



## 2016 ANNUAL SCIENTIFIC CONFERENCE

### The Changing Face of Galaxies: Uncovering Transformational Physics

19<sup>th</sup>-23<sup>rd</sup> September 2016, Hobart, TAS, Australia

## POSTER ABSTRACT BOOKLET

### What are the physical reasons behind morphological transformations?

#### 1. Tim Dolley

Monash University

##### *The Clustering and Halo Masses of Galaxies as a Function of their Morphology*

Galaxy morphology is known to depend strongly on environment, with a higher fraction of elliptical and lenticular galaxies in denser regions. We have examined the morphological dependence on environment in detail, with the most robust clustering measurements to date as a function of both visual morphology and infrared luminosity (which is a proxy for stellar mass). We find that elliptical and lenticular galaxies have similar clustering and reside with the highest mass halos, while spirals are typically found within halos  $<10^{13} M_{\odot}$ . This is consistent with environmental quenching, where star formation is truncated in halos above this mass threshold. We see an even stronger clustering dependence on morphology at small scales ( $<1 \text{ Mpc}$ ). We show that Sc galaxies are 10 times less likely to have satellite companions than bulge dominated galaxies, suggesting that morphological transformation to a bulge dominated galaxy is associated with interactions and mergers. We find that halo mass has a dependence on stellar mass for all morphologies except Sc galaxies. Sc galaxies are always found within typical halo masses of  $\sim <10^{12} M_{\odot}$ , regardless of their stellar mass. This also indicates a larger likelihood of morphological transformation in higher mass halos. Lastly, we measure the cross-correlation functions of morphology-selected samples with each other to show their relative mixing within halos. We find that close galaxy pairs have similar morphologies more often than one would expect by random chance, and have thus identified an example of “galactic conformity” previously observed in galaxy colour and star formation rate.

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#### 2. Lulu Fan

Institute of Space Sciences, Shandong University, China

##### *WISE-Selected, Dust-Obscured Galaxies: IR SED Decomposition and Host Galaxy Morphology*

We present our recent works on IR SED decomposition and host galaxy morphology analysis of WISE-selected, hyperluminous dust-obscured galaxies (Hot DOGs). We confirm that they are hyperluminous, with torus emission dominating the IR energy output ( $>75\%$ ). Hot DOGs have both high IR luminosity of cold dust and high dust temperatures. As a result, they have relatively low dust mass. The hyperluminous Hot DOGs have high dust covering factors. The torus luminosity has been found to be well correlated with that of cold dust, which is consistent with the model predictions of AGN-dominated systems. Thanks to heavy obscuration, host galaxy morphology of Hot DOGs can be revealed directly with HST WFC3 H band imaging. Using visual classification on a small sample of Hot

DOGs, we find that  $\sim 62\%$  of them show the merger signal, suggesting that both intense AGN and starburst activities are likely merger-driven. According to fitting the surface brightness profiles, we find that the distribution of Sérsic indices of Hot DOGs peaks around 2, which suggests that most of Hot DOGs have transforming morphologies. Combining the results of SED decomposition and morphology analysis, we suggest that Hot DOGs may lie at or close to both peaks of star formation and black hole growth histories, and represent a transit phase during the evolution of massive galaxies, transforming from the dusty starburst dominated phase to the optically bright QSO phase.

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### 3. Angela Hempel

Universidad Andres Bello

#### *The Morphologies of Red Sequence Galaxies, from High to Low Density Environments*

Many of the physical processes that influence the evolution of galaxies depend on both their mass and the local environment in which they reside, be it through merging, harassment and/or stripping.

In order to distangle both effects on the evolution of structural parameters like size, mass and compactness, a consistent study of the parameters involved over a wide range of redshifts, environments and masses is required.

I have used the HST Frontier Fields to study the morphologies of galaxies comprising the red sequence. The common understanding refers to these galaxies as systems with an evolved stellar population, implying that their star formation episodes are well behind them. Indeed, stellar population studies have shown, that under the assumption of a single stellar population, the last episode of star formation happened in a monolithic collapse like event at redshifts of 2 and earlier. I used stellar population modelling to determine colour criteria suitable for the selection of Cluster Red Sequence galaxies. For each of the cluster fields several 100 of cluster member candidates have been found, without using the photometric and/or spectroscopic redshift information.

I have included all members of the red sequence without any limits to the cluster centric radius. By adding the parallel fields to the study, it is possible to study the environmental effects out to R200. All the parallel fields of the HST Frontier Field sample lie within that distance, and although it can be argued if such a distance can be considered as "field" environment (especially in case of MACSJ1149.5+2223), the parallel fields are placed away from the direction of extended distribution of luminous matter.

I will describe the methods to select the galaxy cluster members and how their structural parameters were determined. The focus will be on the comparison between clusters at different redshifts and if any effect of the environment can be detected, e.g. the distribution of galaxies of a given size ( $r_{\text{eff}}$ ) and Sercic index.

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### 4. Berta Margalef Bentabol

University of Nottingham

#### *The Formation of Bulges, Discs and Two Component Galaxies in the CANDELS Survey at $z < 3$*

The most massive galaxies in the local Universe can be classified as disc-dominated and spheroid-dominated (i.e. Hubble type). However, it is unclear how and when these dominant structures form and the possible connection between them. To address this issue we have investigated massive

galaxies ( $\log M > 10$ ) in the CANDELS fields at the epoch of  $1 < z < 3$ , when the Hubble sequence forms, by fitting their light profiles with a single Sérsic fit, as well as with a combination of exponential and Sérsic profiles. We split our sample between having 1 component (disc/spheroid-like galaxies) and those formed by an 'inner part' or bulge and an 'outer part' or disc (2 components). I will show in this talk that the most massive galaxies are more likely to consist of a bulge and a disc compared to lower mass galaxies. The number of such 2-component systems decreases at higher redshift; by a factor of 3 from  $z=1$  to  $z=3$ . We find that single 'disc-like' galaxies have the highest relative number densities at all redshifts, and that 2-component galaxies have the greatest increase and become at par with discs by  $z = 1$ . We also find that the 2-component systems have an increase in the sizes of their outer components, or 'discs' by about a factor of three from  $z = 3$  to  $z = 1.5$ , while the inner components or 'bulges' stay roughly the same size. This suggests that these systems are growing from the inside out, whilst the bulges or protobulges are in place early in the history of these galaxies.

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## 5. Burcin Mutlu Pakdil

University of Minnesota Twin Cities

### *The Nonbarred Double Ringed Galaxy PGC 1000714*

Hoag-type galaxies are quite rare peculiar systems which bear strong resemblance to Hoag's Object with an elliptical-like core, a detached outer ring, and no signs of bar and stellar disc. This morphology is important because they represent extreme cases and help to understand the formation of galaxies in general by providing clues on formation mechanisms. The nature of outer rings in Hoag-type galaxies is still debated and may be related either to slow secular evolution, such as dissolution of a bar-like structure, or to environmental processes, such as galaxy-galaxy interactions or gas infall. Due to a fairly superficial resemblance to Hoag's Object, PGC 1000714 is a good target for detailed study of the peculiar structure of this type. We present the first photometric study of PGC 1000714 that has not yet been described in the literature. Our aim is to evaluate its structure and properties as well as understand the origin of outer rings in such peculiar galaxies. Surface photometry of the central body is performed using near-UV, BVRI and JHKs images. Based on the photometric data, the nearly round central body follows well a de-Vaucouleurs profile for more than 5.0 mag almost all the way to the center. The detailed photometry reveals a reddish inner ring-shaped structure that shares the same center with the central body. However, no sign of a bar or stellar disc is detected. The outer ring appears as a bump in the surface brightness profile with a peak brightness of  $25.77 \text{ mag arcsec}^{-2}$  in the B-band and shows no sharp outer boundary. By reconstructing the observed spectral energy distribution (SED) for the central body and the rings, we recover the stellar population properties of the galaxy components. Our work suggests different formation histories for the inner and outer ring. We rule out the slow secular evolution model as being a formation mechanism for the outer ring. The colors of the outer ring are consistent with a feature that may have experienced a burst of star formation due to a possible recent accretion event. In addition, our work supports that the central body may be formed by a relatively dry major merger or in a single, short and highly effective star formation burst, and the inner ring may be formed as a result of the intergalactic medium (IGM) accretion or a secular evolution in a possible gaseous disc.

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## What drives the kinematic transformation of galaxies?

### 6. Dilyar Barat

Australian National University

#### *Constructing a Unified Galaxy Scaling Relation with SAMI*

Using the integral field spectroscopy data from the Sydney-AAO Multi-object Integral field (SAMI) Galaxy Survey, we study the scaling relation between stellar mass and the kinematics of galaxies of all morphologies. The sample includes the stellar and gas of both early and late type galaxies. By combining the effects of rotation velocity and velocity dispersion via the  $S_{\{K\}}$  parameter, we confirm the results from previous similar studies that  $S_{\{K\}}$  provides a better mass estimation than the conventional stellar mass Tully-Fisher and Faber-Jackson relations. Upon further investigations, we find the scatter of the relation can be reduced by choosing different K values for gas and stellar component, as well as morphologies of the galaxies. Then we reconstruct the scaling relation with the ATLAS<sup>3D</sup> project galaxy sample. Using the additional information provided from their dynamical models, namely the Jeans Anisotropic MGE, we demonstrate that using the dynamical JAM mass instead of the photometric mass estimation, the scatter of the relation can be improved significantly. Thus making the scaling relation a reliable mass estimation tool for a wide range of galaxy morphologies, and potential distance indicator for cosmological studies.

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### 7. Sabine Bellstedt

Swinburne University of Technology

#### *SLUGGS Survey: Disentangling Formation Histories of S0 Galaxies Using Kinematics.*

Although lenticular and elliptical galaxies are both historically classified as 'early-type galaxies', lenticular galaxies have been observed to be distinct from both elliptical and spiral galaxies with respect to their structure and kinematics. S0 galaxies have been proposed to host a larger range of formation histories than E galaxies, especially at lower stellar masses.

I present a detailed analysis of 2D kinematic data to  $\sim 2-3$  effective radii for a number of low-mass lenticular galaxies. The large radial extent of these data allow judgements to be made regarding the global behaviour of each galaxy. We compare the kinematic properties of our galaxies with results from simulations, to best interpret the formation scenarios for our galaxies. We additionally present a local stellar spin parameter space that provides a kinematic separation between elliptical and lenticular galaxies.

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### 8. Hoseung Choi

Yonsei University

#### *The Spin Evolution of Galaxies in the Cosmological Zoom-In Simulations of Galaxy Clusters*

Spin is considered an effective alternative to morphology for describing the current status of galaxies and excavating their evolution history. The observed spin properties of galaxies however do not allow a direct interpretation. In the hope of finding hints we have performed a hydrodynamic zoom-in simulation for 19 clusters of galaxies extracted from a large cosmological volume simulation. We inspect the spin evolution of the  $\sim 2000$  constituent galaxies and present our preliminary results. The

model galaxies do show the spin properties that are comparable with the recent IFU observations of SAURON, ATLAS3D, and SAMI. The broad distribution of spin parameter has a peak at  $\lambda = 0.2$  without an apparent dichotomy. Spin shows a strong negative mass dependency. At  $z=0$ , the top 1% massive galaxies are exclusively slow rotators. At high redshift, most galaxies spin much faster, e.g.,  $\lambda = 0.4$  at  $z=2$ . The mean value of spin parameter decays with time slowly but robustly. Since galaxy mergers are frequent in the LCDM universe and mergers have impacts on spin (Oh et al. 2016), LCDM presents a unique prediction on the spin evolution of galaxies. Major merger do have a strong impact on the galaxy spin; but unlike our initial guess, they cause a rise as frequently as a fall in spin depending on the details of merger conditions. The net effect of major mergers since  $z=3$  is not necessarily so negative as to explain the decay of spin in the bulk of galaxies. The decay in spin seems to be more importantly determined by the cumulative effect of numerous events of minor mergers and smooth accretion. Our results are based only on the cluster simulation and thus limited; but, it seems reasonably safe to conclude that the LCDM presents a consistent picture with observation. Spin measurement on distant galaxies will put a test on the prediction.

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#### 9. Francesco D'Eugenio

Australian National University

##### *The SAMI Galaxy Survey Scaling Relations*

The SAMI Galaxy Survey (SGS) is the largest Integral Field Spectroscopy Survey to date. We present relatively simple dynamical models of the SGS galaxies, and use them to construct three fundamental scaling relations: the Fundamental Plane, the Mass Plane and the Mass vs Angular Momentum relation. These results are then used to suggest strategies for upcoming and future surveys spectroscopic surveys of galaxies.

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#### 10. Ivana Ebrov

Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences

##### *Galaxies with Prolate Rotation in the Illustris Simulation*

Life of dwarf spheroidal galaxies is still not well understood. Due to their low surface brightness, spatially and kinematically resolved observations are restricted to the limited number of Local-Group spheroidal and cosmological simulations usually do not have good enough resolution on such small scales. Collisions between dwarf galaxies are assumed to be rare, but the prolate rotation, observed in the Local-Group spheroidal Andromeda II, may be an exceptional indicator of a past major merger. In our previous work we constrained the initial conditions leading to the observed kinematics of Andromeda II using controlled, self-consistent simulations of mergers between disk dwarf galaxies. The next step is to investigate the origin of prolate rotation in the cosmological context. For this purpose, we use the Illustris project, a large-scale cosmological simulation following the evolution of different baryonic components and containing a large sample of sufficiently resolved dwarf satellite galaxies. Among them, we identified tens of galaxies exhibiting prolate rotation, some of them showing signs of a recent merger event. We will discuss in detail their photometric and kinematic properties as well as formation histories determined by examining their merger trees. Our study will help to explain the origin of prolate rotation and identify pathways leading to this phenomenon in a realistic simulation of the Universe.

**11. Caroline Foster**

Australian Astronomical Observatory

*The SAMI Galaxy Survey: The Shape of Galaxies*

The intrinsic or true three-dimensional shape of galaxies is one of their most fundamental characteristic. Yet, due to projection effects, the true shape of galaxies is a difficult property to measure accurately. The most reliable method for inferring intrinsic shapes require large samples of spatially resolved stellar kinematic maps. Large IFU surveys are now enabling this type of science to be done accurately on carefully selected samples of galaxies. I am using the SAMI Galaxy Survey to uncover the physical processes that are involved in shaping various types of galaxies. Recent results and highlights will be presented.

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**12. Minju Lee**

The University of Tokyo

*Galaxies in Transformation at  $z=2.49$  Protocluster*

This talk presents the results of ALMA CO(3-2) molecular line observation toward a protocluster at  $z=2.49$ , that has targeted star forming galaxies associated to it. We focus on how galaxies could transform from disks to elliptical, red-and-dead, galaxies under the certain circumstance of environment, i.e., in the early stage of cluster formation at high redshift, inspired by the fact that massive ellipticals reside on denser regions compared to spiral galaxies in local universe. Our ALMA observation unveils the galaxy kinematics with the molecular line in 7 HAEs among 22 targeted at  $0''.7 \times 0''.9$  resolution (4-6 kpc in physical). From the spectral and 3D analysis, we find that more than a half of them appear to be experiencing mergers with lower gas mass fraction and higher star formation efficiency in more massive galaxies. I will summarise these results and conclude with implications on galaxy transformation in the early universe at the protocluster.

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**13. Sree Oh**

Yonsei University

*Impact of Galaxy Interactions in Stellar Kinematics*

Galaxy mergers are important elements that determine the fate of a galaxy e.g. changing morphology, activities, and mass growth. Analyses detecting merger signatures via observed images have been used for decades, and now we can inspect the impact of mergers on kinematics, a fundamental factor deciding the evolution of a galaxy, using the new technique of Integral Field Spectroscopy (IFS). We visually chose merger-featured galaxies from deep images ( $\mu r \sim 28$  mag/arcsec<sup>2</sup>) using a MOSAIC II CCD mounted on the Blanco 4-m telescope at the Cerro Tololo Inter-American Observatory. We found that 23 out of 63 galaxies in Abell 119 have post-merger signatures. We investigated their kinematically distinct features of orientation, perturbation, and angular momentum with stellar kinematics from the Sydney-AAO Multi-object Integral field on the 3.9-m Anglo-Australian Telescope. Mergers induce large scatters in the Tully-Fisher relation suggesting angular momentum changes via mergers, and merger-featured galaxies are also involved with changing the orientation of the mean stellar motion and perturbing their velocity. Therefore, our results from extra deep images enable us to suggest that kinematically distinct features are



tightly correlated to recent mergers. In addition we found that half of slow rotators show merger features and discuss the role of mergers in the origin of slow rotators.

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## What are the Process Controlling the Quenching of Star Formation?

### 14. Paula Calderón-Castillo

Universidad de Concepción

#### *Merging Galaxies and their Position on the SFR-Mstellar Plane*

As galaxies pass through the merging process, they can undergo substantial transformations in their atomic and molecular gas distribution, resulting in gas collapse, and triggering star formation (SF) bursts. The increase in SF can be so high that the galaxy appears above the Main Sequence of star formation, inhabited by typical galaxies. We are conducting a comprehensive study of galaxy location on the SFR-Mstellar plane for a large sample of colliding galaxies. By combining multiple wavelength data from UV to sub-mm, we separate the galaxies into different stages of merger, and analyse their morphology, AGN activity, and their SF history and dust content. We find that some systems in the intermediate to late stage of the merger process show enhanced SF, and these often present spiral and very disturbed morphology. However many of the merging spirals show no enhancement or even a reduction in SF. We cross-correlate our galaxies' SF activity with dust and AGN content to better understand how mergers evolve across the SFR-Mstellar plane.

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### 15. Jacob Crossett

Monash University

#### *GAMA Post-Starbursts and the Quenching of Star Formation in the Field and Groups*

Post-starburst galaxies are undergoing a very rapid quenching of star formation, although the reasons for this transformation after having a burst of star formation remain unclear. We have created a clean sample of post-starburst galaxies using traditional spectroscopic indicators (including H delta, H alpha, and [OII]) in the GAMA survey to conduct a multi-wavelength investigation into the formation of these galaxies. Compared to a control sample of mass and colour matched galaxies, our post star burst galaxies have photometric signatures associated with a more rapid quench of star formation, confirming a different star formation history. Despite this difference in star formation history, no obvious environmental difference exists between these samples. We therefore outline alternate scenarios for the existence of this population.

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### 16. Amelia Fraser-McKelvie

Monash University

#### *A Photometrically and Spectroscopically Confirmed Population of Passive Spiral Galaxies*

It is often assumed that the truncation of star formation requires (or at least coincides with) the transformation of galaxies from late- to early-type morphologies, even though mechanisms exist that can quench star formation without affecting galaxy morphology. Optically selected samples of red spiral galaxies frequently suffer from dust obscuration or low levels of star formation when

examined in ultraviolet (UV) or infrared (IR) wavelengths, leading Cortese (2012, A&A, 543,132) to question whether passive spiral galaxies exist in the local Universe.

I will present results from the first mid-IR-selected sample of 51 passive spiral galaxies with spatially-resolved follow-up spectroscopy and robust morphologies. We find a mid-IR selection criterion identifies passive galaxies with no indication of star formation at other wavelengths, including the UV and optical. Six galaxies form a pilot sample for spectroscopic follow-up using the WiFeS IFU. These six galaxies possess absorption line spectra with 4000 Angstrom breaks consistent with an average luminosity-weighted age of  $\sim 2.3$  Gyr. We see no evidence for substantial nebular emission across the entire galaxy as found in some previous red spiral samples. From this we conclude that we have definitive proof of local passive spiral galaxies with little or no star formation (2016, MNRAS, 462,11).

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### **17. Rhythm Shimakawa**

SOKENDAI/NAOJ

#### *The Low-Mass End of Sizes and Star Formation Rates of Galaxies at $z=2-3$*

We conducted deep narrow-band imaging surveys with the Subaru Telescope to search for Ly $\alpha$  emitters (LAEs) and H $\alpha$  emitters (HAEs) at  $z=2-3$  in field and protocluster environments. These samples allow us to study a low mass regime of the scaling relations of star-forming galaxies, namely, mass–SFR, mass–size relations, and these environmental dependencies.

This work shows that the LAEs are located along the same main sequence traced by normal star-forming galaxies such as HAEs, but towards a significantly lower mass regime. The result can be obtained only by the deep LAE imaging data of this kind, which assures high completeness even at this low-mass end. Also, the high-resolution stellar images by WFC3/IR on the HST suggest that LAEs seem to share the same mass–size relation with typical star-forming galaxies within the margin of error, while they tend to have smaller sizes of  $\sim 1$  kpc. These results suggest that LAEs trace normal star-forming galaxies apart from the fact that they tend to be much less massive and smaller systems. They also suggest that the escape of Ly $\alpha$  photons may not require starbursts.

This kind of studies have been also conducted to the protocluster regions at  $z=2-3$ , and now we are intensively working on it. This poster will show some preliminary results obtained from the fresh data.

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### **18. Miguel Socolovsky**

University of Nottingham

#### *Analysing Environmental Quenching in Distant Galaxy Clusters*

I will present a study of galaxy populations in distant galaxy clusters, focussing in particular on post-starburst galaxies as probes of the likely quenching processes. I will first introduce the method, based on friends-of-friends algorithm, I have developed and optimised for the detection of galaxy clusters within deep photometric surveys, and apply this method to the  $0.8 \text{ deg}^2$  UDS survey. By comparing the mass functions of cluster and field galaxies in the redshift range from 0.5 to 1.0, I will show that galaxy populations at this epoch are significantly affected by their environment. Low-mass galaxies, in particular, are seen to be preferentially quenched in dense environments, as shown by a clear excess of low-mass passive and post-starburst galaxies. The radial distributions of these



galaxies shed further light on the quenching processes. While post-starburst galaxies have very similar mass functions to young star-forming galaxies, their radial distributions are very different, and more consistent with the quiescent population. Our results suggest that star-forming galaxies are quenched as they enter the dense inner regions of clusters. I will conclude by proposing a model involving two possible environmentally-driven quenching pathways: rapid quenching of low-mass (perhaps by merging or ram-pressure stripping), and slow quenching, triggered by a more gentle gas removal, leading to the strangulation of the galaxies.

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**19. Christian Wolf**

Australian National University

*Star Formation in Red Spirals in A901/2 seen from Different Angles*

We have studied the cluster complex Abell 901/2 at redshift 0.16 with our multi-band survey COMBO-17, our HST survey STAGES, Spitzer MIPS, H-alpha tuneable filter imaging and spatially resolved spectroscopy. The cluster contains over 500 galaxies detected in H-alpha, many of which are infalling red spirals, and is an intriguing laboratory of galaxy transformation. Here, we investigate star formation properties measured with indicators from restframe UV over H-alpha to 24 micron. These indicators have both, different time responses to the star formation history and different response to dust extinction. We also probe these indicators as a function of galaxy inclination, which correlates with dust optical depth, and find interesting trends.

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**What is the role of AGN and star-formation feedback?****20. Julie Banfield**

Australian National University

*Green DRAGN and their Implication on AGN feedback*

There is general agreement within the astronomy community that AGN activity can influence the host galaxy in different ways. We call this impact "AGN feedback". We have discovered a number of radio-loud Double Radio Sources Associated with Active Galactic Nuclei (DRAGN) living in galaxies with visible OIII and Halpha outflows. In this presentation I will discuss our sample of Green DRAGN and their interaction with the observed outflows. I will present the radio-loud timescale of the DRAGN in context with the overall AGN feedback phenomena.

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**21. Ryan Brennan**

Rutgers University

*Tracking Galactic Scale Outflows around Simulated AGN*

We use hydrodynamical simulations with an updated, custom version of the smoothed particle hydrodynamics code GADGET to study the effects of AGN feedback on the gas content of galaxies. Our simulations include a detailed and novel treatment of AGN-driven feedback, including thermal, mechanical, and radiation feedback as described in Choi et al. (2015; 2016). We examine inflows and outflows at two different radii for two suites of cosmological zoom-in runs that both include the

accretion of new gas from satellites and the intergalactic medium. One set of zoom-ins includes our prescription for AGN feedback while the other does not. We examine the large-scale outflows around galaxies in these two suites due to both accreting black holes and stellar feedback. We keep track of the density and temperature of inflowing and outflowing material in both cases and examine how material is swept up in winds, re-accreted, or removed from the galaxy completely. In this way we can make predictions of how efficiently AGN feedback removes gas from the AGN's host galaxy. We also study the implications for galaxy quenching.

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## 22. Rodrigo Canas

University of Western Australia

### *Robust identification of stellar structures in simulations: the effect on scaling relations*

The latest generation of galaxy formation simulations have been producing statistical samples of galaxies whose properties can be compared with galaxy survey data. However, the structures that form in these simulations are complex, and how we interpret the results of these simulations can be affected by how we identify these structures. Estimating stellar masses in galaxies and their surroundings is an important quantity but challenging to define robustly, particularly in the case of galaxy interactions. Here we present an improved version of the publicly available 6-D friends-of-friends.

Halo finder code VELOCiraptor. Its new features include the robust identification of kinematically distinct, but very close stellar structures that reside in the same dark matter halos, and of the environment that surrounds a given system, i.e. intra-halo stellar mass (IHSM). We find that this new version of VELOCiraptor successfully separates galaxies that are as close as a few kpc. We find that the consequences of this improved algorithm on the predicted scaling relations can be important, particularly if focus is placed on interacting galaxies.

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## 23. Pascal Elahi

ICRAR

### *nIFTy Cluster Galaxies: Are Synthetic Galaxies Close to the Real Thing?*

I will present results from the nIFTy Cluster Comparison Project: which aims to compare state-of-the-art hydrodynamical codes using simulated clusters to assess how well these codes agree with one another and whether they reproduce the observable universe. We compare large swath of state-of-the-art codes from AREPO to RAMSES to the newest Smooth Particle Hydrodynamic codes using a zoom simulation of an unrelaxed cluster. The bulk properties and profiles of cluster shows  $\sim 0.1$  dex scatter arising from the variety of feedback formulations used and the underlying hydro solver. All codes without AGN and even some with AGN feedback do not produce clusters with stellar and gas fractions within the observed range. Critically, codes produce very different galaxy populations, both within the cluster itself and the surroundings. Though systematic differences are present between codes with and without AGN feedback, in general there is a great deal of scatter. Galaxy properties such as stellar mass or angular momentum varying by  $> 0.2$  dex. Few codes are capable of reproducing observed stellar and gas fractions for individual galaxies. Clearly the scatter shows the issue of fine-

tuning for hydrodynamic codes is still not solved and few codes reproduce observations over a wide range of stellar masses and environments.

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**24. Marcin Glowacki**

University of Sydney

*Tracing the HI Content in Distant Reddened QSOs with ASKAP*

Powerful active galactic nuclei (AGN) provide a key mechanism for transforming massive galaxies from gas-rich star-forming systems to passively-evolving red galaxies. In particular, radio jets from an AGN can couple directly to the cold interstellar medium (ISM) of their host galaxy. There is growing evidence (e.g. Morganti et al. 2003) that jet-driven outflows of neutral gas can rapidly deplete or even remove the cold gas reservoir in these galaxies.

When seen in absorption against the continuum emission of radio-loud AGN, the 21-cm line of neutral hydrogen (HI) can provide a powerful probe of these cold gas outflows, but until very recently observational evidence was largely restricted to nearby objects (redshifts of  $z < 0.15$ ). In this talk, I will present some early results from commissioning the new Australian SKA Pathfinder (ASKAP) radio telescope, probing HI absorption across the largely unexplored epoch between  $z = 0.4$  and 1. I will discuss how these results, including findings from a sample of dust-obscured radio AGN, inform us on prospects for future large-area HI surveys of the evolving radio AGN population.

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**25. Noelia Jimenez**

University of St Andrews

*The Role of Supernovae Type Ia Feedback in Galaxy Formation.*

The nature of the Type Ia supernovae (SNIa) progenitors remains still uncertain. This is a major issue for understanding one of the key processes that transforms galaxies. Chemical and energetic feedback from SNIa play a major role in the gas dynamics, star formation, and therefore in the overall stellar evolution. The progenitor models for the SNIa available in the literature propose different distributions for regulating the explosion times of these events. These functions are known as the Delay Time Distributions (DTDs). In this talk, I will present a study of five different DTDs for SNIa, implemented in hydrodynamical simulations of galaxies. Although finding good fits to the present observed SNIa rates, the [O/Fe] ratios shown by the bulge of the Milky Way, and the correlation between the specific SNIa rate and the specific star formation rate, this does not happen for all the proposed DTDs. Only a few progenitors scenarios can reproduce simultaneously all the observational constraints. Our results suggest that combining the observations of galaxies with very low and very high specific star formation rates with their [O/Fe] ratios will impose a very stringent constraints on the SNIa progenitors and the galactic evolution. (N Jimenez, P. Tissera, F. Matteucci)

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**26. Rebecca McElroy**

University of Sydney

*The Close AGN Reference Survey (CARS): The Changing Face of Mrk 1018*

We report the discovery of an AGN that has changed spectral type not once, but twice. So called 'changing look' AGN are an uncommon phenomenon, but twice changed AGN are much rarer. This AGN first transitioned from a narrow line AGN (type 2) to a broad line AGN (type 1) in the 1980s. It was recently observed as part of The Close AGN Reference Survey (CARS). CARS aims to provide a detailed multi-wavelength view of 40 nearby ( $0.01 < z < 0.06$ ) unobscured AGN to study the link between AGN and their host galaxies. The primary CARS observations come from the MUSE integral field unit on the VLT, and complementary multi-wavelength observations have been approved from a wide array of sources (SOFIA, Chandra, VLA, HST, and others). Examination of the MUSE data for this particular source showed that it no longer had the spectral features typical of a type 1 AGN. The continuum emission from the accretion disk was no longer visible and the broad lines were dramatically diminished. In this talk we describe the possible reasons for this change, supported by analysis of multi-epoch optical photometry and spectroscopy, alongside data obtained through director's discretionary time from Chandra, HST, and the VLA. We then conclude by discussing the implications of this discovery on our understanding of AGN timescales and the physics behind AGN spectral types.

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**27. Jesse Swan**

University of Tasmania

*Analysing Cosmic Evolution of Radio Luminosity Functions*

The third data release from the Australia Telescope Large Area Survey (ATLAS) provides access to 1.4 GHz observations of two elds: Chandra Deep Field South (CDFs), and European Large Area ISO Survey South 1 (ELAIS-S1). ATLAS reaches sensitivities of between 14 and 17 Jy beam<sup>-1</sup> over the combined 6.3 deg<sup>2</sup> of the two elds. Of the 5118 5 radio detections, 1149 targeted spectroscopic redshifts have been obtained via the OzDES program; a further 613 redshifts are available from literature. With higher sensitivity than previous data releases, we are probing lower radio luminosities to more broadly sample star forming populations, and weak radioactive galactic nuclei. We present radio luminosity functions for spectroscopically classified AGN and star-forming galaxies out to  $z > 2$ , and study the cosmic evolution of these populations.

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**28. O. Ivy Wong***Radio AGN Dominates 1.4 GHz Emission for Radio-Quiet AGN*

We investigate the 1.4 GHz radio properties of 92 nearby ( $z < 0.05$ ) ultra-hard X-ray selected Active Galactic Nuclei (AGN) from the Swift Burst Alert Telescope (BAT) sample. Through the ultra-hard X-ray selection we minimise the biases against obscured or Compton-thick AGN as well as confusion with emission derived from star formation that typically affect AGN samples selected from the UV, optical and infrared wavelengths. We find that all the objects in our sample of nearby, ultra-hard X-ray selected AGN are radio quiet; 83% of the objects are classed as high-excitation galaxies (HEGs) and 17% as low-excitation galaxies (LEGs). While these low- $z$  BAT sources follow the radio–far-infrared correlation in a similar fashion to star forming galaxies, our analysis finds that there is still

significant AGN contribution in the observed radio emission from these radio quiet AGN. In fact, the majority of our BAT sample occupy the same X-ray–radio fundamental plane as have been observed in other samples, which include radio loud AGN —evidence that the observed radio emission (albeit weak) is connected to the AGN accretion mechanism, rather than star formation.

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**29. Patrick Yates**

University of Tasmania

*The Feedback Efficiency of Restarting Jets from Active Galactic Nuclei*

Feedback from Active Galactic Nuclei is required to maintain the delicate heating/cooling balance in massive galaxies over the latter half of the Hubble time. The process usually invoked is kinetic feedback from radio jets, which do work on their host hot atmospheres through supersonic outflows, shocks and gas uplifting. An open question is whether the efficiency of this feedback mode depends on the jet duty cycle.

We present PLUTO numerical hydrodynamic simulations of radio jets interacting with a cluster-like environment. In each simulation, the same total energy is injected at the same time-averaged rate (i.e. using the same average jet power), but using a different number of jet episodes. We quantify the fraction of injected energy that couples to the surrounding gas, and compare AGN feedback efficiencies in different energy injection scenarios.

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**How does gas accretion and the refuelling of galaxies modulate star formation?****30. Luke Barnes**

University of Sydney

*How the Cosmological Constant Ends Accretion*

Theories of cosmological inflation often predict that cosmic conditions will vary from place to place in the universe as a whole. In particular, the value of the cosmological constant can plausibly explained by a combination of environmental variation and its effect on galaxy formation. In such models, it is crucial that we understand how quickly and efficiently the onset of accelerating expansion shuts down accretion of matter into dark matter haloes and galaxies. I will show simulations, based on the cosmological galaxy formation code of the Eagles collaboration that investigates this effect. More generally, I will show how an understanding of galaxy transformation can inform fundamental cosmology.

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**31. Michael Brown**

Monash University

*Calibration of Ultraviolet, Mid-Infrared and Radio Star Formation Rate Indicators*

We present new calibrations for star formation rate indicators in the ultraviolet, mid-infrared and radio continuum bands, including the first direct calibration of 150 MHz as a star formation rate indicator. Our calibrations utilize up to 64 nearby star forming galaxies with Balmer decrement corrected H $\alpha$  luminosities, which span 5 orders of magnitude in star formation rate and have

absolute magnitudes of  $-24 < M_r < -12$ . We use self-consistent measurements of photometry and spectrophotometry, combined with revised measurements of emission line fluxes, to mitigate systematic errors that may have been present in the prior literature. Our calibrations are comparable to those from the prior literature for  $L^*$  galaxies, but for dwarf galaxies we often find star formation rates need to be revised upwards relative to those from the prior literature (in some instances, by an order of magnitude). We find WISE 22.8 micron, Spitzer 24 micron and 1.4 GHz luminosities have relatively tight correlations with Balmer decrement corrected H-alpha luminosity, with scatters of approximately 0.2 dex.

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### 33. Tim Dolley

Monash University

#### *A Signature of Merger Driven Star Formation in Spiral Galaxies*

Local galaxy star formation is thought to be dominated by secular evolution, but star formation triggered by mergers must also contribute. We have measured the clustering of spiral galaxies as a function of specific star formation rate (SSFR), for a morphology selected sample. We find that large scale clustering of spiral galaxies is independent of SSFR, indicating spiral galaxies with high and low SSFRs typically reside within the same mass dark matter halos. On intermediate scales ( $\sim 500$  kpc), spiral galaxies with high SSFRs have a deficiency in satellite companions, but an excess of satellite companions at smaller scales ( $\sim 50$  kpc). This appears to be the signature of recent or ongoing mergers, where the suppressed correlation function at  $\sim 500$  kpc scales is due to the infall of a satellite companion.

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### 34. Simon Ellingsen

University of Tasmania

#### *Methanol Megamasers: A Powerful New Tracer of Star Formation in Starbursts?*

Within the Milky Way some rotational transitions of OH, water and methanol are commonly observed to exhibit maser emission towards star formation regions. Very different astrophysical processes produce megamaser emission (approximately 1000000 times more luminous than Galactic star formation masers) and this has been detected from molecular transitions of OH and water towards more than 100 galaxies. The OH megamasers are associated with ULIRGs and major-merger systems, while water megamasers arise close to low-luminosity AGN either in circumnuclear accretion discs or nuclear outflows. Searches for methanol megamasers from the powerful 6.7 GHz transition in the 1990s and 2000s failed to detect anything, however, we have recently detected the first methanol megamasers from the 36 GHz transition towards the nearby starburst NGC253 and the prototypical LIRG Arp 220. Follow-up observations suggest that the luminosity of the methanol megamaser emission is correlated with the star formation rate in the host galaxies. The physical cause of the correlation remains uncertain, but it is likely that the 36 GHz methanol transition traces large-scale low-velocity shocks and that these are also critical for triggering large-scale star formation. Here we present new results from high-resolution studies of the masers associated with the NGC253 starburst and results from a GBT search of OH and water megamaser systems.

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**35. Masao Hayashi**

National Astronomical Observatory of Japan (NAOJ)

*Physical Conditions of the Interstellar Medium in Star-Forming Galaxies at  $z \sim 1.5$* 

Nebular emissions are sensitive to physical conditions of star-forming regions in galaxies. The ratios of nebular emissions are thus frequently used to derive galaxy properties such as metallicity. However, recent studies have reported a difference in line ratios between high- $z$  galaxies and local ones. If so, this can cause a large uncertainty in the derived galaxy properties and then discussion of its redshift evolution. Here, we report the physical conditions of the interstellar medium in normal star-forming galaxies with  $\text{Log}(M_{\text{star}}/M_{\text{sun}}) > 8.5$  at  $z \sim 1.5$  which are derived with six major nebular emission lines in the individual and composite rest-frame

optical spectra: H $\alpha$  in 115 galaxies, [OIII]5007 in 45 galaxies, and H $\beta$ , [NII]6584, and [SII]6716,6731 in 13, 16, and 6 galaxies, respectively, in addition to [OII]3727 for all of the galaxies. This is based on the results from Subaru/FMOS NIR spectroscopy of 118 [OII]3727 emission line galaxies at  $z = 1.47$  and  $1.62$  which are

selected from Subaru narrow-band imaging (Hayashi et al. (2015), PASJ, 67, 80). With the dataset, we find that the star forming galaxies at  $z \sim 1.5$  have strong [OIII] emission lines. The [OIII]/[OII] ratios are larger than normal star-forming galaxies in the local universe, suggesting a higher ionization parameter. Also, less massive galaxies have larger [OIII]/[OII] ratios. With evidence that the electron density is consistent with local galaxies, we argue that the high ionization of galaxies at high redshifts is attributed to a harder radiation field by a young stellar population and/or an increase in the number of ionizing photons from each massive star.

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**36. Steven Janowiecki**

ICRAR/UWA

*Gas and Star-Formation Properties of Galaxies in Groups*

Observations of gas in galaxies have shown dramatic differences between rich clusters and isolated field environments. However, pre-processing in intermediate group environments is expected to be responsible for much of the transformation between gas-rich blue and gas-poor red galaxies. We investigate this by taking advantage of the deepest observations to date of atomic and molecular gas in local galaxies from the GASS and COLD GASS surveys and their extensions to low stellar masses. This sample is uniquely suited to quantify gas and star formation properties of galaxies across environments, reaching the gas-poor regime of groups and clusters. We present the scaling relations of gas content for central and satellite galaxies as a function of halo mass, and show that central galaxies in small groups are more gas rich (in both HI and molecular gas) and star-forming than galaxies in isolation.

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**37. Jung-Sung Moon**

Yonsei University

*Assessing the Role of Neighbouring Galaxies in Induced Star Formation*

One of the remarkable features found in interacting galaxies is their enhanced star formation (SF) activity. While the interaction-induced SF is qualitatively confirmed, the quantitative details are still in question due to the difficulty in controlling the selection bias. Here we investigate the impact of

neighbouring galaxies on the interaction-induced SF from the SDSS galaxies with a special care of minimizing the selection bias. In particular, we identify interacting pair galaxies and classify them into two groups; those with a star-forming neighbour and those with a quiescent neighbour. Each pair is matched with an isolated control galaxy in terms of stellar mass, redshift, and large-scale environment. Comparison of SF indicators (H $\alpha$  emission and NUV-r & u-r colours) between the pairs and the corresponding control sample shows that interactions with a star-forming neighbour are more effective to induce SF activity than interactions with a quiescent neighbour. Only star-forming galaxies interacting with a star-forming neighbour show 3-4 times higher star formation rates than isolated galaxies. Contrary to the usual notion that the SF enhancement is triggered by the tidal effect, this suggests hydrodynamic mechanisms also play a pivotal role in the galaxy-galaxy interactions.

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### 38. Vaishali Parkash

Monash Centre for Astrophysics, School of Physics and Astronomy, Monash University

*Relationship between HI Gas Mass, Stellar Mass and Star Formation Rate of HICAT+WISE Galaxies.*

We use the HI Parkes All Sky-Survey Catalog (HICAT) and the Wide-field Infrared Survey Explorer (WISE) to investigate star formation activity with respect to HI gas properties. WISE provides better star formation rate measurements, with higher completeness, compared to previous studies of HICAT because WISE achieves a greater sensitivity than the InfraRed Astronomical Satellite in the 12  $\mu$ m band. Also, WISE conveniently traces stellar mass content in nearby galaxies. Of the 4,315 HICAT sources, we find mid-infrared counterparts for 3,204 sources (74%). We also obtain HI detections for 90% of spiral galaxies with an apparent 3.4  $\mu$ m band magnitude of  $w1 < 10$  mag ( $\sim 30$  mJy) and a redshift of  $z < 0.01$ . We find a clear correlation between HI gas mass, star formation rate and stellar mass. This is despite the fact that for a fixed HI gas mass, the star formation rates and stellar mass vary by 2 and 4 orders of magnitude, respectively. Low stellar mass galaxies have higher HI gas-to-stellar mass ratios and longer HI gas depletion times, suggesting that low mass galaxies are inefficient at converting HI gas to molecular hydrogen compared to more massive galaxies. We also identified 161 starburst galaxies based on their enhanced star formation rate relative to the sample. Starburst and non-starburst galaxies of comparable stellar masses have similar HI gas-to-stellar mass ratios, but starburst galaxies have shorter HI gas depletion times. We conclude that starburst galaxies do not have HI gas excesses, but rather they utilise their HI more efficiently than the rest of the sample.

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### 39. Tomoko Suzuki

SOKENDAI/NAOJ

*Star Formation Activity and ISM Conditions of [OIII] Emitters before the Peak Epoch*

The epoch of  $z \sim 3-3.7$  corresponds to about 1-2 Gyr before the highest peak of the cosmic star formation history at  $z \sim 2$ . This epoch is key to reveal what physical processes are driving the increased star formation rates (SFRs) in galaxies as they evolve from  $z > 3$  to  $z \sim 2$ , and to reveal the formation scenario of compact quiescent galaxies (red nuggets), which are one of the most characteristic galaxy populations at  $z \sim 2$ . In order to understand galaxy formation at  $z > 3$  including the internal structures of galaxies, we need a less biased sample of star-forming galaxies at  $z > 3$  with the high resolution images taken with HST or with the AO-assisted observations by ground-based

telescopes. We have been constructing a sample of star-forming galaxies at  $z > 3$  traced by [OIII] emission line at 5007Å. These [OIII] emitters are obtained by the two narrow-band imaging surveys, namely Mahalo-Subaru (Kodama et al. 2013) and HiZELS (Best et al. 2010). We investigated the stellar masses, SFRs, and sizes of the [OIII] emitters at  $z = 3.2, 3.6$  in the SXDF-UDS-CANDELS field. The [OIII] emitters show a clear correlation on the stellar mass-SFR diagram. Comparing with star-forming galaxies at  $z \sim 2$  on that diagram, the [OIII] emitters show an offset along the main sequence, indicating a significant mass growth of star-forming galaxies from  $z > 3$  to  $z \sim 2$ . On the stellar mass-size diagram, the [OIII] emitters have the same sizes with  $z \sim 2$  star-forming galaxies at a fixed stellar mass. Recently, we have performed a NIR spectroscopic observation for [OIII] emitters at  $z = 3.24$  in the COSMOS field. We will show more detailed physical conditions of the [OIII] emitters at  $z > 3$  using the line ratios of [OII], H $\beta$ , and [OIII], and discuss the redshift evolution of the excitation states of star-forming galaxies from  $z > 3$  to  $z \sim 2$ .

## What is the relative importance of external vs internal process in galaxy formation?

### 40. Sung-Ho An

Yonsei University

#### *Assessing the Environmental Effect on the Interaction Fraction between Dark Matter Halos via Cosmological Simulations*

Dark matter halos residing in distinct environments (cluster, filament and field), are apt to have different properties. Here we investigate the environmental effect on the interaction fraction between dark matter halos via cosmological N-body simulations. In particular, we perform statistical analyses of the interactions using cosmological simulations by the Grid-of-Oct-Tree-Particle-Mesh (GOTPM) code and halo findings by the Physically Self-Bound (PSB) algorithm. At redshift  $z = 1 - 0$  (64 snapshots with a time step of  $\sim 0.08$  Gyr),  $\sim 2,400$  pairs with mass ratio of 1:1 - 1:3 are identified among  $\sim 65,000$  Milky Way-sized halos with mass of  $10^{11.0} - 10^{12.4} M_{\odot}$  in each snapshot. We classify all the interactions into flyby (a system's total energy,  $E_{12} > 0$ ) and merger ( $E_{12} < 0$ ), and examine them as functions of redshift, halo mass and environment. We confirm that the interaction fraction between Milky Way-sized halos in clusters ( $F_{\text{merger+flyby, cluster}} \sim 0.187$ ) is  $\sim 3$  times greater than that in fields ( $F_{\text{m+f, field}} \sim 0.065$ ) regardless of redshift. Interestingly, at  $z \sim 0$ , the merger fraction in filaments ( $F_{\text{m, filament}} \sim 0.094$ ) is  $\sim 1.2$  times greater than that in clusters ( $F_{\text{m, cluster}} \sim 0.077$ ), suggesting that the filament is where the Milky Way-sized halos galaxies experience a dramatic evolution at the present epoch. We also find that flybys is as frequent as, or even outnumber, mergers in clusters ( $F_{\text{f, cluster}} > F_{\text{m, cluster}}$ ) at high redshift ( $z \sim 1$ ) when flybys played an important role as drivers of galaxy evolution in dense environments.

### 41. Boris Deshev

Tartu Observatory

#### *Effects of Dynamic Environment on Galaxy Evolution*

In the past decades multi-wavelength observations have been used to pinpoint the physical processes that shape the evolution of galaxies as they move within the large scale structure of the universe. This global environment however, is also known to evolve. In particular the clusters of galaxies, a part of the smooth accretion of field galaxy population, also experience mergers with

other groups and clusters. The mergers between massive clusters are the most energetic events in the universe after the big bang. Their effects on the merger-member galaxies, however, are still poorly understood. The, usually, supersonic velocities involved in those mergers, and the clumpy gravitational potential within which the galaxies move, can potentially strengthen the effects of some physical mechanisms like ram-pressure stripping and tidal interactions.

I will present results from our ongoing survey of the properties of galaxies in the merging cluster A520 at  $z=0.2$ . This is a merger between at least two clusters of approximately the same mass, observed  $\sim 1$  Gyr after the core passage and evolves in the plane of the sky. It exhibits a clear separation between the galaxy concentrations and the intra-cluster medium. We use multi-fibre spectroscopy to identify  $>300$  cluster members and try to determine the overall structure of the merger. We use this information to probe how the present and past star-formation activity of A520's members was altered by the merging event. To put A520 into perspective we compare the results with other clusters at the same redshift.

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**42. Jaehyun Lee**

Korea Astronomy and Space Science Institute

*Formation and Assembly History of Stellar Components in Galaxies as a Function of Stellar and Halo Mass*

Structure formation accompanies galaxy mergers, ending up with stellar mass assemblies. Galaxy mergers are an end product of LCDM cosmology, and thus galaxy mass evolution needs to be described in cosmological context for better understanding. We investigate the assembly history of stellar components in galaxies as a function of halo and stellar mass by using semi-analytic approaches and a large cosmological volume simulation. In our fiducial model, older formation time and higher ex situ fractions of stellar mass are found in more massive galaxies or centrals in more massive haloes. Ex situ fractions gently increase with increasing halo mass, but sharply rise with stellar mass at massive end ( $\log M^*/M_{\text{sun}} > 11$ ). This results suggest that the relation between stellar mass and formation ages or ex situ fractions found in previous studies is derived from their halo mass dependence according to stellar-to-halo mass relation. The evolution of ex situ fractions in our model reveals that the centrals of the most massive haloes already have  $\sim 50\%$  of ex situ fractions at  $z=4$  and merger accretion is necessary to build up stellar mass above  $\log M^*/M_{\text{sun}} \sim 11$ . More massive galaxies have lower specific star formation rates and higher specific stellar mass accretion rates at all epochs. Consequently, merger accretion becomes a primary mass growth channel for the main progenitors of massive galaxies ( $\log M^*/M_{\text{sun}} > 11.5$  at  $z=0$ ) or central galaxies finally hosted by haloes in  $\log M_{200}/M_{\text{sun}} > 13$  at  $z \sim 1$ . Specific mass growth rates of galaxies binned by stellar or halo mass at each epoch show that central galaxies migrate to the merger-dominant phase when their host halo mass begins to be more massive than  $\log M_{200}/M_{\text{sun}} \sim 13$ .

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**43. Ian Roberts**

McMaster University

*A Product of their Halo Environment: How Galaxy Properties Depend on Group X-ray Luminosity and Dynamical State*

Star formation rates and morphologies of galaxies, particularly low-mass galaxies, are strongly linked to the properties of their environment. Using a large sample of galaxies in SDSS groups, we investigate the dependence of star formation and morphology on host properties such as the X-ray

luminosity and dynamical state, while controlling for stellar and halo mass. We find that galaxy populations in groups with strong X-ray emission have preferentially low star-forming and disc fractions, both within and beyond the radius associated with the X-ray emission. Additionally, we consider the effect of group dynamics on the properties of member galaxies and the infalling galaxy population separately. We show that the fraction of both star-forming and disc galaxies are independent of dynamical state for infalling galaxies, while galaxies within the virial radius are sensitive to the dynamical state of their host group. Specifically, low-mass galaxies in unrelaxed groups show somewhat higher star-forming and disc fractions. Together these findings help constrain the mechanisms at play in environmentally driven galaxy evolution.

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**44. Rory Smith**

Yonsei University

*Phase Space - a Crucial Tool for Understanding Galaxy Cluster Environmental Mechanisms*

A galaxy-cluster phase space diagram is a simple plot of clustocentric velocity versus clustocentric radius for each member of the cluster. Using state-of-the-art, cosmological hydrodynamical simulations, we investigate where simulated galaxies fall in phase space. We find the galaxies with different cluster infall times often separate cleanly in phase space. For example, backsplash galaxies neatly separate from first infallers. We also investigate how a galaxy's location in phase space is correlated with its tidal mass loss, and ram pressure stripping. By comparing our simulated cluster galaxies to observed cluster galaxies, including the BUDHIES survey and VIVA survey, we demonstrate how phase space diagrams are essential tools for understanding environmental effects acting on cluster galaxies.

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**How do the key physical processes of galaxy formation change with cosmic time?****45. Rebecca Allen***Tracing Galaxy Size Growth to  $z \sim 7$ .*

How do the sizes of a mass-complete sample of star-forming galaxies evolve?

Understanding how galaxies grew in the early universe is paramount to constraining the dominate growth mechanisms of galaxies as a function of time. The stellar mass–size relation has been used for several years to calculate the growth rate of galaxies, and has revealed differential growth for star-forming and quiescent galaxies.

Until now, samples of Lyman break galaxies have been used exclusively to study the size evolution of star-forming galaxies above  $z=4$ . However, these galaxies are selected via dropout techniques, have bright UV magnitudes, have median masses less than  $10^{10}$  solar masses, and do not represent a mass-complete sample of star-forming galaxies.

To create a more comprehensive study of the mass-size relation as a function of redshift, we use a mass-complete sample of star-forming galaxies from the ZFOURGE medium band survey. In my talk, I will discuss the growth rates we calculate for star-forming galaxies from  $z \sim 7$ , using average sizes from both the mass-size relation and image stacking. I will also compare my results to the growth rate found for Lyman break galaxies.

**46. Themiya Nanayakkara**

Swinburne University of Technology

*In-situ IMF at  $z \sim 2$* 

The development of sensitive Near Infra-Red instruments has made it possible to study the galaxy properties at  $z \sim 2$ , just 3Gy after the Big Bang. This is expected to be the time period where galaxies are actively star forming and evolving rapidly to form the massive galaxies that are observed in our local neighbourhood. ZFIRE is a survey, which utilises the MOSFIRE instrument on Keck telescope over 18 nights to study properties of ZFOURGE selected mass complete galaxies in rich environments at  $z \sim 2$ .

My poster will present results of the first ever attempt to constrain the Initial Mass Function (IMF) of galaxies at these redshifts using a cluster and a field sample. We have investigated the degeneracy between the star formation histories and the IMF to make strong constraints on the stellar mass distribution of these galaxies using synthetic stellar spectra. The poster will focus on the role of dust, star-bursts, stellar rotation, binaries, and metallicity on determining observed galaxy properties at  $z \sim 2$  to address whether ZFIRE results favour the canonical concept of a universal IMF.

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**47. Alberto Nigoche**

Universidad de Guadalajara

*Dark Matter inside Early-Type Galaxies as Function of Mass and Redshift*

We study the behaviour of the dynamical and stellar mass inside the effective radius ( $r_e$ ) of early-type galaxies (ETGs). We use several samples of ETGs - ranging from 19 000 to 98 000 objects - from the ninth data release of the Sloan Digital Sky Survey. We consider Newtonian dynamics, different light profiles and different initial mass functions (IMF) to calculate the dynamical and stellar mass. We assume that any difference between these two masses is due to dark matter and/or a non-universal IMF. The main results for galaxies in the redshift range  $0.0024 < z < 0.3500$  and in the dynamical mass range  $9.5 < \log(M) < 12.5$  are: (i) a significant part of the intrinsic dispersion of the distribution of dynamical versus stellar mass is due to redshift; (ii) the difference between dynamical and stellar mass goes from approximately 0 to 70 per cent of the dynamical mass depending on mass and redshift; (iii) the amount of dark matter inside ETGs would be equal to or less than the difference between dynamical and stellar mass depending on the impact of the IMF on the stellar mass estimation.

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**48. Adam Stevens**

Swinburne University of Technology

*Angular Momentum as a Driver of Galaxy Evolution*

I will present the first results from "DARK SAGE", a new semi-analytic model with consideration of resolved disc structure that treats galaxy evolution as an explicit function of angular momentum. I will show how the mass—specific angular momentum relation of galactic discs evolves and that Toomre disc instabilities regulate this sequence. The assumptions and results of this model are compared against results of the EAGLE hydrodynamic simulations. Despite the manner in which angular momentum settles in galactic discs being more complex than what is considered in DARK



SAGE, we find consistency in the mass—specific angular momentum sequence and its evolution. Observations, analytics, semi-analytics, and hydrodynamic simulations are all converging on the idea that angular momentum is perhaps the most important driver of the changing faces of galaxies.

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**49. Aaron Wilkinson**

University of Nottingham

*The Clustering of High-Redshift Submillimetre Galaxies; are they the Progenitors of Massive Elliptical Galaxies?*

Submillimetre galaxies (SMGs) are among the most luminous dusty galaxies in the Universe, but their true nature remains unclear; are SMGs the progenitors of the massive elliptical galaxies we see in the local Universe, or are they just a short-lived phase among more typical star-forming galaxies? To explore this problem further, we investigate the clustering of 914 SMGs identified in the coincident area of the SCUBA-2 Cosmology Legacy Survey and the UKIDSS Ultra Deep Survey (UDS). Using angular cross-correlation techniques, we estimate the halo masses for the largest sample of SMGs to date and compare them with passive and star-forming galaxies selected in the same field. I demonstrate that SMGs, on average, occupy high-mass ( $M > 10^{13} M_{\text{solar}}$ ) dark matter halos at redshifts  $z > 2.5$ , consistent with being the progenitors of massive quiescent galaxies in present-day galaxy clusters. I will also show evidence of downsizing, in which SMG activity shifts to lower mass halos at lower redshifts. In terms of their clustering and halo masses, SMGs appear to be consistent with other star-forming galaxies at a given redshift. Finally, I will discuss the clustering of a rare population of recently quenched galaxies, known as post-starburst galaxies (PSBs). We have recently identified a large sample of these galaxies in the UDS using a PCA technique. I will show tentative evidence that these PSBs are possible descendants of SMGs.

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**Other****50. Maren Hempel**

Instituto de Astrofísica, Pontificia Universidad Católica de Chile

*Quasars Hidden Behind the Milky Way - How do we find them?*

Quasars are ideal probes to study the high redshift Universe and in particular the evolution of galaxies. Various scenarios see the quasar activity depending on galaxy interactions or even as a result of major galaxy mergers. Whichever scenario applies, studying the three-dimensional distribution of quasars is vital for our understanding of the early structure formation in the Universe. Not surprisingly, large observational efforts have been made aiming at the detection of quasars throughout the observable Universe, with one notable exception- the Zone of Avoidance. The extreme and varying galactic extinction and contamination by foreground sources hamper the various photometric and spectroscopic surveys searching for quasars, given that most are conducted in the optical wavelength range. Here we present the results of our quasar search behind the central region of the Milky Way Bulge based on the multi-epoch/ multi-color data obtained by the VISTA Variables in the Via Lactea survey (VVV, PI: D. Minniti). A 6 year time-base line and between 60-100 observing epochs allowed us to use the structure function of quasar variability and detect quasar candidates, despite the large number of other variable sources found in the Milky Way, e.g. RR Lyrae, Beta-Cepheids, Long Period variables. These quasar candidates are currently used in follow-up

spectroscopic programs to confirm their quasar status. We include a parallel study on the quasars behind the Magellanic Clouds, which have already been confirmed by independent observations and serve as a training set for our detection method.

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**51. Nicholas Seymour**

Curtin University

*The GaLactic and Extra-Galactic All-Sky MWA (GLEAM) First Data Release*

Using the Murchison Widefield Array (MWA), the low-frequency Square Kilometre Array (SKA1\_LOW) precursor located in Western Australia, we have completed the GaLactic and Extragalactic All-sky MWA (GLEAM) survey, and present the resulting extragalactic catalogue, utilising the first year of observations. The catalogue covers 24,402 square degrees, over declinations south of  $+30^\circ$  and Galactic latitudes outside  $10^\circ$  of the Galactic plane, excluding some areas such as the Magellanic Clouds. It contains 305,613 radio sources with 20 separate flux density measurements across 72–231 MHz, selected from a time- and frequency- integrated image centred at 200 MHz, with a resolution of  $\approx 2'$ . Over the catalogued region, we estimate that the catalogue is 90% complete at 170 mJy, and 50 % complete at 55 mJy, and large areas are complete at even lower flux density levels. Its reliability is 99.97% above the detection threshold of  $5\sigma$ , which itself is typically 50mJy. These observations constitute the widest fractional bandwidth and largest sky area survey at radio frequencies to date, and calibrate the low frequency flux density scale of the southern sky to better than 10%. All source measurements and images will be available online.

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**52. Adam Thomas***Public Data Release of the Siding Spring Southern Seyfert Spectroscopic Snapshot Survey (S7)*

The public data release of the Siding Spring Southern Seyfert Spectroscopic Snapshot Survey (S7) will occur in the coming months. The release will provide data cubes covering the innermost  $38 \times 25$  arcseconds of  $\sim 130$  radio-selected, nearby ( $z < 0.02$ ) active galaxies, observed using the Wide Field Spectrograph (WiFeS) on the ANU 2.3m telescope at Siding Spring Observatory. The data cubes cover wavelengths of 340-710nm with an unusually high spectral resolution of  $R=7000$  in the red (530-710nm), and  $R=3000$  in the blue (340-560nm). Emission-line flux maps for strong lines in each galaxy will be provided in the data release, along with other information such as maps of gas kinematics and the identification of forbidden high-ionisation emission lines. The S7 data is a treasure trove of information on the morphology, ionisation state, metallicity and dynamics of the extended narrow-line regions (ENLRs) in present-day active galaxies. Published work using S7 data has already provided insights into the ionising spectrum of active galaxies and the influence of radiation pressure in ENLRs.

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**53. Jesse Van de Sande**

The University of Sydney

*SAMI Galaxy Survey Data Release 1: Emission Line Physics*

Abstract: We present the first data release from the Sydney-AAO Multi-bundle Integral field Spectrograph (SAMI) Galaxy Survey at the Anglo-Australian Telescope. The data release will contain reduced spectral cubes, emission-line maps, star-formation-rate maps, and dust extinction maps for 772 galaxies at  $0.02 < z < 0.10$ . Our poster highlights several key results from the SAMI Galaxy Survey: an offset starburst in a dwarf galaxy (Richard et al. 2014), a previously identified kinematically offset AGN that shows a strong discrepancy between the kinematic properties of the ionized gas and those of the stars (Allen et al. 2015), and evidence for wind dominated galaxies (Ho et al. 2016). For more information about data release 1, please see: <http://sami-survey.org/emdr>

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**54. Ross Turner**

University of Tasmania

*Spectral Constraints on AGN Energetics*

We use dynamical radio source models to infer physical properties such as jet kinetic powers, ages and magnetic field strengths, from spatially resolved multi-frequency radio continuum observations. We apply our method to 39 3CRR sources. We also investigate the utility of our approach for limited observations, for example poorly resolved sources at high-redshift or sources lacking multi-frequency data. We find that:

- AGN kinetic jet power and lobe magnetic field strength estimates require at least a measure of the lobe luminosity and radio SED curvature.
- Radio source active lifetimes are estimated using at least the lobe luminosity and source linear size.
- Jet powers cannot be accurately measured using the single-frequency luminosity in isolation, as done by several other authors.

We find the median lobe magnetic field strength to be 0.34 of the equipartition value, in agreement with inverse-Compton X-ray observations.

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