THE ART OF MEASURING GALAXY PHYSICAL PROPERTIES

PROGRAM

as of November 19, 2019

MONDAY 18/11

09:00 - 09:30
REGISTRATION

09:30 - 09:45
WELCOME

09:45 - 10:15 Rachel Somerville *(Flatiron Institute)*
Opening Talk

10:15 - 10:30 Clotilde Laigle *(Institut Astrophysique de Paris)*
The Horizon-AGN Virtual Observatory: how well can we estimate galaxy redshifts, masses and SFR from SED-fitting of broad-band photometry?

From the lightcone of the cosmological hydrodynamical simulation Horizon-AGN, we produced a virtual photometric catalogue over 0<z<4 with apparent magnitudes in COSMOS, DES, LSST-like, and Euclid-like filters at depths comparable to these surveys (Laigle et al. 2019). The virtual photometry accounts for the complex star formation history and metal enrichment of Horizon-AGN galaxies, and consistently includes magnitude errors, dust attenuation and absorption by inter-galactic medium. The COSMOS-like photometry is fitted with LePhare in the same configuration as the COSMOS2015 catalogue. We then quantify random and systematic errors of photometric redshifts, stellar masses, and star-formation rates (SFR), and highlight the successes and limitations of the SED-fitting method. In order to pave the way for future imaging surveys, we also use this virtual observatory to predict the photometric redshifts and stellar masses accuracy expected with Euclid and LSST.

10:30 - 10:45 Marc Huertas-Company *(IAC - OBSPM)*
Confronting the theory of galaxy formation with observations with generative models

The volume and complexity of observations and simulations are rapidly increasing. Comparing both to identify successes and failures in the modeling, is a key step in order to advance in our understanding of the physics of galaxy formation. I will show on-going work illustrating how deep learning can be used to compare simulations and observations in different ways. I will focus in particular on quantifying the realism of galaxy morphologies in most recent numerical simulations. Recent hydrodynamical cosmological simulations are now able to reproduce with great detail the diversity of galaxy morphologies. I will show how generative models can be trained to learn the morphological diversity of galaxies in observations and then investigate if simulations arise from the same probability distributions. This enables to compare different simulations with a unique probabilistic metric and also to identify “anomalous” objects not well rendered by the state-of-the art simulations.

10:45 - 11:00 Rhea-Silvia Remus *(University Observatory Munich)*
How to Decipher a Galaxy’s Assembly History from its Stellar Populations, Kinematics, and Metallicities: Insights from the Magneticum Simulations

The complex formation histories of galaxies are known to lead to a broad range of morphological and kinematical features observed in present-day galaxies. However, how to disentangle the individual formation history of a galaxy from observable tracers like its mass, kinematics, and stellar ages and populations is still an unsolved puzzle. State-of-the-art hydrodynamical cosmological simulations of large volumes with enough

resolution to trace galaxy properties over a broad range of masses and morphologies are essential to solve this puzzle. I will present insights obtained from the Magneticum simulations into the connection between mass, kinematics, and stellar populations, and how this helps to decipher the formation history of galaxies. I will demonstrate how to use the information provided by kinematical properties and metallicities to disentangle in-situ and accreted components of galaxies, and how to successfully compare the simulation outputs to modern IFU observations.

11:00 - 11:30
COFFEE BREAK

11:30 - 12:00 Andrew Battisti on behalf of Elisabete da Cunha
Current challenges in modelling the SEDs of high-z galaxies

The spectral energy distributions (SEDs) of galaxies contain valuable information about their stellar populations and interstellar medium, and they allow us to translate multi-wavelength observations of large samples of galaxies into physical parameters to gain physical insight into galaxy evolution processes. Several ultraviolet-to-infrared SED models have become available to the community in the last decade or so, with successful applications from local galaxies to the high-redshift Universe. However, as more detailed observations of high-redshift galaxies become available, some populations of galaxies and some wavelength regimes are becoming a challenge for SED models. It is becoming clear that some of the physical ingredients in SED models need to be revised or expanded. In this talk, I will review some of the main current challenges in SED modelling at high-redshift, and discuss some recent progress in addressing them.

12:00 - 12:15 Alexander de la Vega *(Johns Hopkins University)*
Testing dust attenuation assumptions in spatially resolved galaxies with CANDELS

Determining how galaxies stop forming stars remains an open issue in our understanding of galaxy evolution. The mechanisms behind the cessation of star formation can be identified by studying the radial profiles of the star formation rate (SFR) for galaxies of different integrated masses, star formation properties, and at different redshifts. Estimating radial SFR profiles, however, depends sensitively on assumptions of the nature of dust attenuation within galaxies. We examine the effects of assuming different attenuation curves in spatially resolved spectral energy distribution fitting of massive galaxies at redshift about 1 in the CANDELS survey. Surprisingly, we find different results in the shape and normalization of the radial profiles when assuming different attenuation curves. In this talk, I present results and hints of a varying slope of the attenuation curve within galaxies, provided other parameters degenerate with dust are accounted for adequately.

12:15 - 12:30 Emma Curtis Lake *(Kavli Institute of Cosmology, Cambridge)*
Modelling the mass-SFR relation at high redshifts - future constraints from JWST

The mass-SFR relation of galaxies encodes information of present and historical star formation in the galaxy population. We expect the intrinsic scatter in the relation to increase to low mass where SFR becomes more stochastic. Measurements from the Hubble Frontier fields have hinted at this (Santini et al. 2017), however, with the added uncertainty of lensing magnification we await JWST to provide robust measurements. Even with data-sets provided by JWST, uncertainties on mass and SFR estimates are often large, potentially covariant and dependent on assumptions used. I will present our method of Bayesian hierarchical modelling of the mass-SFR relation that self-consistently propagates uncertainties on mass and SFR estimates to uncertainties on the mass-SFR relation parameters. I will demonstrate that for this measurementexpose the biases imposed by standard SED-modelling practices, and address to what significance we can measure an increase in intrinsic scatter to low masses with JWST

12:30 - 12:45 William Bowman *(The Pennsylvania State University)*
The Properties of z ~ 2 Emission-line Galaxies from MCSED

We present the initial results of MCSED, a new spectral energy distribution (SED)-fitting code which mates flexible stellar evolution calculations with Markov Chain Monte Carlo algorithms. The power of MCSED is its flexibility: it accepts a variety of input constraints (photometry, emission-line fluxes, and absorption-line indices),

applies adjustable prescriptions (for stellar evolution, metallicity, star formation history, dust attenuation, and emission from ionized gas, dust, and PAH molecules), and returns parameter probability distributions and best-fit SEDs. We use MCSED to study a sample of 2000 [O III]-emitting galaxies at z~2 in the CANDELS fields which are similar to the systems that Euclid and WFIRST will find. We explore the physical properties of this sample and show the variation of dust attenuation, star formation history, and median SED with stellar mass. We use a subset of this sample to investigate the connection between mid-IR emission and UV dust attenuation.

12:45 - 13:00 **Adam Carnall** *(Royal Observatory Edinburgh)*
Inferring physical parameters from spectroscopy with BAGPIPES

In order to take full advantage of superior data from upcoming spectroscopic instruments (e.g. MOONS) it is important to develop correspondingly superior analysis techniques, moving beyond index measurements to obtain stronger constraints on subtle physical parameters through full spectral fitting. I will introduce Bagpipes, a new public Python code which allows sophisticated model galaxy spectra to be built and fitted to combinations of spectroscopic and photometric data. Crucially, BAGPIPES allows for the modelling and fitting of systematic uncertainties arising from instrumental and atmospheric effects. I will demonstrate the use of this method to analyse a sample of massive quiescent galaxy spectra from VANDELS at $1.0 < z < 1.3$, investigating quenching physics at high redshift by constraining the stellar mass vs stellar age relationship, and probing the relationships between green valley, post-starburst and quiescent galaxies by considering the time evolution of their UVJ colours.

13:00 - 14:15
LUNCH BREAK

14:15 - 14:45 **Viviana Acquaviva** *(CUNY / University of Barcelona)*
How can machine learning help measure the physical properties of galaxies?

Machine learning techniques are found to be increasingly useful in analyzing data from large galaxy surveys, solving tasks such as automatic classification of galaxy morphology, estimation of photometric redshifts, outlier recognition, and data compression, just to quote a few examples. With respect to traditional template-fitting techniques, machine learning methods can help optimally harvest information from heterogeneous data sources, limit the biasing impact of model dependence, and improve speed; however, validation is often challenging, and they may be hindered by lack of interpretability. In this talk, I will review some applications of machine learning and deep learning to the problem of measuring galaxy physical properties, and highlight what in my opinion are the most significant challenges we need to solve in order to be ready for the next generation of surveys.

14:45 - 15:00 **Sebastian Turner** *(Liverpool John Moores University)*
Testing a cosmological galaxy simulation with unsupervised machine learning

Simulations enables astrophysicists, usually limited to studying observations, to run numerical experiments and test their theories. Simulation results must, though, be tested against observations in order to check how realistic they are. Previous comparisons of galaxy simulations and observations have considered only one or two features at a time (e.g. GSMFs). Using clustering, an unsupervised machine learning technique, invites a comparison that considers more features at a time, so that all aspects of galaxy formation and evolution are captured concurrently. Our work represents the first time that simulations and observations have been compared in this way. We compare simulated and observed galaxies via the k-means clustering algorithm, evaluating the outcomes we find using stability. Simulated galaxies are taken from EAGLE, and observed galaxies from GAMA. We ensure a consistent selection of 5 features for both simulations and observations. We interpret the clusters we find in the context of theories of galaxy evolution. We compare simulated and observed galaxies via the k-means clustering algorithm, evaluating the outcomes we find using stability. Simulated galaxies are taken from EAGLE, and observed galaxies from GAMA. We ensure a consistent selection of 5 features for both simulations and observations. We interpret the clusters we find in the context of theories of galaxy evolution. We compare with results from a z~0 SDSS sample of ~500000 galaxies, to understand the evolution of the galaxy population, in terms of clusters, since z~1. The same algorithm and input features are used, and yield 12 clusters in this z~0 sample. Advantages of the algorithm, which combines dimensionality reduction with clustering, will also be discussed.

15:00 - 15:15 Daniel Masters *(JPL/Caltech)*
Maximizing the information from imaging surveys of the 2020s

Large-scale imaging surveys of the 2020s (LSST/Euclid/WFIRST) will usher in a new era of extragalactic astronomy, with huge discovery potential for both cosmology and galaxy evolution. However, for the vast majority of galaxies, these surveys will rely on the information contained in a limited number of optical/near-IR broadband images. These images will be used to infer galaxy properties - redshift, importantly, but also other physical properties such as stellar mass, star formation rate, and metallicity. In this talk I will discuss the application of a branch of machine learning known as non-linear dimensionality reduction (or manifold learning) to this problem. I will show how manifold learning techniques have the potential to bring us much closer to realizing the full information potential of broadband imaging for galaxy parameter estimation. I will also discuss pathways to obtaining the deep training samples required to fully exploit this approach for upcoming large-scale surveys.

15:15 - 15:30 Yannick Copin *(Institut de Physique Nucléaire de Lyon - Université Lyon 1)*
Forward modeling of galaxy kinematics in slitless spectroscopy

Slitless spectroscopy has usually been considered as a complicated technique, plagued by self- and cross-confusion effects. However, since the era of space-based instruments, it has become an adopted survey tool to study large galaxy samples. We will present its application to single object studies, with a method to extract both more precise redshifts and potentially resolved kinematic parameters of galaxies. Our approach is based on a forward model of the 2D slitless spectrum of a galaxy under thin cold disk and spectro-spatial separability hypotheses. We apply this method to 3D-HST and GLASS observations and first results on kinematic measurements will be presented. There are promising applications to future slitless spectroscopy surveys such as EUCLID (but also JWST and WFIRST) which will possess a better spectral resolution and a larger number of targets

15:30 - 15:45 Sandro Tacchella *(Center for Astrophysics | Harvard)*
The challenge of combining photometric and spectroscopic data: measuring quenching timescales

I would like to present results on quenching timescales by combining Keck DEIMOS spectroscopic data with >10-band photometry. I will discuss how one can self-consistently fit both photometric and spectroscopic data together with the tool Prospector, which allows fitting for nonparametric star-formation histories and complex stellar, nebular, and dust physics inherited from the Flexible Stellar Population Synthesis code. I show that a flexible pixel-by-pixel outlier model and an optimization step over emission line luminosities were needed to get statistically acceptable fits. These components soften the likelihood space by accounting for systematics in the models (e.g. fixed elemental abundances) and poorly characterized noise (e.g. sky lines). I will then focus on the information gained when fitting photometric and spectroscopic data together than when fitting them separately. I show that this allows determining star-formation histories and hence quenching timescales.

15:45 - 16:00
POSTERS GALLERY

16:00 - 16:30
COFFEE BREAK

16:30 - 17:15 Shoubaneh Hemmati
DISCUSSION ON NEW TECHNIQUES

17:15 - 17:30 Marziye Jafariyazani *(University of California, Riverside)*
Combining spatially resolved photometric and spectroscopic measurements to constraint evolution of non-local galaxies

We developed the methodology of studying resolved properties of galaxies with combining highest-resolution spectroscopic and photometric data available aiming to constraint galaxy evolution process at kpc-scales. We measured reliable spatially resolved emission line maps for individual galaxies using data from the MUSE Wide

Survey. Besides, we derive spatially resolved physical parameters using pixel-by-pixel SED fitting on high resolution multi-band data from the CANDELS survey. During this talk, I first present my latest results on investigating the spatial distribution of star formation rate, specific SFR, and reddening across individual sources for a sample of galaxies at 0.1< z < 0.42. Then, I will present our preliminary results on studying metallicity gradient and the resolved mass-metallicity relation in a sample of intermediate redshift galaxies.

E

17:30 - 17:45 **Bianca Iulia Ciocan** *(University of Vienna, Department of Astrophysics)*
The slow quenching of CLASH RXJ2248-4431 cluster galaxies as traced by their gas phase metallicities

In order to explore the environmental effects on gas regulation within galaxies, we have conducted a spectroscopic analysis of emission line, CLASH-VLT RXJ2248-4431 cluster galaxies (z=0.35) in comparison to a sample of field galaxies of similar redshift. The fluxes of [OII] λ3727, Hβ λ4861, [OIII] λ5007, Hα λ6564 and [NII] λ6584 emission lines were measured allowing the derivation of (O/H) gas metallicities, star formation rates based on extinction-corrected Hα and [OII] fluxes and active galactic nuclei contamination. In order to explore the accretion history of the cluster members, a phase-space analysis was conducted. The chemical evolutionary paths of the cluster members were also investigated based on the Fundamental-Metallicity- Relation expectation of Lilly et. al (2013), in order to search for signs of star formation quenching as the galaxies travel towards the cluster centre.

Sf

17:45 - 18:00 **Luca Costantin** *(Centro de Astrobiología (CSIC-INTA))*
A few StePS forward in unveiling the complexity of galaxy evolution

In the context of forthcoming wide area spectroscopic surveys, we aim at defining simple but meaningful physical parameters that can be used to trace recent star-formation episodes superimposed on otherwise undisturbed older stellar population. We produce realistic spectra of galaxies mimicking WEAVE-StePS data. We analyze such mock spectra with a Bayesian approach, deriving the PDF of r- and u-band light-weighted ages as well as of their difference. This straightforward diagnostics, handily and robustly retrievable for large galaxy samples even observed at low SNR, allows us to be sensitive to secondary episodes of star formation younger than ~ 1 Gyr for galaxies older than ~ 5 Gyr, but younger than ~ 0.1 Gyr for galaxies older than ~ 1.5 Gyr. The difference between the value of r- and u-band light-weighted ages can be used to explore the fundamental interplay between galaxy star formation history and physical parameters like galaxy mass, morphology, and environment.

TUESDAY 19/11

Sf

09:30 - 10:00 **Christina Williams** *(University of Arizona)*
A brief (~2 billion year) formation history of massive galaxies

Surveys have revealed that massive galaxies evolved rapidly in the early Universe, halting their star-formation as early as 2 billion years after the Big Bang. Still, the astrophysics behind their rapid growth and early death are longstanding problems in our theoretical understanding of galaxy formation. In this talk I will focus on current measurement challenges to understanding the evolution of massive galaxies above z>3. These include characterizing the earliest known quiescent galaxies at 3<z<4, and the recently discovered "infrared-dark" galaxies at z>4 that have been missed by current extragalactic surveys. Dark galaxies are a missing link in our picture of massive galaxy growth, and represent a preview of discoveries to come with the James Webb Space Telescope (JWST). JWST will revolutionize our understanding of galaxy evolution by breaking the redshift and sensitivity barriers of existing facilities. I will quantify some key measurement breakthroughs to show how JWST will illuminate the detailed formation histories of galaxies in the early Universe, and discuss future challenges to answering key outstanding questions.

Sf

10:00 - 10:15 **Kartheik Iyer** *(Dunlap Institute)*
Galaxy Evolution Probed through Observationally Reconstructed Star Formation Histories

The star formation history (SFH) of a galaxy is a key ingredient in modeling its spectral energy distribution (SED). A flexible description of this quantity during SED fitting is therefore crucial in constraining dependent quantities like the stellar masses and star formation rates of individual galaxies. The Dense Basis method (Iyer et al. 2019) introduces a flexible, non-parametric description for galaxy SFHs based on the lookback times at which a galaxy assembles certain quantiles of its stellar mass. The method uses Gaussian Processes to create smooth SFHs that are independent of any functional form, with a flexible number of parameters that are adjusted on a galaxy-by-galaxy basis to extract the maximum possible amount of SFH information from the SEDs being fit. We present results from fitting a sample of nearly 50,000 galaxies at 0.5<z<3.0 in the five CANDELS fields, along with future prospects for correlating SFHs with ancillary observables like morphology and environment.

10:15 - 10:30 Chiara Mancini *(University of Padova/INAF-OAPd)*
Rejuvenated galaxies with very old bulges at the origin of the bending of the main sequence and of the ``green valley"

We study in detail a sample of 10 galaxies at 0.5<z<1 with reduced sSFR and log(M*/Mo)>10.3, those objects that seemingly cause a reported bending of the star-forming main sequence (MS). The fact that such objects host large bulges recently led some to suggest that the bulge formation was a late event that induced the sSFRs of massive galaxies to drop in a slow downfall, and thus the MS to bend. Based on secure SFR from FIR, deep optical spectra, and HST/CANDELS imaging, we perform multi-band bulge/disk decomposition, and derive SFHs for the separated bulge and disk components. We find that all the bulges are maximally old, while disks are young (T_50~1.5 Gyr). We conclude that the bending of the MS is, for a major part, due to rejuvenation, and we disfavor mechanisms that postulate the internal bulge formation at late times. Our bulge SFHs suggest a number density of ETGs at z=1-3 higher than observed. This might represent a validations of hierarchical assembly of bulges at high-z.

10:30 - 10:45 Lucia Pozzetti *(INAF - OAS Bologna)*
Reconstruction of galaxy physical properties and Star Formation Histories of high-z star forming galaxies: from VANDELS to WEAVE/STEPS and MOONS

The physical properties of high-z star_forming galaxies (SFGs), for both stellar populations and gas, are generally inferred from rest-UV spectra, accessible at z > 1. Estimates of ages, metallicities, stellar masses, extinction and SFRs are derived from SED fitting or investigating the UV continuum. Some of the absorption or emission UV spectral features visible can also be used as tracers of their properties. In this work, we apply full-spectrum fitting and decomposition to a sample of high-SNR spectra of SFGs at 2<z<3 from the public survey VANDELS (McLure,Pentericci) to derive evolutionary properties (i.e. ages, metallicities, dust extinction) and the SFHs. This represents a step forward with respect to many works which rely on a-priori assumption of the SFHs. I also show that similar studies can be done using WEAVE/STEPS and MOONS.

10:45 - 11:00 Kiyoaki Christopher Omori *(Nagoya University)*
Investigating the Spatially Resolved Star Formation Histories of Interacting Galaxies using MaNGA Data

Galaxy interactions are known to trigger episodes of star formation, and are an important process in galaxy evolution. Despite its importance, however, there are still many unknowns. Our study aims to further our understanding of galaxy interactions and their physical processes by investigating their star formation histories. We focused on spatially resolved star formation histories, to confirm whether the star formation in an interacting galaxy was triggered by a merging event or another process. We have identified interacting galaxies in the Mapping Nearby Galaxies at APO (MaNGA) catalog (Bundy et al. 2015) using CNNs developed by Ackermann et al. (2018). Star formation histories obtained in the MaNGA FIREFLY VAC (Goddard et al. 2017, Parikh et al. 2018) and results from PCA conducted by Rowlands et al. (2018) indeed show that recent episodes of star formation have occurred in the areas of galaxy interaction. We will discuss this and other findings.

11:00 - 11:30
COFFEE BREAK

11:30 - 11:45 Vivienne Wild *(University of St Andrews)*
The star formation histories of rapidly quenched galaxies at z~1

I will present measurements of the star formation histories of ~40 z~1 galaxies with strong Balmer absorption lines indicating recent and rapid quenching of star formation, alongside well defined control samples of star-forming and quiescent galaxies. High quality VLT spectra and multiwavelength photometry, combined with a comparison between both state-of-the-art Bayesian parameterised and unparameterised SFH model fitting, provide tight constraints on physical properties such as the age and strength of the starburst, and fraction of old stars. A significant fraction are consistent with being close to single-epoch burst events with peak star formation rates consistent with sub-mm galaxies. This data provides a perfect example of the science that will be possible in the upcoming MOONS GTO reference survey at 0.8<z<1.8, where the prevalence and global importance of starburst events and rapid quenching of star formation in building today's red sequence is still much debated.

11:45 - 12:00 Stefano Zibetti *(INAF-Osservatorio Astrofisico di Arcetri)*
From points to galaxies: learning from IFS surveys of nearby galaxies

I will present results on the spatially resolved stellar population (SP) properties of nearby galaxies, obtained by joining integral field spectroscopy from CALIFA and broad-band images in a Bayesian framework with a highly complex SP modelling. These results highlight the role of local scales in determining the physical properties of SPs, resulting in local scaling relations linking age and metallicity with stellar mass surface density (Zibetti et al. 2017, 2019). The spatial variations of SP parameters provide invaluable insights into the formation and evolution of early-type galaxies: our original results (Zibetti et al. 2019) suggest a two-phase scenario as the most plausible one. I will also show that not only spatial resolution enhances the diagnostic power of spectral/SED fitting techniques, but also the mutual links between the physical properties of different regions of galaxies in structural and kinematical continuity allow us to refine our spectral/SED fitting techniques.

12:00 - 12:15 Ivana Damjanov *(Saint Marys University and Harvard-Smithsonian CfA)*
Active evolution of passive galaxies in the last six billion years

The history of quiescent galaxy mass assembly is encoded in the evolutionary trends we observe in their structural and dynamical properties. I will present the synergy between magnitude-limited large-area spectroscopic surveys (SHELS and HectoMap) and high-quality ground-based imaging (HSC) that provides measurements of galaxy stellar mass, stellar population age, velocity dispersion, size, and shape for mass-limited quiescent samples in the redshift interval 0.1<z<0.6. Using this suite of measurements we have constructed a simple empirical model that links systems at intermediate redshift and in the local volume, revealing the dominant physical mechanisms that drive quiescent galaxy growth at z<0.6. I will describe the effort to extract information from low surface-brightness features in HSC images in search for signatures of the physical processes favoured by our model.

12:15 - 13:00 Eric Gawiser
DISCUSSION ON SFH

13:00 - 14:15
LUNCH BREAK

14:15 - 14:45 Carl Ferkinhoff *(Winona State University)*
The Long Wavelength School of Measuring Galaxy Physical Properties

Observations at mid- and far-infrared, millimeter and radio wavelengths paint a critical portrait of the physical characteristics of galaxies and process internal to them. The long-wavelength regime providies both complementary and, some cases, entirely unique probes of galaxy properties as compared to methods in the UV, optical or near-IR. For instance, the far-IR fine structure lines trace directly the energetics, gas density, and chemical composition of the interstellar medium relevant to star formation processes yet are minimally susceptible to effects of dust obscuration and gas temperature. The long wavelength regime is also the only place to trace the low temperature molecular gas that is the fuel for the growth of stars. In this talk I will summarize the need for the Long Wavelength School, the basic physics of some the most useful probes, the complementarity in utilizing this expanded pallet, and lastly some recent works from members of the school.

Along the way I will highlight several current and future facilities that make the art of the Long Wavelength School possible.

E

14:45 - 15:00 **Darko Donevski** *(SISSA, Trieste, Italy)*

Characterising the very distant, dusty star-forming galaxies in deep extragalactic fields

Despite a recent, huge progress in unveiling the high-z (z > 4) dusty star-forming galaxies (DSFGs) thanks to pre-selection techniques from large surveys made with Herschel telescope (e.g. Donevski et al. 2018) there are important drawbacks, such that far-IR selection of DSFGs in wide fields are restricted only to sources from the brightest-end of the luminosity function at z > 4,. Due to the lack of information from shorter wavelengths, some vital properties of DSFGs, such as stellar mass and AGN-fraction, remained unconstrained. In this talk, I will present how to benefit from rich panchromatic data available in deep fields and apply state-of-the art SED modelling techniques in order to unveil the nature of fainter DSFGs. I will discuss how the the dust-to-stellar mass ratio can be used as a powerful diagnostics tool and how we can refine selection criteria in order to disentangle different populations of dusty sources in the very early Universe.

D

15:00 - 15:15 **Vasily Kokorev** *(DAWN, University of Copenhagen)*

In Search of Molecular Hydrogen, constraining the gas content of star forming galaxies.

The mechanisms behind galaxies moving away from the main sequence of star formation towards a starburst mode is one of the holy grails of galaxy evolution, with gas mass (Mgas) estimates offering a crucial insight into this critical open question. To this end, dust emission can act as one of the Mgas tracers. In this talk I will introduce a novel SED fitting technique for near-IR to (sub)mm photometry, which relies on the linear combination of a subset of pre-selected stellar, AGN and far-IR templates and show 1) how this new technique reproduces the well-established scaling relations and successfully extracts robust quantities, while at the same time being an order of magnitude faster than other available codes and 2) how these results coupled with our recent ALMA [CI] observations of distant galaxies, that allow for an alternative Mgas estimates, take us a step further into the proper characterisation of the star formation mode of the galaxies across cosmic time.

D

15:15 - 15:30 **Wouter Dobbels** *(Ghent University)*

Dust and stellar property estimates via machine learning techniques

Large surveys have been performed from the ultraviolet (UV) to the far-infrared (FIR). Some galaxies are observed over this whole wavelength range, and through SED fitting we get accurate estimates of their stellar and dust properties. Unfortunately, most galaxies are only detected at a limited part of this spectrum. With machine learning techniques, we can use the UV-FIR galaxies as a blueprint: we learn the mapping from their fluxes to their properties. For example, a mapping from UV-NIR to dust mass can be established, and then applied to galaxies that lack FIR data. We present this approach using DustPedia and H-ATLAS data, and show the superiority over energy balance SED fitting. Besides what can be directly estimated from the SEDs alone, this technique implicitly uses relations that follow from galaxy evolution. To avoid a black box, we take special care to estimate uncertainties on our predictions and to interpret the model.

A

15:30 - 15:45 **Quirino D'Amato** *(INAF/IRA, DIFA (University of Bologna))*

On the dust and gas content of high-redshift galaxies hosting obscured AGN in the CDF-S

Submillimeter Galaxies (SMGs) at high redshift are among the best targets to investigate the early evolutionary phases in the lifetime of massive systems, during which large gas reservoirs sustain vigorous star formation and efficiently feed the central, buried Super Massive Black Hole (SMBH). I present the analysis of new ALMA band 4 (1.8-2.4 mm) continuum and high-J CO observation of six obscured QSOs (log N_H > 23) hosted by SMGs at z > 2.5 in the 7 Ms Chandra Deep Field South (CDF-S). Sizes and masses of the galaxies are measured to estimate to which extent the host ISM may contribute to the nuclear absorption. We found that at high redshift the galaxy ISM can substantially contribute to the AGN obscuration up to the Compton-thick (10^24 cm^-2) regime. In addition, we found that all the detected sources show a velocity gradient possibly ascribed to a rotating system, even though two of them could be even associated with a chaotic, possibly merging, structure.

15:45 - 16:00
POSTERS GALLERY

16:00 - 16:30
COFFEE BREAK

D

16:30 - 17:00 Anna Rita Gallazzi *(INAF-Osservatorio Astrofisico di Arcetri)*
Metal abundances of galaxy stellar populations: estimates and implications for galaxy evolution

The metal abundances of galaxy stellar populations are the result of the interplay between star formation, gas recycling and galaxy-environment interactions. Tracing metallicities and abundance ratios, together with ages and masses, for galaxies of different types and over cosmic time can shed light on galaxies star formation efficiencies and quenching mechanisms and can help us better connect progenitors and descendants. I will highlight some observational results in this respect and few related open questions. This goes together with a discussion of some observational and methodological requirements. Ongoing and planned spectroscopic surveys and upcoming facilities have the potential to address these issues and further our understanding of galaxy physical properties.

D

17:00 - 17:15 Sarah Leslie *(Leiden University)*
Disk inclination: a painful bias when measuring galaxy properties, but a useful tool for constraining dust geometry.

We show how accurately taking into account inclination effects can be leveraged to gain insight into the average 3D dust distribution of galaxies and how it evolves over time. In a sample of SDSS galaxies at z~0.07 and a sample of COSMOS galaxies at z~0.7, the inclination dependency of a disk's FUV attenuation was used to derive the average dust opacity and clumpiness fraction. We find that the dust geometry of massive galaxies is evolving with redshift, similar to the SFR activity, with important implications for models. We have also derived correction factors to account for the inclination dependence of the stellar mass, size, Sersic index, and star formation rates derived from these surveys. Galaxy parameters derived from optical data alone can be strongly biased.

D

17:15 - 17:30 Ivana Barisic *(Max Planck Institute for Astronomy)*
A novel approach to measure dust attenuation law at z~1

The distribution and properties of dust in galaxies, and its evolution with cosmic time remains a debated topic. We present a novel approach to measure the attenuation of z~1 galaxies: we reconstruct intrinsic stellar spectra based on deep optical spectra from the VLT/VIMOS LEGA-C survey and measure attenuation through a comparison with the multi-band photometry. We present the variation of the dust attenuation law slope and strength of the UV bump feature with galaxy orientation, specific star-formation rate (sSFR) and stellar mass for a sample of star-forming galaxies. We find diversity in dust attenuation law properties: attenuation A(4500A) increases with sSFR and stellar mass, while slope and UV bump exhibit no trends. Face-on galaxies are less attenuated, with steeper slope values, and an indication for a strong bump at low-masses. Additionally, we do not find a trend between the slope and the UV bump strength, in contrast to some local and high-redshift dust attenuation studies.

D

17:30 - 17:45 Zachary Pace *(University of Wisconsin - Madison)*
Resolved and Integrated Stellar Masses in the SDSS-IV/MaNGA Survey from PCA Fits

We present measurements of resolved stellar masses for galaxies in the SDSS-IV/MaNGA IFS galaxy survey. We describe the orthogonal basis set used for our spectral-fitting, obtained through principal component analysis (PCA) of 40k synthetic spectra; show tests performed on held-out synthetic spectra. We apply the measurements of stellar mass-to-light ratio (after a transformation to stellar mass surface density) to a comparison with dynamical mass surface density measurements from the DiskMass Survey, suggesting revisions to typical assumptions about disk scale-heights. We aperture-correct the IFU-summed resolved stellar masses, and obtain estimates of total galaxy stellar mass for most MaNGA galaxies. Finally, we describe the resolved stellar mass maps and integrated stellar mass catalog to be released in SDSS DR16.

17:45 - 18:00 Nima Chartab Soltani *(University of California, Riverside)*
The Role of the Environment in Star Formation Activity

We present a robust method, weighted von Mises kernel density estimation along with boundary correction to reconstruct the underlying number density field of galaxies. We apply this method to galaxies brighter than HST/F160< 26 AB mag at the redshift range of 0.4< z < 5 in the five CANDELS fields (GOODS-N, GOODS-S, EGS, UDS, and COSMOS). We then use these measurements to explore the environmental dependence of the star formation activity of galaxies. We find strong evidence of environmental quenching for massive galaxies (M > 10^11 M_sun) out to z~ 3.5 such that an over-dense environment hosts > 20% more massive quiescent galaxies compared to an under-dense region. We also find that environmental quenching efficiency grows with stellar mass and reaches ~60% for massive galaxies at z~0.5. The environmental quenching is also more efficient in comparison to the stellar mass quenching for low mass galaxies (M < 10^10 M_sun) at low and intermediate redshifts (z<1.2). Our findings concur thoroughly with the "over-consumption" quenching model where the termination of cool gas accretion (cosmological starvation) happens in an over-dense environment and the galaxy starts to consume its remaining gas reservoir in depletion time. The depletion time depends on the stellar mass and could explain the evolution of environmental quenching efficiency with the stellar mass.

WEDNESDAY 20/11

09:00 - 9:30 Ylva Götberg *(Carnegie Observatories)*
Advances in our understanding of massive stars and how that affects spectra of stellar populations

Massive stars are responsible for ionizing and ultraviolet radiation, mechanical feedback through their supernovae and strong stellar winds, and chemical pollution of the surroundings. These processes directly affect the emission and morphology of stellar populations. Understanding how massive stars evolve is, therefore, important when analyzing spectra from full stellar populations, both nearby and at high redshift. Recent advances in stellar astrophysics imply that massive stars emit more ionizing photons and also at later times than what is commonly assumed. This impacts the characterization of stellar population, affecting for example age and mass estimates. I will give an overview of physical processes that significantly affect the predicted spectra for stellar populations, including the evolution of very massive stars, the effect of rotation, and envelope-stripping in binaries, which may result in the creation of X-ray binaries, stars that evolve chemically homogeneously, and a top-heavy IMF.

09:30 - 09:45 Margherita Talia *(University of Bologna)*
The VANDELS view on the inter-stellar medium in SFGs at z>2.5

VANDELS is an ESO public spectroscopic survey targeting high-redshift galaxies within the CDFS and UDS survey fields. Specifically, VANDELS used the VIMOS spectrograph to obtain ultra-deep, medium resolution, optical spectra of >2100 high-redshift galaxies. The fundamental science driver of the VANDELS survey is to move beyond basic redshift determination, providing spectra with sufficient signal-to-noise to investigate the astrophysics of galaxy evolution of well defined samples of high-redshift galaxies. The rest-frame wavelength range probed by the VANDELS spectra is rich of strong absorption lines of various elements (e.g. C, Si, Fe) at different ionization stages and is therefore the sweet spot to investigate the properties of the warm phase of the inter-stellar medium (ISM). In my talk I will present the analysis of a sample of ~700 SFGs at 2.5<z<5.5 from the VANDELS DR2 and discuss the trends among low-/high-ionization absorption features and integrated galaxy properties.

09:45 - 10:00 Nor Pirzkal *(STScI)*
Resolved Star Formation in Galaxies Using Slitless Spectroscopy

The ability to spatially resolve individual star-formation regions in distant galaxies and simultaneously extract their physical properties via emission lines is a critical step forward in studying the evolution of galaxies. Rather than taking a blurry view of the summed properties of galaxies, our methodology allows us to paint a detailed picture of how star-formation behaves in galaxies over a wide range of redshifts. Here, we present our study of

resolved star formation derived using HST/WFC3 IR slitless observations. The unique capabilities of the WFC3 IR Grism allows us to accurately identify the exact spatial origin of emission lines in galaxies and determine how star-formation occurs within a galaxy. Using multiple position angles on the sky, we show that we can accurately derive both the location and the observed wavelengths of these emission lines, which is crucial to derive accurate redshifts for these sources. We present the properties of [OII], [OIII] and Ha lines and how

10:00 - 10:15 **Fergus Cullen** *(IfA, University of Edinburgh)*
The stellar mass-metallicity relation at 2.5 < z < 5.0 with VANDELS

I will present initial results from the VANDELS survey (DR2) quantifying the relationship between stellar mass and stellar metallicity for a sample of ~ 700 star-forming galaxies at 2.5 < z < 5.0. Stellar metallicities were determined for a set of high signal-to-noise ratio composite rest-UV spectra in bins of redshift and stellar mass (spanning the range 8.5 < log(M/Mo) < 10.2). We find evidence for a monotonic increase in metallicity with stellar mass, with values ranging from 7% solar at the lowest stellar masses to ~ 25% solar at the highest stellar masses. We do not find evidence for evolution in metallicity with redshift within our sample, which is consistent with predictions from simulations given the relatively narrow redshift range. However, a comparison to the local stellar mass-metallicity relationship indicates an increase of a factor of ~ 4 in the stellar metallicity between z ~ 3.5 to z=0 across all stellar masses.

10:15 - 10:30 **Marcella Longhetti** *(INAF - Osservatorio Astronomico di Brera - Milano)*
Metallicity gradients in quiescent galaxies at z~2

The advent of the upcoming JWST space telescope and of the next decade E-ELT ground telescope, combined with the new generation instruments, will provide astronomers with the possibility to reach spatial resolution higher than ever before combined with larger collecting areas. These new facilities will then offer the possibility to study the stellar content OF galaxies and IN galaxies at z~2-3, that is in a range of redshift where a large part of their evolution is expected to take place. Here we present a pilot study of the analysis of the metallicity gradient in an early type galaxy at z ~ 2, based on the slitless low resolution WFC3@HST spectra. The target galaxy is one of the 15 quiescent galaxies confirmed members of the z=1.8 JKCS 041 (Andreon et al. 2009). Preliminary results will be presented, discussing their dependence on the adopted procedure and on models assumptions.

10:30 - 11:00
COFFEE BREAK

11:00 - 11:15 **Kathryn Grasha** *(Australian National University)*
The Most Massive Stars do the Most Damage: Improving Stellar and Photoionized Models in HII Regions

Integral field spectroscopy with instruments such as MUSE or SITELLE provide an extraordinary dataset to study the resolved spatial and spectral properties of HII regions in nearby galaxies. Having self-consistent stellar tracks and atmosphere modeling are crucial to accurately interpret such observations. To date, only a handful of stellar evolution models are available and they all use the same metallicity abundances. We know now that the assumed metallicity abundances impacts the relative scaling of the lines ratios and will have a significant impact on measurables, such as metallicity, geometry, and ionization parameter. It is crucial that we improve currently available stellar models as they impact our interpretation of galactic properties and how they evolve over cosmic time. We will present our new physically motivated stellar models and the impact that the different assumed elemental abundances, metallicity, and rotation have on the observable spectral energy distributions.

11:15 - 11:30 **Shuang Zhou** *(Tsinghua university)*
Bayesian modelling and analyzing galaxy spectra with BIGS

We develop a suit of full spectra fitting code, which is called Bayesian Inference of Galaxy Spectra (BIGS), to infer various galaxy properties from spectra of unresolved stellar populations. The Bayesian inferences method used in BIGS allows one to rigorously explore the posterior distributions of model parameters as well as potential degeneracy between them, and to distinguish different models with Bayesian evidence. We apply this

code to the IFU data-cubes of galaxies in MaNGA to infer the stellar initial mass functions (IMF) of a large sample of early type galaxies (ETGs). We find that the IMF slope depends systematically on galaxy velocity dispersion, in that galaxies of higher velocity dispersion prefer a more bottom-heavy IMF, but the dependence is almost entirely due to the change of metallicity, Z, with velocity dispersion. We also apply this Bayesian spectra fitting methods to study the star formation history (SFH) in the least massive galaxies in MaNGA. We reveal the existence of a significant old stellar population in those galaxies, and discuss how the assumed models may bias the inferences of the SFH.

11:30 - 11:45 Núria Salvador-Rusiñol *(Instituto de Astrofísica de Canarias)*
Tiny fractions of young stellar populations in massive ETGs

Early-type galaxies (ETGs) are considered to be the end-products of the formation of massive galaxies. Spectroscopic studies of ETGs using optical features reveal an early (z>2) and fast (<1Gyr) formation process, but are insensitive to small episodes of recent star formation. This can be tackled in the ultraviolet (UV) spectral range, which provides a unique window to disentangle such small contributions from young populations. I will show a detailed study comprising high-quality stacked spectra from the SDSS/BOSS survey at redshift z~0.4, producing unambiguous constraints on the fraction of very young stellar populations in massive ETGs thanks to their near-UV features. We constrain the young stellar mass fraction (<2Gyr) with unprecedented sensitivity (~0.1-0.6\%), finding a decreasing trend with galaxy mass, consistent with a down-sizing scenario. Our results pose stringent constraints on numerical simulations of galaxy formation.

11:45 - 12:00 Carlos Barbosa *(Steward Observatory)*
A multilevel Bayesian framework to study spatially resolved galaxies

The advent of Integral field instruments have been providing unprecedented observations of the universe, unveiling the details of galaxies with great spatial resolution. However, the methodology to study these data sets has not yet coped with other important recent advances in the field of statistics and data analysis, hampering the full potential of the scientific output provided by these new data sets. We present a general, hierarchical Bayesian method to study spatially resolved stellar populations in galaxies even at low signal-to-noise ratios which can take full advantage of integral field observations, allowing accurate inferences of kinematics and stellar populations of galaxies, without the necessity of spatial binning to increase the signal-to-noise ratio. We will present applications of this method for narrow-band surveys, such as S-PLUS and J-PAS, and to MUSE spectral cubes to illustrate the gains in relation to traditional methods.

12:00 - 12:15 Sree Oh *(Australian National University)*
Kinematically disentangling bulges and disks using IFS data

We aim to quantitatively understand the distribution of angular momentum and scaling relations through disentangling bulge and disk components. For the SAMI integral field spectroscopy (IFS) data, we decompose bulge and disk kinematics using a full spectral fitting code pPXF with the predefined weights of two components from photometric bulge/disk decomposition. We investigate the rotation velocity and velocity dispersion of bulge and disk components and address how the combination of two components draw the kinematics of galaxies. We also find a tight correlation between the stellar mass and velocity dispersion of disk component, which has not been reported and makes us reconsider the simple view of rotationally-supported disks. Looking further ahead, we explore galactic scaling relations and seek to develop a unified understanding of galaxy dynamics and scaling relations.

12:15 - 13:00 Claudia Maraston & Elizabeth Stanway
DISCUSSION ON STELLAR POPULATION MODELS

13:00
FREE AFTERNOON

THURSDAY 21/11

09:30 - 10:00 **Paul Torrey** *(University of Florida)*
Bridging the divide between simulations and observations

Cosmological simulations have advanced to a point where they can make a myriad of predictions ranging from the detailed internal structure of galaxies to large scale structure. Yet, making even handed, unbiased, and insightful comparisons with observations remains challenging. I will discuss the predictive power available in modern cosmological simulations. I will discuss the core elements of the Illustris and IllustrisTNG simulations while highlighting some of the key observational comparisons that have been carried out with those simulations. My talk will focus on the value that large simulated galaxy populations provide by creating clear predictions both for galaxy scaling relations and for the scatter. I'll highlight the oftentimes overlooked value of analyzing the scatter in galaxy scaling relations and discuss how upcoming observations with JWST of high redshift galaxy populations may be used to differentiate between various galaxy feedback models.

10:00 - 10:15 **Xiangcheng Ma** *(University of California, Berkeley)*
Confronting cosmological simulations with upgraded observations of distant galaxies

Comparing observations and cosmological simulations is the only way for testing our understanding of galaxy formation physics, yet this is a challenging task. In this talk, I will present a series of results from state-of-the-art cosmological zoom-in simulations of high-redshift galaxies. These simulations predict a broad range of observables of distant galaxies that will be confronted with better measurements of galaxy properties in the foreseeable future, such as metallicity gradients, bursty star formation, morphology and sizes, kinematics, etc. of galaxies at z~2-10. I will discuss some outstanding discrepancies between simulations using different models for star formation and feedback and what observations of distant galaxies achievable in the near future can be used to test against these models.

10:15 - 10:30 **Sidney Lower** *(University of Florida)*
Ground-Truthing SED Fitting Methods in Galaxy Observations

Of the many assumptions that go into modeling the SED of a galaxy, the SFH and dust attenuation law dominate the uncertainty in stellar mass and SFR recovery. Classically, SFHs are modeled via parameterized functional forms, but these forms are unlikely to capture the true diversity of galaxy SFHs and may impose systematics on results. Recently, non-parametric SFH models have shown promise in marginalizing over some of these uncertainties. Here, I examine the efficacy of these SFHs by ground-truthing them against high-res cosmological hydrodynamic galaxy formation simulations. I demonstrate that stellar masses can be estimated with greatly improved accuracy over traditional SFH forms, with uncertainties falling below the inescapable 'factor of 2' that has historically plagued stellar mass estimates. I also demonstrate the impact on our understanding of the evolution of stellar mass functions and the unexplained mismatch between the theoretical and observed SFR-M* relation in galaxies.

10:30 - 10:45 **Ana Trcka** *(Ghent University)*
EAGLE in SKIRT versus DustPedia: physical properties from simulated and observed galaxies

We compare the SEDs and derived physical properties for simulated and observed galaxies. We have used a radiative transfer code to calculate UV-submm mock SEDs for ~8000 z=0 galaxies extracted from the EAGLE suite of cosmological simulations, and compare these to ~800 observed UV-submm SEDs from the DustPedia sample of nearby galaxies. To derive global properties, we have applied the SED fitting code CIGALE consistently to both data sets. Results from this comparison show overall agreement between simulations and observations, both in the observable SEDs and in the derived physical properties. We do find a number of discrepancies, which we attribute to a combination of galaxy population differences and limitations in the subgrid treatment of star-forming regions. Our findings show the importance of detailed radiative transfer calculations for the derivation of physical properties from mock galaxies, and offer vital information on the possibilities for improving our numerical models.

10:45 - 11:00 **Joel Leja** *(Center for Astrophysics | Harvard)*
A Hierarchical Model of Galaxy Formation from Prospector

The Prospector inference framework is designed to put robust constraints on high-dimensional galaxy SED models, largely made possible by generating galaxy SED models on-the-fly. In particular, it allows nonparametric star-formation histories and is packed with complex and self-consistent web of stellar, nebular, and dust physics inherited from the Flexible Stellar Population Synthesis (FSPS) code. I have shown in previous work that these components result in higher-mass galaxies (~0.2 dex) than simple SED fits and lower star formation rates (~0.2 dex) than state-of-the-art UV+IR SFRs. Now, I use a Bayesian hierarchical model to knit these results into an redshift-dependent stellar mass function and a star-forming sequence. This model implies a qualitatively different picture of galaxy stellar mass buildup than measured in previous work. I will discuss the implications for the star formation rate density and the rate of galaxy assembly.

11:00 - 11:30
COFFEE BREAK

11:30 - 11:45 Robert Feldmann *(University of Zurich)*
How to deal with incomplete and uncertain data: The star forming sequence of galaxies

Incomplete and uncertain data, such as those arising from detection limits and measurement uncertainties, are commonplace in astronomy and astrophysics. Unfortunately, many standard techniques, such as least squares regression, are not well equipped to deal with such data sets potentially resulting in strongly biased or even inconsistent estimates of the underlying model parameters. I will present a novel, general approach to handle such data sets and, with its help, study the properties of the star forming sequence of nearby galaxies. I will demonstrate that the slope and intrinsic scatter can be derived in a consistent manner for such data sets and without separating galaxies into star forming and quiescent populations. In fact, this analysis shows that galaxies with star formation rates two orders of magnitude below the peak position may be considered part of the star forming sequence. The presented method is implemented as a flexible, easy-to-use, and open-source Python package.

11:45 - 12:30 Sarah Wellons
DISCUSSION ON SIMULATIONS

12:30 - 12:45 Lamiya Mowla *(Yale University)*
Breaking the law: A revised view of the relation between the sizes and masses of galaxies since z~3

The most massive galaxies at z~2 live today in the centers of groups- and cluster-sized halos and host the most extreme black holes, such as that seen in M87. Because they are rare, little is known about the structure of these galaxies during their build-up at early epochs. With the advent of the Drift And SHift (DASH) technique with the Hubble Space Telescope, we have tripled the extragalactic survey area in the near-infrared at HST resolution, allowing us to conduct a structural study of a large sample of these massive galaxies. I will present the first results from the COSMOS-DASH survey, the widest HST imaging survey that has so far been done in near-IR. We find that the sizes of the most massive galaxies are larger than expected from an extrapolation of the low mass size – M∗ relation. Hence, we reassess the size – M∗ relation with a broken power law, with a clear change of slope at a pivot mass. We find remarkable agreement between the pivot stellar masses and the slopes of Mhalo – M∗ and size – M∗ relations suggesting that the pivot mass reflects a transition from dissipational to dissipationless galaxy growth in both the cases. Furthermore, using ALMA observations of molecular gas kinematics of massive galaxies we find that there maybe an inclination bias in the size – M∗ relation due to dust and projection effect. Taken together, our results suggest a straightforward relation between the size scale of dark matter halos and that of galaxies, with the effects of dust and young stars being the main remaining uncertainty. This issue will be resolved with early JWST observations, providing rest-frame 3 micron morphologies of galaxies.

12:45 - 13.00 Marianna Annunziatella *(Tufts University)*
Fantastic Beasts and Where to Find Them: Monster Galaxies at z>3 and their characterization

One of the most controversial questions regarding the formation and evolution of galaxies is when and how today's most massive galaxies (UMGs) form. What are the progenitors of today's massive galaxies in the first 2 Gyr of cosmic history? What are their properties? At what epoch do they assemble? Do they grow their stellar mass primarily through in situ star formation or via merging? Are they always found in over-dense environments

or do they also form in isolation? I will present the characterization of the stellar population properties, number density, AGN incidence, and environments of the largest sample, to-date, of UMGs at z>3 constructed from state-of-the-art multi-wavelength photometric catalogs over ~10 sq. deg. in XMM and CDFS. This sample, comprising ~200 UMGs, down to a mag limit of 23.5, is the first representative stellar-mass complete sample of UMGs in the first 2 Gyr of comics history including including both quiescent and dusty star-forming galaxies.

13:00 - 14:15
LUNCH BREAK

14:15 - 14:45 Arjen van der Wel *(Ghent University)*
LEGA-C: Stellar Populations and Stellar Kinematics of Massive z~1 Galaxies

The LEGA-C spectroscopic survey with VLT/VIMOS represents the first substantial investment in obtaining high-resolution continuum spectroscopy of high-redshift galaxies. For the first time we can access information on the stellar population characteristics and stellar kinematics of z>0.5 galaxies of all types, usually thought of as future science cases for >30m ground-based telescope and JWST. I will show how the dynamical scaling relations and dynamical structure of galaxies evolved over the past 7 Gyr and how this evolution connects with the star formation histories of individual galaxies as inferred from their spectra.

14:45 - 15:00 Emiliano Merlin *(INAF - OAR)*
Properties of high redshift passive galaxies: number density and contribution to the cosmic star formation history

I analyze the properties of the CANDELS passive galaxies at z>3, selected and discussed in Merlin 2018, Santini 2019 and Merlin 2019. The selection on the five CANDELS fields yields a minimal number density of 1.73 - 0.17 x10^-5 Mpc-3 for 3<z<5. I compare these value with those from four hydrodynamical cosmological simulations from the Illustris and Eagle projects, finding a reasonable agreement at z<4; tension arises at earlier epochs. Then, I use the SFHs from the SED-fitting best models to estimate the contribution of the passive candidates to the global Star Formation Rate Density during their previous phase of activity, finding that they account for ~5-10% of the total star formation at 3<z<8, despite being only ~0.5% of the total in number. The resulting overall picture is that early and strong star formation activity, building massive galaxies on short timescales and followed by a quick and abrupt quenching, is a rare but crucial phenomenon in the early Universe.

15:00 - 15:15 Paola Santini *(INAF - Osservatorio Astronomico di Roma)*
Selection and confirmation passive galaxy candidates in the early (z>3) Universe

The selection of passive galaxies in the early Universe is very challenging, and crucial to constrain theoretical modelling of the processes responsible for their rapid assembly and abrupt shut-down of the star formation. I will present the ad-hoc SED fitting technique which we developed to select z>3 quiescent galaxies, and discuss its advantages over a standard color-color selection. With this technique, we selected ~100 candidates in the 5 CANDELS fields. I will then show how ALMA archival observations (available for 40 sources) can confirm the selection by breaking the dust/age degeneracy. None of the candidates except one is detected nor is their stack. This poses constraints to the SFR that statistically confirm the passive nature of the population. Moreover, 60% of the candidates are confirmed individually with robust assumptions (including the detected source). Finally, the analysis of the gas fraction of the candidates is on-going, to shed light on the quenching mechanisms.

15:15 - 15:30 Nushkia Chamba *(Instituto de Astrofisica de Canarias)*
The size of galaxies in an era of ultra-deep imaging

The traditional measure for galaxy size, the effective radius Re, is a relic of the epoch when shallow imaging failed to capture full galaxy extensions. However, deep imaging surveys have revolutionised our view of galaxies, allowing us to regard critically our own conventions. In this sense, it is time to move from a light concentration measure, Re, to one that intuitively captures the concept of galaxy size. In this talk, we introduce a new measure of size based on the gas density threshold value for star formation in galaxies. Remarkably, our new measure not only captures what the human visual system identifies as a galaxy's edge, but also

dramatically decreases the scatter in the stellar mass M-size plane by a factor of 2. Even more uniquely, our size unifies galaxies across 5 orders of magnitude in M on a single M-size relation. The application of our size to explain the nature of ultra-diffuse galaxies and to locate the onset of a galaxy's stellar halo will also be discussed.

15:30 - 15:45 Katherine (Wren) Suess *(University of California, Berkeley)*
Color gradients are responsible for most of the evolution in the mass-size relatio

Galaxy sizes are a key physical observable, and their growth over cosmic time provides clues to how galaxies evolve. However, the light profiles used to measure galaxy sizes do not directly trace the underlying stellar mass profiles: radial mass-to-light ratio gradients cause half-mass and half-light radii to differ. We use multi-band imaging to measure the half-mass radii of ~7,000 galaxies at 1.0<z<2.5 in the CANDELS fields. We find that half-mass radii are generally smaller than half-light radii. Furthermore, the strength of color gradients evolves with redshift. Between z~2.5 and z~1, half-mass radii grow by only ~1/3 the amount that half-light radii do. Color gradients are thus responsible for much of the previously-discovered size growth of quiescent galaxies. Finally, I will discuss recent work that investigates how the half-mass radii of galaxies vary as a function of the galaxy's rest-frame spectral energy distribution shape.

15:45 - 16:00 Vicente Estrada-Carpenter *(Texas A&M)*
Stellar Population Properties of Massive Quiescent Galaxies Derived from Deep Hubble Space Telescope Grism Data

The spectra and spectral energy distributions of galaxies encode important information about their formation. This is useful in interpreting the histories of high redshift (z>1) massive quiescent galaxies, where star-formation is rapid and quenching occurs early. In this presentation, I will discuss work from Estrada-Carpenter et al. (2019) to measure stellar population parameters (e.g., ages, metallicities) using a forward modeling technique to model deep HST IR grism spectra of galaxies. Applied to massive galaxies at 1<z<1.8, I will show they formed ~70% of their stars prior to z>3, enriching to Solar metallicities by that time. I will also discuss new work using non-parametric star-formation histories to constrain the formation and quenching timescales of galaxies at 0.8<z<2.5 using deep HST grism spectroscopy and photometry. I will show correlations between galaxy star-formation histories and morphologies, and will discuss the implications for the galaxies' evolution.

16:00 - 16:30
COFFEE BREAK

16:30 - 16:45 Paolo Saracco *(INAF - Osservatorio Astronomico di Brera)*
Stellar age and metallicity estimates of (ultra)massive galaxies over ~12 billion years

Age and metallicity of the stellar component are two foundamental parameters to infer the star formation history of a galaxy and to trace its likely evolution. Here, I will present stellar age and metallicity estimates derived with different approach and different reference stellar population models from spectra of massive early-type galaxies in the redshift range 1<z<3.5. The talk will mainly focus on the uncertainty/dependency of the estimates on the method/code used and on the different stellar population models assumed.

16:45 - 17:30 Amber Straughn
DISCUSSION ON MASSIVE GALAXIES

20:00
SOCIAL DINNER

FRIDAY 22/11

09:30 - 10:00 **James Aird** *(University of Leicester)*
Connecting the physical properties of AGN and galaxies

The relationship between the properties of Active Galactic Nuclei (AGN) and the physical properties of the galaxies they lie in can reveal the environments that promote supermassive hole growth and the potential impact of AGN feedback on galaxy evolution. I will discuss how AGN may be identified at a range of wavelengths - X-ray, optical, infrared and radio - and how all of these selection methods suffer from biases that depend on the properties of the host galaxy. I will present work that accounts for these selection biases, revealing the true extent of AGN across the galaxy population and the detailed dependence of black hole accretion activity on galaxy stellar mass and star formation rate. These measurements also show how the level of black hole accretion can vary on short timescales relative to galaxy-wide processes and how this variability blurs the underlying connections between AGN and the physical properties of galaxies.

10:00 - 10:15 **Myrto Symeonidis** *(MSSL-UCL)*
The impact of AGN on our understanding of galaxy evolution

Over the years, much effort has been expended in determining the SEDs of galaxies and AGN over the entire electromagnetic spectrum. However, the primary origin of far-IR emission in galaxies hosting AGN has always been a subject of much contention. We have recently challenged the assumption that stellar-heated dust is the major contributor to the far-IR and showed that AGN can heat dust at kpc scales and hence dominate over the far-IR emission of their host. I will talk about our current work which, based on these results, has succeeded in throwing light on many “puzzling” observations, such as the IR luminosity function, the number density of hyperluminous galaxies, the distribution of galaxy dust temperatures and the observed relations between SFR and AGN power. I will also talk about the impact of AGN on our measurements of galaxy SFRs and highlight its implication with respect to the potential “limit” in SFR as a function of reshift.

10:15 - 10:30 **Yunkun Han** *(Yunnan Observatories, Chinese Academy of Sciences)*
Modelling and interpreting the multi-wavelength spectral energy distributions of galaxies with machine learning and Bayesian inference

The galaxy spectral energy distributions (SEDs) from far-UV to far-IR are very important source of information about the properties of its stellar population, interstellar gas and dust, and AGN. To better understand the complex interplay among the three important physical components during the formation and evolution of galaxies, we need a reliable and efficient method and tool to extract useful information about them from the huge amount of data sets stemming from both ground- and space-based missions. To this end, with the combination of machine learning techniques and Bayesian inference, we have built the BayeSED code. In this talk, I will introduce the next generation of our BayeSED code which is capable of efficiently modeling and interpreting the full far-UV to far-IR SEDs of galaxies. Especially, I will demonstrate its application to the CANDELS_GDSS_workshop and DustPedia photometric catalog.

10:30 - 10:45 **Ray Sharma** *(Rutgers University)*
Evidence of Black Hole Feedback in Simulated Dwarf Galaxies

While supermassive black holes are known to be vital to the evolution of high-mass galaxies, their role in low-mass galaxy evolution is only now beginning to be understood. The occupation fraction of black holes within low-mass galaxies as well as the effects of black holes on host structural evolution are not well-constrained. Simulations provide a way forward in understanding the complex feedback system between black holes and low-mass galaxies. We study the cosmic population of supermassive black holes in low-mass galaxies with the Romulus25 cosmological hydrodynamic simulations. We find a connection between the growth history of supermassive black holes and the growth history of their low-mass host galaxies, suggesting that black hole feedback indeed occurs even in low-mass galaxies.

10:45 - 11:00 **Ena Choi** *(Columbia University, Korea Institute for Advanced Study)*
Simulations and mock observations of Active Galactic Nuclei and their hosts

The lives of galaxies and their supermassive black holes (SMBH) are probably intimately linked. Although mergers are considered a promising triggering mechanism for AGN activity, numerous studies have shown that

AGN hosts are no more likely to appear morphologically disturbed than inactive galaxies. We run a suite of state-of-the-art simulations to study the AGN-host galaxy connection. These simulations are post-processed with a radiative transfer code, with a sub-grid model of torus-scale obscuration, and short timescale AGN variability. Using mock images created from the simulations, we study the predicted morphologies and stellar populations of AGN hosts and "normal" galaxies with similar stellar masses. In this talk, I will discuss how SMBH growth is fueled and fed, and what triggers rapid feeding, and (2) how AGN feedback regulates BH growth and also the growth of the host galaxy.

11:00 - 11:30
COFFEE BREAK

11:30 - 11:45
POSTERS PRESENTATION

T

11:45 - 12:15 Michaela Hirschmann *(DARK, Niels Bohr Institute, University of Copenhagen)*
Black holes, AGN and their spectral observables in state-of-the-art cosmological simulations

I will present a brief review on the success and challenges of modelling BHs and AGN feedback in state-of-the-art cosmological simulations. Current models can predict fairly realistic black hole and AGN populations over cosmic, demonstrate the necessity of AGN feedback for massive galaxies, and challenge the classic picture of a merger-driven co-evolution of galaxies and black holes -- consistent with recent observations. But the success of the simulations is based on a large variety of sub-grid models for BH growth and AGN feedback, to some extent limiting their predictive power. I will discuss how a more accurate comparison via detailed spectral modelling to novel observational constraints may help to break the degeneracies of adopted sub-grid models.

A

12:15 - 12:30 Ivan Delvecchio *(CEA-Saclay)*
Low Accretion Signatures of AGN Emission (LASAGNE): recipes from the radio

Maintenance-mode AGN feedback is invoked as one of the main culprits for quenching massive galaxies, however increasing evidence is now pointing against its leading role in the high-z (z>1) Universe. A fair comparison between models predictions and observations of radio AGN feedback requires large and complete samples of high-z radio AGN. I will show how the synergy between deep radio interferometry observations with VLA and VLBI techniques can provide an unbiased view of AGN activity from the radio. The unprecedented depth reached in the VLA-COSMOS 3GHz Large Project, combined with VLBA follow-up of at <0.01” resolution, are paramount to investigate the incidence, intrinsic size and compactness of radio AGN emission, while circumventing the galaxy contamination at larger scales. Calibrating these techniques has profound implications for studying highly obscured AGN at z>3, and for designing the next observing strategies with the SKA.

A

12:30 - 12:45 Qingling Ni *(Pennsylvania State University)*
Does black-hole growth depend fundamentally on host-galaxy compactness?

Possible connections between black-hole (BH) growth and host-galaxy compactness have been found observationally. However, it is not yet clear if BH growth is fundamentally related to the compactness of the host galaxy, due to observational degeneracies between compactness, stellar mass (M■), and star formation rate (SFR). To break these degeneracies, we carry out systematic partial-correlation studies to investigate the dependence of sample-averaged BH accretion rate (BHAR) on the compactness of host galaxies, represented by the surface-mass density, Σe, or the projected central surface-mass density within 1 kpc, Σ1. We utilize 8842 galaxies with H < 24.5 in the five CANDELS fields at z = 0.5–3. When testing is confined to star-forming galaxies at z = 0.5–1.5, we find that the BHAR-Σ1 relation is not simply a secondary manifestation of a primary BHAR-M■ relation, which may indicate a link between BH growth and the central gas density of galaxies.

E

12:45 - 13:00 Matthew Bayliss *(MIT/University of Cincinnati)*
Strong Lensing Assisted Observations of X-Ray Emission From Young Stellar Populations at Cosmic Noon

Deep X-ray observations of the most highly magnified, strongly lensed galaxies remain an unexplored frontier. Combined with rest-frame optical, UV and NIR data, X-ray observations of bright giant arcs can provide new constraints on the properties of the stellar populations in distant starburst galaxies, especially the high mass stars and the high end of the initial mass function. Moreover, lensing allows us to distinguish the X-ray properties of different star forming regions, which themselves can span a wide range in metallicity, age, and stellar mass. I will present new work to detect, and spatially resolve, the X-ray emission associated with ongoing star formation in existing Chandra observations of highly magnified strongly lensed galaxies, and discuss the prospect for future work combining broad wavelength coverage (X-ray, UV, optical and NIR) diagnose the properties of star formation and stellar populations during the era when most of the Universe's stars formed.

13:00 - 14:15
LUNCH BREAK

14:15 - 14:30
POSTERS PRESENTATION

14:30 - 14:45 **Bryan Terrazas** *(Harvard-Smithsonian Center for Astrophysics)*
The relationship between black hole mass and galaxy properties: clues to the physics behind quiescence

Evidence from across the electromagnetic spectrum supports the theory that black hole (BH) feedback causes quiescence in massive galaxies. However, the form of this feedback and how it operates remains uncertain. I will describe results from a sample of 91 galaxies with dynamical BH masses and show that the BH-stellar mass relation has significant scatter which correlates strongly with star formation activity. In fact, for this diverse sample ranging from massive ellipticals to isolated spirals, the specific star formation rate is a smoothly decreasing function of the BH-stellar mass ratio. These results present a powerful diagnostic with which to test BH feedback?s effects on star formation in the latest galaxy formation models. I will show how the relationship between BH mass, stellar mass, and star formation rate encodes information on the physics of quiescence in simulations such as IllustrisTNG, EAGLE, and L-Galaxies, thereby allowing a novel interpretation of the observations.

14:45 - 15:00 **Ian McCheyne** *(University of Sussex)*
Using deep LOFAR data measure the far infrared radio correlation and the effect of AGN on star formation

AGN can have a profound impact on the SFR of their host galaxy, with some studies suggesting they inhibit star formation, with others find evidence that SFR increases with AGN powe. The well known far infrared radio correlation (FIRC) is caused by SF, so in previous works AGN have been removed from samples used to study it. By modelling the FIRC as a combination of AGN and SFG we can investigate the effect of an AGN on its host galaxy's SFR as well as identify the fraction of AGN hosting galaxies. This allows us to investigate any biases introduced, by the removal of AGN, to the FIRC. This study is facilitated by new deep LOFAR data (~20■Jy rms across ~20 square degrees at 150MHz) which allows for the detection of rare luminous AGN as well as fainter objects at higher redshifts then previous low frequency surveys. In addition, we have used deblended Herschel fluxes provided by HELP using XID , a prior based bayesian inference tool.

15:00 - 15:45 Myrto Symeonidis
DISCUSSION ON AGN

15:45 - 16:00
WRAP UP