"

6.19 AGN feedback and colour evolution of local galaxies

Dr Stanislav Shabala | University of Tasmania
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Abstract

I discuss the effects of kinetic AGN feedback on the colour evolution of galaxies in local groups and clusters. A fundamentally different picture emerges for low and high-power radio AGN. Galaxies located within the lobes of powerful Fanaroff-Riley type II (edge-brightened) sources show much redder colours than neighbouring galaxies that are not spatially coincident with the radio source. By contrast, no similar effect is seen near Fanaroff-Riley type I (core-dominated) radio sources. Moreover, the observed colours near FR-II radio sources are consistent with star formation being truncated as the expanding bow shock overruns a galaxy. A similar analysis of clusters with no detectable radio emission suggests that galaxy colours in these clusters carry an imprint of past AGN feedback. AGN activity in the low-redshift Universe is predominantly driven by low-luminosity radio sources with short duty cycles. These results show that, despite their rarity, feedback from powerful radio sources is an important driver of galaxy evolution even in the local volume.

6.20 KMOS: A New Observational Tool for Studies of Galaxy Evolution

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Abstract

We present the current status of KMOS, the first multi-object near-infrared integral field spectrograph under construction for the ESO VLT. KMOS is in an advanced integration phase and commissioning is predicted to start in Spring 2012. We discuss the design drivers for KMOS and some of the key science programmes that will be undertaken during the guaranteed time observations.

6.21 Growing black holes in growing galaxies

Dr Masayuki Tanaka | University of Tokyo
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Abstract

We characterize the relationship between AGN activities and host galaxy properties using data from SDSS. We develop a novel method to identify AGNs that allows us (1) to identify 3x more AGNs than the commonly used BPT diagnostics (Baldwin et al. 1981) does, (2) to estimate SFRs of the host galaxies with a factor of 2 accuracy, and (3) to subtract emission line fluxes due to star formation and extract pure AGN emissions, which are crucial to characterize AGNs. We find that AGNs show a wide range of ionization states and that motivates us to introduce a new parameter, a sum of [OII] and [OIII] luminosities, to characterize AGN power over a wide range of AGN activities. Based on these new developments, we find (a) AGNs reside in massive galaxies, (b) the AGN power increases with increasing SFRs of the host galaxies, and most importantly, (c) the black hole growth rate (Eddington parameter) increases with increasing galaxy growth rate (specific star formation rate) – that is, black holes grow in growing galaxies. This result may provide a physical link between the down-sizing in galaxy star formation and the down-sizing in AGN activities.

6.22 Galaxy Distributions as a Probe of QSO Environments at $z \sim 2$–3

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Abstract

We present an analysis of the environments of hyperluminous QSOs at $z \sim 2.7$, as probed by the distribution of their surrounding galaxies. We measure the galaxy distribution in three dimensions by combining imaging data with a large spectroscopic redshift survey ($N_{\rm spec} \sim 2000$) of star-forming galaxies, where each galaxy lies within ∼3' of one of 15 of the brightest QSOs at these redshifts. We find that the average QSO in our sample is associated in redshift with a significant overdensity in the galaxy distribution with a velocity scale of 500 km/s and a transverse scale of ∼25" (∼200 proper kpc). We furthermore use our dataset to obtain estimates of the galaxy-QSO cross-correlation function and galaxy autocorrelation function on small transverse scales, through which we can infer and compare the halo mass scales of QSOs and star-forming galaxies at these redshifts. Finally, the precision of our spectroscopic redshifts allows us to constrain the distribution of galactic peculiar velocities and thereby constrain the dynamical mass scale of the larger groups or clusters containing these QSOs. Taken together, these measurements will help answer the question of whether QSOs inhabit extremely unique environments or are merely observed at special times in an otherwise normal process of galaxy evolution.

6.23 Building Up the Red-Sequence: The AGN-Starburst Connection

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Abstract

Post-starburst galaxies have recently undergone an abrupt cessation of active star formation (within 20–500 Myr). This exceptional and rare stage in galaxy evolution is thought to occur during the transition from gas-rich, star-forming galaxies into early-types. While it is poorly understood what causes the abrupt end of their star formation, there is strong evidence that galaxy-galaxy tidal interactions or mergers trigger the starburst in many of these galaxies. This same mechanism for triggering intensive star formation may also cause strong fuelling onto a central supermassive black hole. By studying the evolution of the properties of post-starbursts, we obtain insights into the origin of the red-sequence and the AGN-starburst connection. The use of post-starbursts as probes is only now feasible with the advent of large optical spectroscopic surveys. Here we compare results from the ∼3000 SDSS DR8 post-starbursts at $z \sim 0.1$ (for which ∼60 have associated archival Chandra data) and the ∼200 post-starbursts from the DEEP2, zCOSMOS, and OPTX surveys at $z \sim 0.9$ (accompanied by deep Chandra imaging). A key benefit of studying post-starburst galaxies is that they are natural chronometers; detailed population synthesis modeling provides an estimate of the time since the peak star-formation event. In this study we address the following questions: 1) Does a visual inspection for near-neighbors and tidal disruptions in our low-redshift sample show a trend with post-starburst age? 2) Do post-starbursts move across optical emission-line diagnostic diagrams as they age and what does this tell us about the time-delay between starburst activity and AGN fueling? 3) Are post-starburst X-ray properties (for individually detected sources and on average via X-ray stacking) correlated with time since peak in star formation activity? We will discuss the implications of our results on galaxy evolution studies and place them in the context of recent AGN-starburst simulations.

6.24 High-Resolution Molecular Gas Dynamics in the Center of NGC 6240

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Abstract

NGC 6240 is a late-stage advance merger harboring two AGNs that have yet to coalesce, but its central dense molecular gas precedes its stellar component counterparts (∼ 1", or 500pc, apart) in gravitating towards the dynamical center of the system. Building on previous submillimeter work, we present high-resolution ($\sim 0.4''$) maps of the CO(3-2) gas taken at the Submillimeter Array. At this spatial scale, we resolve asymmetric gas flux peaks lying inward of the two AGNs and confirm the turbulent nature of the molecular gas. A general velocity gradient along the axis in between the two nuclei is noted along with local disturbances. A simple geometry-based scenario is proposed to explain the observed gas dynamics based on hydrodynamic galaxy-merger simulation models, the continual development of which will shed light on the physics behind gas behavior at these small scales.

6.25 In the Neighbourhood of Tame Monsters

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Abstract

The impact of quasars on their galaxy neighbors is an important factor in the understanding of the galaxy evolution models. The aim of this work is to characterize for the first time the environments of quasars at low redshift ($z < 0.2$) with the most statistically complete sample to date using the seventh data release of the Sloan Digital Sky Survey. We have used quasar-galaxy associations with spectroscopically measured redshifts to calculate how surface densities of galaxies, colors, star-formation rates, oxygen abundances, dust extinction and ionization changes as a function of the distance to the quasars. We also identify and exclude the AGN from our main galaxy sample and calculate surface density of different galaxy types. Our results suggest that there is a significant increase of the galaxy surface density around quasars. We see no significant changes of ionization, dust extinction and metallicity, but might observe a slight change in color and star-formation rate.

7.1 Feedback in Early-Type Galaxies

Mr Pedro R. Capelo | Yale University
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Abstract

We report on the investigation of the effects of AGN and SN feedback on the evolution of the ISM of early-type galaxies, by using 3D mesh-refined simulations, incorporating physics such as gravity (from dark matter and stars), radiative cooling and heating, and injection of momentum. We explore several feedback scenarios, studying a parameter space where we vary the power, the duration, the location and the geometry of the outflows. We study the energy deposition, both as a function of time and radius, by studying the fate of the ISM, its temperature and pressure profiles. We also translate physical properties into X-ray observables and compare those to current observations.

7.2 The dwarf galaxy dark-matter halo occupancy

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Abstract

We show results based on a set of Nbody-SPH simulations of dwarf galaxies, both with initially cusped and initially cored DM halos, as well as DM-only simulations. Our Nbody-SPH simulations include star formation, stellar feedback, radiative cooling and metal enrichment. For the cusped halo we employ the NFW profile; for the cored halo a Kuz'min Kutuzov (KK) profile is used. Both dark matter halos have been proven to be stable. Our simulations are compared with, and are in good agreement with, observations of dwarf galaxies in the Local Group and in nearby clusters. The NFW simulations including gas dynamics and star formation reveal a gradual transition from a cusped density distribution to a cored density distribution, unlike our DM-only control simulations. The KK simulations on the other hand remain relatively stable, both with and without gas dynamics and star formation. Besides differences in the evolution of DM distributions we can also see effects on the baryonic component. The simulations with NFW halos have a lower star formation rate, lower metallicity, and lower circular velocity than the simulations with a KK halo of comparable mass and scalelength. This brings our NFW simulations in close agreement with detailed observations of dwarf galaxy stellar populations, of the dark-matter halo occupancy (particularly the slope of the M_{halo} vs. M_{star} relation), and of the Tully-Fisher relation.

7.3 Properties of fossil groups in cosmological simulations and galaxy formation models

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Abstract

we here investigate fossil groups identified in the hydrodynamical simulations of the GIMIC project, which consists of resimulations of five regions in the Millennium Simulation (MS) that are characterized by different large-scale densities, ranging from a deep void to a proto-cluster region. For comparison, we also consider semi-analytic models built on top of the MS, as well as a conditional luminosity function approach. We identify galaxies in the GIMIC simulations as groups of stars and use a spectral synthesis code to derive their optical properties. The X-ray luminosity of the groups is estimated in terms of the thermal bremsstrahlung emission of the gas in the host halos, neglecting metallicity effects. We focus on comparing the properties of fossil groups in the theoretical models and observational results, highlighting the differences between them, and trying to identify possible dependencies on environment for which our approach is particularly well set-up. We find that the optical fossil fraction shows no clear environmental dependence in either of the semi-analytic models, but there is evidence for a weak effect in the GIMIC hydrodynamic simulations. Interestingly, the X-ray luminosity distribution of groups in GIMIC also shows an environmental effect, making X-ray bright groups disproportionally rare in low-density regions. Combining the optical and X-ray selection criteria for fossil groups, we find that the fossil fraction exhibits a peak as a function of halo mass, at a mass scale of around $10^{13} - 10^{14} h^{-1} M_{sun}$. Over the GIMIC halo mass range we resolve best, $9.0 \times 10^{12} \sim 4.0 \times 10^{13} h^{-1} M_{sun}$, the central galaxies in the fossil groups show similar properties as those in ordinary groups, in terms of age, metallicity, color, concentration, and mass-to-light ratio. These results support an interpretation of fossil groups as transient phases in the evolution of ordinary galaxy groups rather than forming a physically distinct class of objects.

7.4 Implementation of feedback in SPH: towards concordance of methods

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Abstract

We perform simulations of feedback from supernovae with smoothed particle hydrodynamics (SPH). We show for the first time that, in the absence of radiative cooling, concordance of thermal and kinetic feedback is achieved when using an appropriate time integration. In order to preserve a high level of energy conservation when using the hierarchical time-step scheme, we implemented in the GADGET-2 code a modified version of the time-step limiter proposed by Saitoh & Makino (2009). We apply the limiter to general test cases, and find necessary, not only to ensure a fast information propagation, but also to enforce a prompt response of the system to the energy perturbation. The method proposed here to handle strong feedback events enables us to achieve energy conservation at percent level in all tests, even if all the available energy is injected into only one particle. Finally, we show that, even if cooling processes are taken into account and providing a sufficiently high resolution, simulations of an individual supernovae explosion with the different feedback methods are still reaching concordance. Animations available at: http://www.mpe.mpg.de/ fdurier/Concordance/

7.5 Formation of stellar inner discs and rings in spiral galaxies through minor mergers

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Abstract

Recent observations show that inner discs and rings (IDs and IRs) are not preferentially found in barred galaxies, a fact that points to the relevance of other formation mechanisms besides the traditional bar-origin scenario. In contrast, the role of minor mergers in the formation of these inner components (ICs), while often invoked, is still poorly understood. We have investigated the capability of minor mergers to trigger the formation of IDs and IRs in spiral galaxies through collisionless N-body simulations, analysing the remnants resulting from minor merger experiments run with different orbits, mass ratios, and primary galaxy models (Sab or Sc). All the simulated minor mergers develop thin rotationally-supported ICs out of satellite material. A wide morphological zoo of ICs has been obtained (including IDs, IRs, pseudo-rings, nested IDs, nuclear bars, and combinations of them), all with structural and kinematical properties similar to observations. Their existence can be deduced through the features that they imprint to the isophotal profiles and kinemetric maps of the final remnant, as in many real cases. The realistic density ratios between the merging galaxies used make the satellites to experience more efficient orbital circularization and disruption than in previous studies. Combined with the disc resonances induced by the encounter, these processes give place to highly aligned co- and counter-rotating ICs in the remnant centres. The present models prove that minor mergers are an efficient mechanism to form rotationally-supported stellar ICs in spiral galaxies, without requiring strong dissipation or noticeable bars, and suggest that their role in the formation of ICs must have been much more complex than just bar triggering.

7.6 Star formation in cosmological simulations of galaxies

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Abstract

Cosmological simulations often use a fixed density threshold criterion in the sub-grid modeling of star formation. Since star formation is observed to take place within molecular clouds a potentially more physical approach is to let star formation depend on the presence of molecular hydrogen. In this way, the modeling of star formation acquires an explicit dependence on the metallicity and the interstellar UV radiation field of the ISM. I will present some implications of such an approach for cosmological simulations of galaxies. In particular, I will discuss the star formation laws on 100 pc to ∼kpc scales and the H2-CO conversion factor.

7.7 Numerical Simulations of High-Redshift Galaxy Populations

Dr Kristian Finlator | University of California Santa Barbara
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Abstract

The last decade has produced an explosion in observational constraints on galaxy growth at high redshifts. These data offer a wealth of insight into fundamental questions such as the form in which gas accretes onto galaxies and the feedback processes that regulate their stellar mass growth while coupling their gas reservoirs to their surroundings. Over the same period, advances in computing have enabled cosmological hydrodynamic simulations to incorporate remarkably detailed treatments for galaxy growth and feedback in representative cosmological volumes. Simulations that account for inflows, outflows, and mergers have reached maturity, and state-of-the-art efforts are beginning to incorporate spatially-resolved, self-consistent treatments for photoionization feedback. Broad agreement between predictions and observations provides strong support for smooth gas accretion as the dominant gas-delivery mechanism, but lingering discrepancies indicate room for improvement in our understanding of feedback. I will discuss current and future efforts to understand the processes that dominate galaxy growth through comparisons between numerical predictions and observations of fundamental galaxy distributions such as the luminosity and mass functions, the "main sequence" of star-forming galaxies, the mass-metallicity relationship, and their evolution in time. I will illustrate how these measurements constrain the relative roles of smooth accretion versus mergers in driving stellar mass growth, emphasizing the need for statistical constraints on star formation histories. In the near future, JWST will trace these trends into the reionization epoch, necessitating a self-consistent treatment for photoionization feedback. To this end, I will use a new generation of calculations to consider the relative roles of outflows and photoionization feedback in regulating star formation within the low-mass halos whose stellar populations may have dominated cosmological reionization. Finally, I will comment on future progress on both theoretical and observational fronts.

7.8 Forming Massive Disk Galaxies in LCDM

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Abstract

The successful formation of Milky Way-sized disks in cosmological simulations requires the correct treatment of complex baryonic physics at sub-grid scales, particularly gas cooling, star formation, and supernovae feedback. In this talk, I will briefly review some of the challenges that have plagued numerical simulations of flat galactic disks, and will present the results of the Eris simulation, state-of-the-art cosmological simulation of the formation of a late-type spiral galaxy, and detailed comparison between three similar simulations with varying resolution, star formation efficiency, and star formation threshold. I will focus on the effect these parameters on the star formation history, the formation of bar instabilities, the evolution of the baryon fraction with redshift, the properties of the satellites, and the distribution of metals.

7.9 Galaxies and the Missing Baryons

Miss Anaelle Halle | Observatoire de Paris
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Abstract

Nucleosynthesis and the CMB predict baryons represents 4% of the matter-energy content of the universe, but 90% of them are not observed. Dark baryons are therefore an interesting lead to address some problems encountered in numerical simulations and their comparisons to observed galaxy properties. Molecular hydrogen gas, difficult to observe, could especially form a significant part of these dark baryons. We use simulations using the TreeSPH N-body code Gadget to study the influence of dark baryons on galaxy evolution.

7.10 Resolving Subhalos' Lives with the Hierarchical Bound-Tracing Algorithm

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Abstract

We introduce a new code based on the merger hierarchy of dark matter halos to find and trace dark matter subhalos in simulations. Here dark matter subhalos are defined as self-bound remnant of dark matter halos. We keep full record of the merger hierarchy of subhalos and allow growth of satellite subhalos through accretion from its subordinate subhalos in the merger hierarchy hence allowing mergers among satellites. Local accretion of background mass is omitted while re-accretion of stripped mass is allowed. The justification of these treatments is provided by case study of the life of individual subhalos and by the success in finding the complete subhalo catalogue. Dependence of the result of this tracing algorithm on the time resolution of simulation output has also been examined. We compare our result to the popular subhalo finder SUBFIND and show that this Hierarchical Bound-Tracing (HBT) code is able to well resolve subhalos in high density environment and keep strict physical track of subhalos' merger history. HBT also features fast speed as it does not need density interpolation or spatial searching when constructing source subhalos, and because it is fully parallelized. This code is available upon request with the author.

7.11 Investigating the Angular Momentum Problem in Disk Galaxy Formation

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Abstract

Cosmological hydrodynamical simulations of galaxy formation have long been plagued by the spurious loss of angular momentum in the baryonic component of disk galaxies. The culprits of this angular momentum problem appear to be insufficient resolution and incorrect prescriptions for star formation and stellar feedback in the simulations. In this work, we conduct several high-resolution, grid-based AMR simulations using the enzo code. We investigate the angular momentum problem by systematically modifying various simulation parameters including spatial resolution, star formation efficiency and criteria, supernovae feedback, and the baryonic equation of state. Our results indicate that the problem appears to be quite complex and there is no single parameter responsible for this effect.

7.12 Thick disk and pseudobulge formation in a clump cluster

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Abstract

Among nearby disk galaxies, the galaxies have a clean-cut and beautiful shape: they have a disk and a bulge as main components. However, in the high-z universe, disk galaxies in its formation stage appear shapeless and clumpy. These infant galaxies are called 'clump clusters', which have some star forming clumps in its disk region. In this study, I investigate by N-body/SPH simulation how the clump clusters evolve into the current disk galaxies like the Milky Way. I found two main conclusions in this study. Clumps formed in the clump clusters are sucked into galactic center by dynamical friction and finally merge into a single bulge. As the first conclusion, I found that this bulge (clump-origin bulge) should be classified into a group of pseudobulges. Properties of the clump-origin bulge resemble to that of pseudobulges closely. The clump-origin bulges have an exponential surface density profile, an oblate shape and significant rotation. However, on the other hand, the clump-origin bulge forms with thick disk by non-secular evolution. The bulge stars are as old as the thick disk. Interestingly, as observationally suggested, the bulge of the Milky Way also seems to be a pseudobulge, but stars in the bulge are old. This result suggests that The Milky Way's bulge may be the clump-origin bulge. Second, I found that a thick disk is made from the clumps. In the formation stage of disk galaxies, the clumps are disrupted by galactic tide and spread out their own stars into disk region, while growing via mergers with other clumps. As a result, the disk is made up from the stars which are wreckage of clumps disrupted by the tide. In my simulation, nearly 80% mass of thick disk was made from clumps.

7.13 Properties of $z > 6$ Galaxies in Cosmological SPH Simulations

Mr Jason Jaacks | University of Nevada Las Vegas
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Abstract

Using cosmological hydrodynamic simulations, we examine the photometric and physical properties of $z = 9$ to $z = 6$ galaxies, such as the color-color diagrams, rest-frame UV luminosity function and galaxy stellar mass function. By performing a fit to the Schechter function we find an evolving faint-end luminosity/mass slope of $\alpha_L = -2.15$ and $\alpha_M = -2.35$ at $z = 6$ and steeper for $z > 6$. Our results suggest a significant population of small faint galaxies which are currently beyond our observational limits. Examination of the star formation rate densities of these faint galaxies suggest that due to their large numbers they are a primary contributor to reionization.

7.14 The Contribution of High-Mass X-ray Binaries to the Heating of the Intergalactic Medium

Miss Gillian James | University of Leicester
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Abstract

Massive stars may have played an important role during the epoch of cosmological reionisation ($z > 6$) as sources of energetic, neutral hydrogen ionising UV photons. The remnants of these stars could continue to be important as X-ray luminous ($L_X \approx 10^{38}$ erg/s) high-mass X-ray binaries (HMXBs). We investigate the contribution of these HMXBs to the heating of the intergalactic medium, and discuss a simple method for including this effect in the modelling of galaxy formation.

7.15 Interaction between dark matter sub-halos & galactic gaseous discs

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Abstract

We investigate the idea of DM sub-halo interaction with the gaseous disc as the origin of the recently observed holes and shells found in the HI regions of galaxies. We particularly concentrate on the disc galaxy IC 2574. We find that a pure DM sub-halo is not able to produce holes, but on the contrary it gives rise to high density regions in the disc. Halos with a small amount of gas in them are able to push the gas from the disc and form holes and shells. The size and lifetime of the holes seem to be dependent on the gas mass, gas density and impact velocity of the sub-halo. In the cosmological framework, only a small percentage of the observed holes are predicted by simulations. This leads us to conclude that either DM impact is not the major channel through which the holes are formed or alternatively.

7.16 Galaxy Mass Assembly: Mergers versus smooth accretion

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Abstract

According to the hierarchical model, small galaxies form first and merge together to form bigger objects. In parallel, galaxies assemble their mass through accretion from cosmic filaments. Recently, the increased spatial resolution of the cosmological simulations have emphasised that a large fraction of cold gas can be accreted by galaxies. In order to compare the role of the two phenomena, we detect baryonic and dark matter structures in multi-zoom numerical simulations, and track them by building merger trees. We study the baryonic mass history of galaxies detected in the simulation, and the accretion and merger fraction as a function of the environment and of the galaxy mass. We find that the smooth accretion mode dominates the mass assembly, in particular at high mass. At smaller masses, gas stripping is frequent, and quenches further growth in dense environments.

7.17 Brightest cluster galaxies and the impact of dry mergers on the core-cusp problem

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Abstract

We investigate the stellar and dark matter components from $z = 3$ to present in a galaxy cluster of 10^{15} $M_{\odot}$ using a high-resolution collisionless simulations presented by Ruszkowski & Springel. Dark matter halos dominating the assembly of the cluster were populated with spherical model galaxies with and without accounting for the adiabatic contraction of the dark matter halo at $z = 3$. The system was then re-simulated to $z = 0$. Cylindrical (2D) and spherical (3D) mass profiles for the total, dark matter and stellar components are presented. The contracted model run produced a cluster in which the dark matter dominates the mass budget in the central galaxy across all radii. Moreover, the projected velocity dispersion of the BCG is too high compared to observational measurements in galaxies of similar masses, reaching a central value of $\sim 350\,\mathrm{kms}^{-1}$ at 5 kpc. This is in contrast to the uncontracted model run, where the stars dominate over the dark matter up to 18 kpc, in better agreement with recent observations by Newman et al.. Moreover, it also matches their measured rising velocity dispersion, with a value of $\sim 300\,\mathrm{kms}^{-1}$ at 5 kpc. The central slope of the dark matter density profile reduces to $\gamma = -dln\rho/dlnr < 1$ due to the interaction between the stars and dark matter. It reaches values of $\gamma \sim 0.6$ and $\gamma \sim 0.9$ at the innermost resolved radius for the uncontracted and contracted runs respectively. The central slope of the uncontracted models is significantly shallower than that for the Navarro -Frenk-White profile, and it is in excellent agreement with recent combined kinematic lensing and X-ray observations of Newman et al., thus alleviating the cluster core-cusp problem.

7.18 Disk Heating by Substructure Bombardment

Mr Benjamin Lowing | Durham University
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Abstract

I will present my recent work using the Aquarius simulations, a set of six high-resolution dark matter only simulations, to explore the heating of the Milky Way disk via substructure bombardment. The origin of the age-velocity dispersion relation in the solar neighbourhood is thought to be a result of the Milky Way disk being heated through dynamic mechanisms. While the heating is thought to be dominated by intrinsic processes such as scattering by molecular clouds and transient spiral waves, the importance of interactions with dark matter substructures is uncertain. It is still an open question whether there are enough substructures present in haloes, and if the interactions deliver enough energy, to contribute a significant fraction to the observed heating. I attempt to answer this question by using a cosmologically realistic population of subhaloes extracted from simulations. Reconstruction of their orbits as they pass through the centre of the halo and the use of a simplified disk interaction model enable us to obtain an upper limit to the level of heating that substructure could generate.

7.19 Formation of Bulgeless Massive Galaxies in the ΛCDM Model

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Abstract

Recent observations have pointed out a large population of massive ($V_{circ} > 150$ km/s) bulgeless ($B/T < 0.2$) galaxies in the local environment around our the Milky Way. This implies that pure-disk galaxies are far from rare and raises the question of how can the CDM hierarchical formation scenario make so many giant, pure-disk galaxies with no evidence for merger-built bulges. Combining semi-analytical models of galaxy formation with high resolution SPH simulation we investigate if the presence of these bulges galaxies around the Local Group is a true challenge for the otherwise successful CDM model.

7.20 Spiral Galaxy Formation in a Cosmological Context

Dr Marie Martig | Swinburne University, Australia
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Abstract

Cosmological simulations have unveiled two main modes of galaxy growth: hierarchical growth by mergers and accretion of cold gas from cosmic filaments. However, these simulations struggle to take into account small-scale mechanisms, which govern internal evolution and are a key ingredient to understand galaxy formation and evolution. We have thus developed a new simulation technique, which consists in extracting the merger and accretion history of a galaxy in a cosmological simulation and performing a re-simulation of this history at high resolution (150 pc). The low computational cost of this technique makes it possible to perform statistical studies and to explore the parameter space of galaxy formation. We have gathered a sample of 30 simulated spiral galaxies with halo masses between 10^{11} and 10^{12} Msun at $z = 0$. We study the link between the $z = 0$ properties and the merger and accretion histories. Unsurprisingly, the most disk-dominated cases correspond to quiet merger histories. In addition, we find that the angular momentum of the accreted gas, and the way this angular momentum varies with time, are crucial factors for disk building. The accretion of gas from filaments is however usually very efficient at building disks, with the spheroids formed at $z > 1$ remaining as central bulges. The first hints of a spiral structure begin to appear at $z = 1$, and are usually well in place by $z = 0.5$, which is also when bars begin to form. An identification of $z = 0$ galaxies with their $z = 1$ progenitors is however complicated: half of these $z = 0$ spirals were bulge-dominated at $z = 1$. We study the interplay between bulge and bar formation, finding in particular that spiral galaxies that were bulge-dominated at $z = 1$ are less prone to bar formation. This suggests the possibility of using bar properties for galactic archaeology.

7.21 Simulated Galaxy Merger Trees: A new numerical tool

Dr Benjamin Moster | MPA-Garching
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Abstract

I present a novel approach to study galaxy evolution combining numerical simulations with semi-analytic models. We use cosmological merger trees extracted from an N-body simulation and a semi-analytic model of galaxy formation to create galaxy merger trees which provide the initial conditions for multi-merger hydrodynamic simulations. Specifically, we evolve the galaxy in the main branch of the merger tree in a simulation and include the satellite galaxies in this simulation at the time when the satellite enters the larger halo using the satellite properties predicted by the semi-analytic model. In this way we exploit the advantages of merger simulations (high resolution and detailed treatment of the gas physics) and semi-analytic models (cosmological background and low computational cost), and integrate them to create a novel tool. This approach allows us to study the dynamical evolution of galaxies in detail with a lower computational time and a higher spatial and mass resolution than standard zoomed hydrodynamical cosmological simulations. Focusing on Milky-Way sized systems we find good agreement with observations for the evolution of the total stellar masses and galaxy scale parameters. We further investigate, whether accreted satellite stars can be distinguished kinematically from stars formed 'in situ' in the central galaxy, and find that this is only possible for a fraction of the disrupted satellites. Even if a star can be attributed to an accreted satellite, it is not possible to determine in which satellite the star was born.

7.22 Measuring Environment and Feedback

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Abstract

Environment and supernova feedback play important roles in galaxy formation yet the meaning of these terms can vary between implementations. For modellers, environment can be measured in 3D spacial coordinates as given by the outputs of simulation. Observers on the other hand do not have this luxury and are limited by the 2D projections on the sky. Usually a property, such as velocity dispersion, is then measured from a galaxy to constrain the third dimension. It is interesting to ask how well these different methods converge as to unify observations and simulations one needs to agree on what is actually being compared. Similarly, supernova feedback is implemented in many models, but different recipes are used construct it. Supernovae are not only responsible for clearing the ISM through a Sedov blast, but can also trigger star formation. Different implementations can lead to different star formation rates based on the same physical event, which should not occur. To constrain these effects, we present results from two projects that use known solutions to compare the accuracy of the different techniques used. The first is an environment project that uses the Millennium Simulation to investigate the different environment parameters in use. The second is a series of supernova blasts conducted in different environments to compared how the feedback models work on the same initial conditions. Through these two comparison projects convergence between the different techniques is investigated, improving our understanding of models of galaxy formation.

7.23 Cosmological SPH Simulations: Formation and Evolution of massive Galaxies

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Abstract

We use a large sample of cosmological re-simulations of individual massive galaxies to investigate the origin of the strong increase in sizes and weak decrease of the stellar velocity dispersions since $z = 2$. At the end of an rapid early phase of star-formation, where stars are created from infalling cold gas, our simulated galaxies are all compact with projected half-mass radii of < 1 kpc and central line-of-sight velocity dispersions of ≈ 262 kms^{-1}. At lower redshifts ($z < 2$) those galaxies grow predominantly by the accretion of smaller stellar systems and evolve towards the observed local mass-size and mass-velocity dispersion relations. We find that the evolution of massive galaxies can be explained by frequent minor stellar mergers which is the dominant mode of accretion for our simulated galaxies.

7.24 Simulating Elliptical Galaxies Throughout the Fundamental Plane

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Abstract

High-resolution simulations have suggested that some elliptical galaxies are formed through major mergers of spiral galaxies, with the dissipation associated with star formation producing a compact spheroid remnant. Including this dissipation is essential in reproducing the slope and scatter of the observed size-mass and Fundamental Plane relations for ellipticals. Subsequent minor mergers can, in turn, preserve these scaling relations while transforming high-redshift compact ellipticals into the large, diffuse objects seen in the local universe. I will discuss my work to include the results of high-resolution simulations within semi-analytic models to predict the effective radius and velocity dispersion of elliptical galaxies following major and minor mergers. Using these results, I will examine the evolution of the size-mass and Fundamental Plane relations as a function of redshift. I will also look at correlations between stellar age and metallicity and the residual surface brightness 'thickness' of the Fundamental Plane. Looking at the merger histories of elliptical galaxies throughout the Fundamental Plane allows us to determine whether galaxies that lie above the Fundamental Plane, with relatively higher surface brightnesses, do so because of their more recent mergers and star formation, or because of intrinsic variations in their mass-to-light ratios and central dark matter fractions. By comparing the results of semi-analytic models with a recent analysis of the Sloan Digital Sky Survey, we can determine the efficacy of major and minor mergers in creating realistic elliptical galaxies.

7.25 The interplay between background and local ionizing radiation sources in shaping neutral gas structures in Milky-Way-like galaxies

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Abstract

We study different properties of the neutral and ionized gas in a zoomed simulation which is similar to the Milky Way at redshift zero. Our method is based on post processing the snapshots at different redshifts with a set of full radiative transfer simulations, using TRAPHIC, in order to investigate the effect of different physical processes which change the distribution of neutral gas inside the galaxy.

7.26 Subhalo Abundance Matching in the Bolshoi Simulation Tested Against SDSS DR7 Galaxies

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Abstract

While cosmological dark matter simulations have consistently improved over time, it remains necessary to relate galaxies with the dark matter in order to make comparisons with observation. To examine this relationship, we have applied abundance matching to dark matter halos in the Bolshoi simulation. The Bolshoi simulation has sufficient resolution to allow subhalo abundance matching (SHAM) for objects dimmer than $M_r = -18$ while having enough volume to make precise statements about their statistical properties. We apply several different SHAM prescriptions, and measure the projected two-point correlation function, the conditional luminosity function and the conditional stellar mass function. These results are then compared against the same measures drawn from the SDSS DR7 galaxy catalog. SHAM reproduces the clustering and the conditional luminosity function found in the SDSS when performing abundance matching with the peak circular velocity before accretion and using a fixed scatter in luminosity. This scatter is constrained to be nonzero and ≤ 0.2 dex.

7.27 Angular momentum as a second parameter in dwarf galaxy evolution

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Abstract

We show results based on a large suite of N-Body/SPH simulations of isolated, flat dwarf galaxies, both rotating and non-rotating [Schroyen et al.]. The main goal is to investigate possible mechanisms to explain the observed dichotomy in radial stellar metallicity profiles of dwarf galaxies: dwarf irregulars (dIrr) and flat, rotating dwarf ellipticals (dE) generally posess flat metallicity profiles, while rounder and non-rotating dEs show strong negative metallicity gradients. These simulations show that flattening by rotation is key to reproducing the observed characteristics of flat dwarf galaxies. Rotation proves particularly efficient in producing flat metallicity profiles, while non-rotating dEs in flattened dark-matter haloes are not able to do this. The addition of angular momentum causes a "centrifugal barrier" which slows down the infall of gas, so that the low-level star formation and the accompanying feedback are not centrally concentrated but occur galaxy-wide. This also prevents large-scale oscillations in the SFR, turning a so-called "breathing" SFH into a more continuous SFH, and causes low density holes to be created in the gas, which is observed in dIrrs. This mechanism of smearing out the SF in space and time proves to be the principal reason for the flat metallicity profiles of dIrrs and flat dEs, instead of the previously suggested "fountain mechanism". We therefore propose our "centrifugal barrier mechanism" which is able to explain the observations. Our general conclusion is that rotation has a significant influence on the evolution and appearance of dwarf galaxies, and we suggest angular momentum as a *second parameter* (after galaxy mass as the dominant parameter) in dwarf galaxy evolution. Angular momentum differentiates between SF modes, making our fast rotating models qualitatively resemble dIrrs, which does not seem possible without rotation.

7.28 Numerical and analytic treatment of supernova feedback: The right answer for the wrong reasons?

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Abstract

Twenty years have passed since the first numerical simulations of supernova feedback in galaxies, years marked by astonishing advances in computational facilities. Yet our analytic treatment of this process seems to have lingered, apparently keeping faith with the results of these simple pioneering experiments. Is this conviction because the net effect on gas supply is indeed simple – underpinned by robust energy conservation arguments – or are we turning to outdated conclusions? To face this question, we have run controlled simulations of disk galaxies, exploring the dependence on resolution, and attempting to understanding the physical reason for the differing results. This exercise reveals a lack of convergence in the numerical technique. However, by extrapolation beyond the highest achievable resolution, it is possible to use these results to support a modified version of the traditional treatment of supernovae feedback. This can be used to improve the physical accuracy of both analytic models and resolution-limited simulations.

7.29 The Fundamental Plane of Galaxy Group Mergers

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Abstract

We present a large sample of collisionless simulations of galaxy group mergers designed to produce elliptical galaxy remnants. The simulations consist of ∼100 groups spanning a range of masses from $3 \times 10^{10} - 10^{13} M_{\odot}$ and are initially composed of 3 to 50 spiral galaxies. The input galaxies are selected from an observed luminosity function and scaled by the Tully-Fisher relation. These simulations are designed to test whether hierarchical multiple mergers of spiral galaxies obeying known scaling relations can produce elliptical remnants on the observed fundamental plane. The simulations are one of the largest samples of galaxy group simulations to date. The resulting galaxies are analysed using a variety of traditional one dimensional profile fitting techniques, as well as two dimensional fits using GALFIT and GALMORPH. We create mock photometric and kinematic observations of the groups, using GALFIT to fit the profiles of the central galaxy and nearby satellites. The resulting morphologies, kinematics and scaling relations are compared to published analyses of local elliptical galaxies. We focus on the best fit Sersic index and bulge fractions in addition to the fundamental plane. Also discussed are systematic effects from seeing, signal-to-noise and fitting method.

7.30 What are Broad Lyman-Alpha Absorbers?

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Abstract

Using high-resolution, hydrodynamical simulations of structure formation (OWLS), we investigate the nature of Broad Lyman-Alpha Absorbers (BLA). In particular, we analyse the mechanisms responsible for their widths, and the physical conditions of the gas and the structures where they arise. We compare our results to observations where possible, and make some predictions about what should be expected from data obtained with e.g. COS.

7.31 The impact of different feedback processes on the Lya emission and the circumgalactic medium of high redshift galaxies.

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Abstract

I will discuss results from different works which explore the effect of feedback processes on the galaxies and the intergalactic medium at high redshift. First I will present 3D resonant radiative transfer simulations of the spatial and spectral diffusion of the Lya radiation from a central source in the host galaxies of high column density absorption systems at $z \sim 3$ (Barnes, Haehnelt, Tescari & Viel 2011, arXiv: 1101.3319, submitted to MNRAS). The radiative transfer simulations are based on a suite of cosmological galaxy formation simulations (run with the SPH code GADGET-2) which reproduce a wide range of observed properties of Damped Lya absorption systems (Tescari et al. 2009, MNRAS, 397, 411). Then, I will present some preliminary results on the same topic, from the work I am doing in Saclay (Paris), under the supervision of Prof. Romain Teyssier, using the Eulerian AMR code RAMSES. I will conclude by discussing the paper 'Cosmic evolution of the triply ionized Carbon (CIV) in high-resolution hydrodynamic simulations' (Tescari et al. 2011, MNRAS, 411, 826), where we investigate the properties of CIV in the intergalactic medium using a set of high-resolution and large box-size cosmological simulations of a LambdaCDM model.

7.32 The effects of baryons on the matter power spectrum

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Abstract

Upcoming weak lensing surveys, such as those with LSST, EUCLID, and WFIRST, aim to measure the matter power spectrum with unprecedented accuracy. In order to interpret these observations, theoretical models are needed that, given a set of cosmological parameters, can predict the non-linear matter power spectrum at the level of 1% or better for scales corresponding to $0.1 \leq k \leq 10\,h\,\mathrm{Mpc}^{-1}$. We have employed the large suite of simulations from the OWLS project to investigate the effects of various baryonic processes on the matter power spectrum. In this talk, I will show that single baryonic processes are capable of changing the power spectrum by up to several tens of per cent, and can even change it by $\sim 1\%$ at $k = 0.3\,h\,\mathrm{Mpc}^{-1}$ already. It will thus be necessary to improve our understanding of feedback processes in galaxy formation, or at least to constrain them through auxiliary observations, before we can fulfil the goals of upcoming weak lensing surveys.

7.33 Radiative Transfer Modeling of Lyman Alpha Emitters and New Effects in Galaxy Clustering

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Abstract

Lyman Alpha Emitters (LAEs), galaxies selected by their Lyα emission, are becoming an important probe of galaxy formation, cosmic reionization, and cosmology. Correct interpretations of the growing observations of LAEs require us to take into full consideration the radiative transfer (resonant scattering) of Lyα photons. For this purpose, a Monte Carlo Lyα radiative transfer code is applied to a state-of-the-art cosmological reionization simulation to study $z \sim 5.7$ LAEs. It is the first time that realistic radiative transfer modeling of LAEs is performed in a cosmological volume. The study reveals a coupling between the observed Lyα emission and the circumgalactic and intergalactic environments induced by the resonant scattering of Lyα photons. Such an environment-dependent radiative transfer effect alone is able to explain an array of observed properties of LAEs. In addition, it gives rise to interesting new features in the clustering of LAEs. The model also predicts extended Lyα halos around star-forming galaxies, including LAEs and LBGs. The study leads to a completely new framework for understanding LAEs, with important implications for using LAEs to study reionization and cosmology.

7.34 Self-Similar Secondary Infall: Trying to Understand Halo Formation

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Abstract

N-body simulations have revealed a wealth of information about dark matter halos, but their results are largely empirical. Using analytic means, we attempt to shed light on simulation results by generalizing the self-similar secondary infall model to include tidal torque. Imposing self-similarity allows us to analytically calculate the structure of the the halo in different radial regimes and numerically compute the profiles of the halo without being limited by resolution effects inherent to N-body codes. I will describe this simplified halo formation model and compare our results to mass and velocity profiles from recent N-body simulations. We find that angular momentum plays an important role in determining the structure of the halo at small radii.