'Galaxy evolution across environments: connecting observations and simulations (GalEvol)' Abstracts

Talks

The Influence of QSOs on the z ~ 6 LAE Luminosity Function Using Resolved Spectroscopy

Authors

Akshara Binu (1), Dr Alyssa Drake (1)

(1) University of Hertfordshire

Abstract

The influence of environment on galaxy evolution across cosmic timescales is a fundamental topic in astrophysics. At high redshifts, the intrinsic luminosity of quasars allows us to target and study some of the most extreme environments in the early Universe. By using the panoramic integral field spectrograph MUSE, we can very efficiently trace emission-line galaxies regardless of stellar mass, offering a unique opportunity to detect and study typical galaxies living in the vicinity of powerful quasars. At high-redshifts, this is primarily carried out through detection of the rest-frame UV emission line Lyα (1216 $\mathring{A}$), which can be used to trace Lyα-emitters (LAEs) across the redshift range $3.0 < z < 6.5 $ with MUSE. In this study, we use MUSE IFU data of 20 quasars at $z\sim6$. By applying the MUSELET detection software to these data cubes, we retrieve over 1300 line-emitter candidates. First, I will briefly outline my analysis of these line-emitter candidates, the intersection of our candidates with those from complementary detection software, and the final reliable LAE catalogue we developed. Subsequently, I will present the detailed analysis and results derived from calculating the average Lyα luminosity function(Lyα LF), followed by comparing this measurement to that in blank fields.

Developing environments -- abandoned cosmic graveyards at cosmic noon

Authors

Amir H. Khoram (1)

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Abstract

Understanding how environment shapes galaxy evolution is crucial at cosmic noon ($z\sim2.5$), when galaxies undergo rapid growth and quenching. Using the Blue Jay sample, we investigate how galaxy properties—including star formation rate, quenching timescale, stellar mass, and metallicity—vary with environment. We characterize environment not only through galaxy over- and under-densities, but also by leveraging IGM tomography maps to trace the properties of the surrounding intergalactic medium and large-scale structure. We find systematic environmental trends in galaxy properties, indicating that galaxy number density and IGM-based tracers probe distinct but complementary aspects of environment. Our results demonstrate that combining galaxy and IGM information provides a more complete view of how environment regulates galaxy growth and quenching at cosmic noon, highlighting the multi-scale nature of environmental influence. More specifically, our findings point out to "developing environments" in protocluster surrounding that host massive quenched galaxies. For the first time, we also find a strong correlation between formation-quenching timeline and the residing environment.

Extreme environments in the early Universe: engines of advanced galaxy evolution

Authors

Callum Witten (1)

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Abstract

At low redshift, dense environments such as clusters host some of the most evolved galaxies. These structures originate from large-scale dark matter overdensities at early times and contain an overabundance of galaxies sustained by vast gas reservoirs. I will present JWST observations demonstrating that the most extreme early proto-cluster environments drive the rapid formation of evolved galaxies with substantial gas and dust masses already at $z > 7$. These unique environments provide key laboratories for studying the burstiness of early galaxies, and I will discuss how they produce a diverse range of recent star-formation histories, from mini-quenched to rejuvenating to highly star-forming systems.

In contrast, I use recent JWST observations combined with the TNG-Cluster simulations to show that galaxies residing in lower-mass, high-redshift protoclusters are highly star-forming. This indicates that environmental effects strengthen with increasing halo mass, while also suggesting that more typical galaxy overdensities act as major powerhouses of early star formation. Simulations further predict that such environments are ideal for the growth of early SMBHs, which I show is supported by an abundance of AGN identified in protoclusters, ranging from Type II AGN to LRDs.

Finally, I will address the tension between the observed abundance of early protoclusters and theoretical expectations, and demonstrate how improved selection criteria, halo mass estimates, and evolutionary modelling can reconcile these differences. These results have important implications for our ability to identify and characterise the most clustered regions of the early Universe, which serve as critical test beds for studying the extremes of galaxy and SMBH evolution.

Does galaxy morphology play a role in the evolution of the inner dark matter halo?

Authors
Sioree Ansar (1), Francesca Fragkoudi (1), Andrew Pontzen (1)

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Abstract
Massive galaxies are expected to build up their mass differently from low-mass galaxies. However, do Milky Way (MW) mass disc galaxies with different morphologies also evolve differently? Idealised N-body simulations of barred galaxies show angular momentum transfer from stellar disc to dark matter (DM) halo through stars in bar orbits, suggesting a bar-halo connection. We investigate 39 MW mass galaxies from the cosmological zoom-in Auriga simulations to examine the connection between DM halo and galaxy properties. We determine DM halo spin (the dimensionless angular momentum) near the stellar disc and quantify bar strength to find that by redshift 0, on average, halos of strongly barred galaxies gain higher specific angular momentum and spin than unbarred galaxies, due to loss of angular momentum within the bar length. However, strong satellite interactions sometimes obscure the source of change in angular momentum. On examining the stellar and DM particle orbital frequencies, we find the main resonances responsible for the angular momentum transfer from the disc to the DM halo. We conclude that MW mass disc galaxies show distinct angular momentum evolution in their inner discs and DM halos, depending on the presence of a stellar bar. This maybe important for identifying dark matter velocity/mass distribution in inner halos of galaxies.

What can activity tell us about the evolution of S0 galaxies across environments? (Online)

Authors

Josep L. Tous (1), Mathias Gort (2), Josep M. Solanes (2), Jaime Perea (3), Helena Domínguez Sánchez (4), Sandra Raimundo (1)

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Abstract

S0 galaxies can be found in different environments where the physics driving their formation range from mergers to hydrodynamic interactions. The diversity observed in the properties of these galaxies suggests multiple evolutionary pathways, yet the relative importance of these mechanisms remains unclear. In this talk, I will present evidence for two dominant spectral classes of S0 galaxies, quiescent and active, identified within a sample of ~70,000 systems drawn from the SDSS main galaxy sample. Quiescent S0s, which constitute the majority of the population, are found across all environments, from the sparsely populated general field to high local density regions. In contrast, approximately 25% of S0s exhibit signatures of activity, including ongoing star formation or AGN emission, and these are preferentially located in lower-density environments. Integral-field spectroscopy reveals that centrally concentrated activity often indicates recent gas accretion events, including minor mergers, while star-forming rings are plausibly triggered by mini mergers. Within relaxed clusters, quiescent S0s dominate at all radii but cluster most strongly toward the center, whereas active S0s are more common in the outskirts. Radial trends in line-of-sight velocity dispersion and inferred infall times indicate that a substantial fraction of the S0s currently residing in cluster cores likely arrived through secondary infall. Furthermore, radial star formation rate profiles reveal that quenching in S0s begins well beyond the cluster's virial radius, likely due to preprocessing in infalling groups where gravitational encounters are frequent. Overall, our results highlight the importance of mergers in the continued evolution of S0 galaxies.

Up to 75% of disc galaxies are featureless at 3<z<7

Authors

Rebecca Smethurst (1), Brooke Simmons (2), Sophie Jewell (1), Chris Lintott (1), Jason Makechemu (2), Hugh Dickinson (3), and the Galaxy Zoo and CEERS teams

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Abstract

We have not yet observed the epoch at which disc galaxies first emerge in the Universe. Discs are expected to form first in the least dense environments, making the study of their emergence an important probe of early galaxy formation. While high-z measurements of large-scale features such as bars and spiral arms trace the evolution of disc galaxies, such methods cannot directly quantify featureless discs in the early Universe. Here, we identify a substantial population of apparently featureless disc galaxies in the Cosmic Evolution Early Release Science (CEERS) survey by combining quantitative visual morphologies of $\sim$7000 galaxies from the Galaxy Zoo JWST CEERS project, with a public catalogue of expert visual and parametric morphologies. While the highest redshift featured disc we identify is at zphot=5.5, the highest redshift featureless disc we identify is at zphot=7.4. The distribution of Sérsic indices for these featureless systems suggests that they truly are dynamically cold: disc-dominated systems have therefore existed since at least $z\sim7.4$. We place upper limits on the featureless disc fraction as a function of redshift, and show that up to 75 per cent of discs are featureless at 3.0<z<7.4. This is a conservative limit assuming all galaxies in the sample truly lack features. With further consideration of redshift effects and observational constraints, we find the featureless disc fraction in CEERS imaging at these redshifts is more likely $\sim$29–38 per cent. We hypothesise that the apparent lack of features in a third of high-redshift discs is either due to a higher gas fraction, or to a higher dark matter vs baryonic matter fraction, both of which allow the discs to be resistant to buckling and instabilities.

Environmental dependence of galaxy evolutionary histories: the dominant role of local density

Authors

Callum O'Kane (1)

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Abstract

Understanding how environment shapes galaxy evolution remains a fundamental challenge, yet most studies focus solely on present-day properties. Here, we move beyond this limitation by reconstructing star formation and chemical enrichment histories using physically motivated galaxy evolution models that incorporate gas inflows and outflows through full spectral fitting.

We analyse a sample of ~10,000 massive ($M_\star > 10^{10.45}\ M_\odot$) galaxies with high signal-to-noise spectra from the Sloan Digital Sky Survey, comparing evolutionary histories across a range of environments spanning the field, filaments, groups and clusters. We identify seven distinct evolutionary pathways and quantify their relative abundance as a function of environment. Galaxies in groups and clusters assemble their stellar mass earlier and over shorter timescales, while those in filaments and the field more commonly exhibit extended, later formation histories.

However, these trends are driven primarily by stellar mass and local density. Once these factors are controlled for, the apparent differences between large-scale environments disappear.

We therefore conclude that, for the high-mass regime probed here, evolutionary histories are governed by small-scale environment, parametrised by local density, rather than large-scale structure. This suggests that environmental effects on galaxy evolution are primarily local in nature, both motivating and enabling future studies that will extend this analysis to the lower-mass regime with next-generation observational facilities.

Galactic dust formation and evolution across cosmological environments

Authors

Alice Ferreira (1), Chiaki Kobayashi (1)

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Abstract

The evolution of dust is important for understanding galaxy evolution as a significant amount of metals are predicted to be locked inside dust grains. However, there remains an open question of how dust formation is impacted by galactic environment. This is particularly true when comparing high and low redshift, where the same models that are able to explain dust scaling relations in galaxies in the local Universe struggle to reproduce the high dust content in z∼7 galaxies observed with ALMA. Therefore, we introduce dust into our cosmological simulations together with the latest nucleosynthesis yields. This allows us to robustly trace the mass of dust in the ISM from initial conditions. This dust mass increases through production in supernovae and AGB stars, as well as accretion from gas phase metals. The dust is destroyed through star formation, supernova shock waves and thermal sputtering. We examine the resulting dust scaling relations in galaxies across environments at both high and low redshift. We show where we are able to match observations and discuss possible reasons behind any discrepancies.

The role of the environment on galaxy evolution with the J-PAS survey

Authors

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Abstract

The Javalambre-Physics of the Accelerating Universe Astrophysical Survey (J-PAS) is an ongoing survey mapping thousands of square degrees in the Northern Hemisphere. The combination of its 56 narrow-band filters, which provide a spectral resolution comparable to very low-resolution spectroscopy (R ~ 60), and its large field of view (FoV) of 4.1 square degrees makes it a powerful tool for studying galaxy evolution across different scales.
The filter system enables the retrieval of stellar population properties through spectral energy distribution (SED) fitting. Its wide FoV allows the detection of galaxies in clusters and groups without pre-selection bias. Moreover, the combination of these capabilities provides data analogous to that of an integral field unit (IFU), making J-PAS particularly well suited for the analysis of spatially resolved galaxies that cannot be covered by other IFU systems.
In this talk, I will summarize our main previous results on galaxies in the most massive cluster and in groups identified in the miniJPAS data release. I will also discuss how these results compare with simulations such as IllustrisTNG. Finally, I will present our findings on spatially resolved galaxies, along with results from our current work.

Environmental Dependences of IR-Bright AGN Incidence in Massive Galaxy Clusters

Authors

Benjamin Floyd (1)

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Abstract

The number of active galactic nuclei (AGN) in galaxy clusters has been observed to grow by nearly two orders of magnitude from the local universe to $z \sim 1.5$. Star formation rates in clusters have also been observed to rise rapidly over this redshift interval. These trends, along with several other recent observations of high-redshift clusters, have led to the idea that this enhanced star formation and AGN activity may be driven by galaxy mergers within the clusters. Since mergers are more efficient in lower mass clusters with smaller galaxy velocity dispersions, the expectation is that AGN incidence should scale inversely with cluster mass. Studies using X-ray selected AGN has offered some support for this model in low-redshift clusters, though with large uncertainties. We select infrared bright AGN from a large, uniform, mass-selected galaxy cluster sample from the South Pole Telescope spanning a redshift range of $0.15 \lesssim z \lesssim 1.7$. With these data we explore the incidence of IR-bright AGN in clusters as a function of cluster mass, redshift, and projected cluster-centric radius. We find evidence of an inverse mass relation between the halo mass and the incidence rate of IR-bright AGN along the lines of sight to massive galaxy clusters which further corroborates a merger-driven AGN triggering mechanism in massive galaxy clusters.

Learning the Cosmic Web: Inferring Cosmic Web Environments of Galaxies from DESI

Authors

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Abstract

Forthcoming and ongoing large galaxy surveys such as DESI offer unprecedented opportunities to study how the Cosmic Web influences galaxy formation and evolution. A central challenge, however, is inference of galaxy environments in observational data, where the underlying dark matter density is not directly accessible.
We present a novel, graph-based ML framework designed to robustly infer the dynamical Cosmic Web environments of survey galaxies. The method is trained on dark-matter particle catalogues from cosmological simulations, learning the relationship between local galaxy connectivity and large-scale dark matter structure without explicit density reconstruction. Our initial results demonstrate that this approach can accurately recover cosmic web environments in simulation data. Building on this, we extend the framework by forward-modelling key observational effects, including survey selection functions and redshift-space distortions, enabling a more realistic application to galaxy surveys.
Our work provides a scalable and physically motivated pathway for environmental classification in galaxy surveys, which will facilitate systematic studies of the impact of the cosmic web on galaxy formation and evolution.

The effect of void-centric distance on galaxy evolution

Authors

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Abstract

The large-scale environment shapes galaxy properties. Galaxies in cosmic voids are typically later type, bluer, less massive, younger, and evolve more slowly than their counterparts in denser environments. However, the effect that the location within the void have on the stellar population properties and star formation histories (SFH) is still to uncover.
We address this question using galaxies from the Bright Galaxy Survey (BGS) of DESI DR1 in the local Universe ($z < 0.08$). Each galaxy is assigned a relative void-centric distance (Reff) by cross-matching with the DESIVAST void catalogue. We derive stellar population properties by convolving the galaxy spectra with the J-PAS filter system and fitting them with BaySeAGal, a parametric SED fitting code.
Our key findings are as follows. As galaxies approach void centers, they become less massive, younger, more metal-poor, and exhibit higher SFR and sSFR. Their SFHs are more extended, and the fraction of blue, star-forming galaxies increases. The void's influence extends out to Reff ~ 1.4. These trends persist when comparing void galaxies to a control sample matched in stellar mass and redshift. However, all differences vanish when we restrict the comparison to star-forming galaxies only in both samples.
These results demonstrate that galaxies in voids experience slower evolutionary paths, an effect that gradually weakens toward filamentary structures. The primary environmental impact appears to be an increased fraction of star-forming galaxies rather than a modulation of star formation activity within the star-forming population itself.

Building an Observable Universe from simulations: Multi-wavelength Galaxy Evolution ($z \approx 0$ to 10) in Euclid-Scale Volumes.

Authors

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Abstract

A growing body of research highlights the importance of consistent multi-wavelength comparisons between observed galaxies and their simulated counterparts in the early Universe, particularly in light of persistent tensions such as the apparent excess of bright, massive galaxies at high redshift, discrepancies in UV and IR luminosity functions, and uncertainties in dust attenuation and star formation rate indicators across environments and cosmic time. To bridge this gap between theory and observations, we present a framework for post-processing semi-analytic models, specifically L-Galaxies, using a spectral synthesis pipeline (synthesizer) to generate broadband photometry, full spectral energy distributions (SEDs), and line emission across cosmic time. This enables direct, observation-ready comparisons, capturing both integrated luminosities and spectral features that trace stellar populations, star formation histories, and the interplay of gas, dust, and radiation.

Our study spans $z = 0$ to $z \sim 10$, enabling a continuous view of galaxy evolution from the local Universe to the epoch of reionization. Leveraging the efficiency of semi-analytic models (SAMs), we incorporate key physical processes including star formation, feedback, chemical enrichment, and dust modelling, while probing large cosmological volumes (~3.6 x 10^8 Mpc^3 at z = 0), comparable to wide-field missions such as Euclid. This combination of physical completeness and statistical power allows us to place environmental trends in a robust cosmological context.

We analyse luminosity function evolution from UV to IR wavelengths, finding good agreement with observations in FUV, NUV, optical, and near-infrared bands at $z = 0$-5, and consistency with recent James Webb Space Telescope results at $z = 5$-12. Crucially, we quantify how galaxy photometry varies across environments, including differences between central, satellite, and orphan galaxies in overdense and underdense regions, while linking UV and IR emission to the underlying distribution of dust and star formation, and demonstrating how environmental definitions impact observable trends.

Overall, this work directly connects theoretical predictions to observational measurements by constructing a unified, multi-wavelength view of galaxy populations across environments. It provides a framework to assess where simulations and observations converge and where discrepancies remain in understanding how environment shapes galaxy evolution across cosmic time.

Peculiar Velocities from DESI: A New Resource for Studying the Local Universe

Authors

Caitlin Ross (1)

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Abstract

Peculiar velocities provide a unique link between galaxy properties and the underlying large-scale structure, offering insight into how galaxies evolve within the cosmic web, beyond the capabilities of traditional redshift surveys. The Dark Energy Spectroscopic Instrument (DESI) Peculiar Velocity Survey is measuring distances and peculiar velocities for over 186,000 nearby galaxies using the Fundamental Plane and Tully–Fisher relations, enabling detailed studies of galaxy environments and mass assembly in the local Universe. In this talk I will present an overview of the DESI Peculiar Velocity Survey and its available data products, with a focus on the Fundamental Plane sample from Data Release 1. The first release contains peculiar velocity measurements for nearly 100,000 early-type galaxies, making it the largest sample of its kind. I will describe how the catalogue is constructed, its calibration, selection properties, and current limitations, and outline the types of science applications for which these data may be useful, including studies of galaxy environment, large-scale flows, and the relationship between galaxies and the underlying matter distribution. I will also discuss ongoing improvements being made to the analysis pipeline for future releases. These developments will enhance the utility of DESI peculiar velocity data for a broad range of galaxy evolution and large-scale structure studies.

The effect of the extragalactic environment on the evolution of S0-type galaxies (Online)

Authors

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Abstract

Lenticular galaxies (S0) represent about 50% of high-mass galaxies in the local Universe. Their number increases at lower redshifts and toward the centers of galaxy clusters, although their overall fraction remains nearly constant across different environments. Despite their morphological similarity, S0 galaxies can exhibit different stellar populations and kinematic properties, suggesting distinct origins and evolutionary pathways. Different formation mechanisms have been proposed depending on the environment: in clusters, S0s may originate from faded spiral galaxies; in groups, they likely form through harassment and minor mergers; and in the field, as some N-body simulations suggest, they may have formed at high redshifts ($z \sim 2$) due to disk instabilities and evolved passively, preserving signatures from early galaxy formation. In this work, we investigate the formation pathway of S0 galaxies by analyzing the role of galaxy mass and environment using S-PLUS DR6 data for 974 lenticular galaxies in Stripe 82, spanning 8 < log(M/M_{sun}) < 12. Structural parameters were derived with GALFITM by fitting two-component Sersic models (bulge + disk) across 12 photometric bands (3543-9134 Angstrom) simultaneously to improve the signal-to-noise ratio. To complement the structural analysis, stellar population properties were obtained from the MPA-JHU spectroscopic catalog from SDSS. The environmental density of each galaxy was estimated using S-PLUS DR1 data and the k-nearest neighbors (KNN) method, allowing us to investigate the influence of the local environment on the formation and evolution of S0s. We also incorporated large-scale structure estimates from the literature. By combining morphological properties, stellar population parameters, and environmental measurements, we identify three main evolutionary pathways. About 60% of the sample has log(M/M_{sun}) > 10.5 and resides in low-density environments, consistent with formation through mergers. Around 35% of the S0s are found in high-density regions, indicating formation via gas removal by ram-pressure stripping. The remaining ~5% are low-mass galaxies in low-density environments, consistent with a formation pathway driven by disk instabilities. To explore the evolutionary pathways of these galaxies, we retrieved preliminary merger trees of simulated analogs from IllustrisTNG100-1 and IllustrisTNG50. These initial results link S0 formation mechanisms, mass, environment, AGN activity, and stellar population properties, potentially allowing us to identify primordial S0s as fossil records of galaxies at $z \sim 2$, which may in the future provide key constraints on galaxy formation models.

The baryon cycle in group and cluster satellites (Invited)

Authors

Yannick Bahé (1)

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Abstract

Satellite galaxies in groups and clusters differ from their more isolated counterparts in nearly all of their baryon properties, suggesting a profound impact of their harsh environment on their baryon cycle. I will summarize what simulations have taught us about the physical origin of this environmental influence, in particular the removal of gas and stars during a galaxy's infall into a massive halo. I will discuss to what extent these influences persist beyond the "edge" of groups and clusters, to their far outskirts and the filamentary cosmic web. Finally, I will present recent work with the COLIBRE simulations testing how accurately this state-of-the-art model with a multi-phase ISM structure can reproduce observations of star formation quenching and cold gas deficiency in the local Universe and beyond.

Multi-Scale Pathways to Galaxy Quenching (Invited)

Authors

Sean McGee (1)

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Abstract

The big evolutionary change in the life of a galaxy is its transition from a star-forming to a passive state. In this talk, I will discuss several possible physical mechanisms that can induce this transition, each acting in a different regime of galaxy mass and/or large-scale environment. I will discuss how satellite galaxies may lose gas as they slam into the hot medium characterising massive haloes, how massive galaxies may be limited by their ability to accrete gas from the large-scale environment, and how intermediate-mass galaxies may fail to retain their gas after internal explosions. I will describe new progress on each of these mechanisms but highlight the puzzles that stand in the way of a complete understanding. Ultimately, I'll discuss how new wide-field surveys will deliver answers to these puzzles.

Anisotropic satellite galaxy quenching in massive clusters (Invited)

Authors

John Stott (1)

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Abstract

A recent observational result finds that the quenching of satellites in galaxy groups at z = 0.1 has an angular dependence relative to the major axis of the central galaxy. This observation is described as 'anisotropic quenching' or 'angular conformity'. The Illustris TNG simulation predicts that this quenching signal is driven by AGN outflows along the minor axis, reducing the density of the intergalactic medium and thus the strength of ram pressure. Here, I present our investigations into anisotropic quenching in massive clusters up to z ~ 0.5, a further 4 Gyr of lookback time, using data from both HST and Subaru. To study the cause of this, I will also present the variation in the strength of this signal with distance from the cluster centre, demonstrating that there are alternatives to the AGN outflow scenario. Finally, I will show our current work on the anisotropic quenching signal in LSST DP1.

Posters

Photometric Prediction of Star Formation Rates in Starburst Galaxies: A Machine Learning Approach in the Era of Large Surveys

Authors

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Abstract

Star formation rate (SFR) is a fundamental tracer of galaxy evolution and is known to vary across different environments, from isolated systems to dense structures such as groups and clusters. In this context, starburst galaxies, exhibiting intense and short-lived star formation episodes, provide a unique laboratory to probe the physical drivers of galaxy evolution.

In this study, we develop a machine learning framework to predict the SFRs of starburst galaxies using photometric features derived from Hubble Space Telescope (HST) multi-band imaging. Key observables, including integrated magnitudes, color indices, and morphological parameters, are used as inputs to supervised learning models such as Random Forest and Gradient Boosting. The predicted SFRs are validated against observational estimates to assess model performance.

By relying solely on photometric data, this approach enables scalable SFR estimation across large galaxy samples, including faint and distant systems where spectroscopy is limited. This is particularly relevant in the context of upcoming large-scale surveys (e.g. JWST, Euclid, Rubin/LSST), where homogeneous and efficient methods are required to connect observed galaxy properties with their evolutionary pathways.

Our results demonstrate that photometric information can recover SFRs with high accuracy, offering a robust tool to statistically explore star formation activity across diverse environments and to bridge observational measurements with models of galaxy evolution.

Constraining the formation pathways of kinematically distinct cores in group and cluster galaxies.

Authors
Runyu Liao (1)

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Abstract
Kinematically distinct cores (KDCs) are regions of distinct dynamics in the centers of galaxies and are commonly interpreted as relics of past galaxy interactions and mergers. Their formation is therefore closely tied to the environments in which galaxies evolve. In this presentation, I will present results constraining the origins of all KDC host galaxies identified in the SAMI Galaxy Survey. We combine spatially resolved observations with environmental information and carry out dynamical modeling based on the Schwarzschild orbit-superposition method. We find that these systems span environments from galaxy groups to clusters, with most residing at the centers of their groups, and cover a range of local environmental densities, as traced by the fifth-nearest-neighbor surface density. These galaxies show diversity in morphology and stellar populations: the ellipticals in richer groups tend to show more similar stellar populations between the KDC and outer regions, suggesting merger-driven evolution. In contrast, the lenticular or early-type disk galaxies in poorer groups tend to exhibit old, metal-rich central stellar populations with younger, more metal-poor outskirts, suggesting more complex assembly histories such as external gas accretion through cosmic filaments or gas-rich galaxy interactions and mergers. These results indicate that KDC formation and local environment are closely linked.

Death by Impact: Evidence for Merger-driven Quenching in a Collisional Ring Galaxy at Cosmic Noon

Authors
Amir H. Khoram (1), Sirio Belli (1)

(1) University of Bologna

Abstract
The role of interactions and mergers in the rapid quenching of massive galaxies in the early Universe remains uncertain, largely due to the difficulty of directly linking mergers to quenching. Collisional ring galaxies provide a unique opportunity, as their morphology allows precise dating of the interaction, which can then be compared to quenching timescales inferred from star formation histories. We study a gravitationally bound system at z = 1.61 in the Ultra Deep Survey field, composed of a host galaxy (M⋆ = 1011.4 M⊙) with a collisional ring and an X-ray active galactic nucleus (AGN), and the Bullet Galaxy (M⋆ = 1011.2 M⊙), located at a projected distance of ~8 kpc. Combining JWST and Hubble Space Telescope imaging with Keck/MOSFIRE spectroscopy, we find compelling evidence for an ongoing starburst in the host concurrent with rapid quenching in the Bullet Galaxy. The ring, ~20 kpc in diameter, is expanding at 127−29+72 km s−1, implying the galaxies first collided 47—96 Myr ago. This timeline is consistent with the host's current starburst and the Bullet Galaxy's sudden quenching, strongly suggesting both phenomena were triggered by the interaction. Crucially, the Bullet Galaxy shows no evidence of a preceding starburst, ruling out rapid gas consumption as the primary quenching channel. Instead, we suggest that merger-driven processes—such as enhanced turbulence and disk instabilities—may have suppressed star formation. An additional possibility, which we term the dragon effect, is that AGN-driven outflows from the host disrupted the Bullet Galaxy's low-density molecular gas, thereby preventing efficient star formation and accelerating quenching.

RAGERS: the interaction between high-redshift radio galaxies and their surrounding protoclusters environments

Authors

Fergus Henstridge (1), Julie Wardlow (1), RAGERS Collaboration

(1) Lancaster University

Abstract

High redshift radio galaxies (HzRGs) are powered by AGN and are thought to be good tracers of protoclusters at cosmic noon, an epoch with significant contributions from dust-obscured star formation. Existing optical/near-IR studies of their environments implicitly exclude the most extreme dust-obscured star-forming galaxies and therefore, to robustly track their environments, far-IR/submillimetre studies are required. I will present new results from RAGERS – a large JCMT/SCUBA-2 submillimetre survey of overdensities around 27 HzRGs at z~1–3.

We find that, when compared with mass- and redshift-matched radio-quiet galaxies, HzRGs reside in significant overdensities of dusty star-forming galaxies (DSFGs), which are strongest closest to the radio galaxy and in fainter DSFGs. We measure number counts and quantify these overdensities using the overdensity parameter, delta, and find a large variation in delta on a field-by-field basis. These overdensities are likely driven by interactions between the AGN and their local environments, which will be further explored by studying the overdensities as a function of mass, redshift and radio luminosity.

MockKATs: Mock MeerKAT HI samples from the Simba and COLIBRE simulations

Authors

Marcin Glowacki (1)

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Abstract

The MeerKAT radio telescope in South Africa is one of the pathfinder instruments of the Square Kilometre Array (SKA). MeerKAT is currently the most sensitive radio interferometer for neutral hydrogen (HI) studies with the 21-cm line. With hundreds of HI-rich galaxies already detected in dedicated science surveys such as LADUMA and MIGHTEE-HI, we are able to replicate these samples using hydrodynamical simulations and make comparisons with observational studies. I will present MockKATs, a project making mock samples from the Simba-C and COLIBRE hydrodynamical suites. I highlight the importance of method of sample selection from these simulations, and the range of mock spectral-line cubes created using new tools developed through the ASymba (ASymmetries in HI of Simba galaxies) collaboration. The MockKATs samples, and similar other samples constructed through ASymba such as of the WALLABY all-sky HI survey, have already been used to investigate relations vital to the study of galaxy evolution such as the baryonic Tully-Fisher relation and HI scaling relations, which span several orders of magnitude. These relations, and studies into HI gas asymmetries, already showcase new findings and can be compared with future SKA pathfinder telescope surveys.

iMaNGA: a virtual IFU survey based on TNG50 hydro-dynamical simulations

Authors
Daniel Thomas (1)

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Abstract
We use a forward-modelling approach to test predictions from hydro-dynamical cosmological simulations of galaxy formation with spatially-resolved observations of the local galaxy population. We generate mock SDSS-IV/MaNGA integral-field spectroscopic galaxy observations from the TNG50 simulations, investigating the dependence of radial gradients in age and metallicity on fundamental galaxy properties. While we identify interesting differences between simulations and observations in some key aspects, we find that the observed negligible dependence of stellar population gradients on galaxy environment is well matched by the cosmological simulations.

Tracing Moderate-Luminosity AGN Across Galaxy Groups and Cosmic Voids

Authors

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Abstract

Supermassive black holes (SMBHs) are fundamental components of galaxies; however, the physical mechanisms governing their growth remain incompletely understood, particularly in relation to the large-scale environment. While internal galaxy properties such as stellar mass, gas content, and morphology are known to influence black hole (BH) accretion, the role of the environment remains an open question. In this work, we explore potential correlations between the presence of moderate-luminosity active galactic nuclei (AGN) in contrasting environments, specifically galaxy groups and cosmic voids, using the IllustrisTNG cosmological magnetohydrodynamical simulations. By linking environmental classifications in simulations with observable galaxy properties, we examine the distribution of SMBH accretion rates and AGN occurrence across these regimes. Our analysis suggests that AGN in group environments are predominantly associated with galaxies of stellar masses below 10^{11} M$_{\odot}$, and their occurrence varies with redshift, being more frequent at z $\approx$ 1 and less common toward z = 0. In contrast, AGN in voids appears to be preferentially located toward the outskirts and are hosted by $\sim$ 10^{11}M$_\odot$ galaxies within magnitudes in the range $-22 < M_{r} < -20$. These trends are presented as part of an exploration of how AGN presence correlates with the environment. Further analysis will be required to disentangle environmental effects from underlying galaxy properties and to enable robust comparisons with observations across cosmic time.

Studying the effect of Fornax like cluster environments on its galaxies using TNG-50 simulations

Authors
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Abstract
The Fornax cluster is a nearby, intermediate-mass system whose proximity and mass make it an ideal laboratory for studying galaxy evolution in a typical cluster environment. Recent results from the MeerKAT Fornax survey have provided a comprehensive characterisation of its HI-rich galaxy population, offering new insights into the processes that regulate neutral gas in such environments.
To further investigate the physical mechanisms responsible for these observations, we analyse Fornax-like clusters in the TNG50 cosmological simulations. We derive HI predictions to characterise the distribution of neutral gas both on cluster-wide scales and within individual galaxies. Our analysis shows that variations in the assembly histories of Fornax-like systems in TNG50 can significantly influence the HI content of both the intracluster medium and cluster galaxies.
By comparing the simulation results with observations, we find evidence that the Fornax cluster has likely experienced a recent influx of infalling galaxies, as indicated by the presence of several low-mass systems that retain substantial HI reservoirs. In the simulations, such galaxies are typically those that have either not yet penetrated the inner regions of the cluster or have only recently been accreted and therefore have not undergone significant gas stripping.
In this talk, I will present an initial comparison at z=0, followed by an analysis of the assembly histories of Fornax-like clusters in TNG50 that lead to these results.

Environmental dependence on elemental abundances in simulated galaxies

Authors

Chiaki Kobayashi (1)

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Abstract

I will show cosmological, hydrodynamical simulations including the latest nucleosynthesis yields that can well reproduce the detailed observations in the Milky Way. Both for stars and gas, our simulations well reproduce the observed mass-metallicity reaction and metallicity radial gradients at z=0, but not at higher redshifts. This is not improved with different feedback modeling: thermal, kinetic, stochastic, and mechanical feedback. The results are insensitive to the AGN feedback, and the environmental dependences is found to be weak. I will then show the time evolution of elemental abundances (such as Nitrogen), which can be observed with future spectroscopic surveys on 8m class telescopes such as Subaru PFS and VLT MOONS.

Halfway to cosmic noon: New HI windows on environmentally driven galaxy evolution with MeerKAT

Authors

Joshua Bishop (1), Julia Healy (1), Robert Beswick (1)

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Abstract

In the hierarchical structure formation picture, galaxies, groups and clusters grow over cosmic time through the gravitational clustering, accretion and merging of smaller structures. As galaxies evolve and migrate through the cosmic web from the lower-density field into denser environments, various astrophysical processes influence their stellar populations, morphology, interstellar medium and star-formation activity, eventually resulting in the overall quenching of star-formation. These processes range from tidal interactions and mergers between galaxies to hydrodynamical events such as ram-pressure stripping. Which of the various processes dominate at which stellar masses and in which local (galaxy-galaxy) and global (cosmic web) environments, however, is not yet clear.

To observe the effects of the environment, we turn to neutral atomic hydrogen (HI). As a gas tracer, HI extends far beyond the optical disk of most field galaxies; therefore, is the first frontier of the ISM to be affected by the environment. This makes it our premier tracer for the evolution of galaxies, especially with regard to the environment.

Previous works have demonstrated that galaxies closer to filaments are more HI gas-poor than galaxies located further from the filament. While others have focused on the effect of denser environments of galaxy clusters.

However, these studies have been limited to the local Universe ($z < 0.1$). This is due to the intrinsic faintness of the HI 21cm line. This faintness is not a problem in the local universe, as HI is incredibly abundant. At $z > 0.1$, detections become increasingly difficult as a result of this faintness. This gives rise to a cosmological desert where many of our scaling relations (used to track this evolution over cosmic time) become unreliable and our general understanding of HI at this epoch is poor. It is also at this epoch that simulations of HI gas and observations also begin to diverge, emphasising the need for more results at these redshifts.

The SKA-mid precursor MeerKAT is of such sensitivty that we are able to begin to push further into these uncharted epochs, especially when we are able to deploy statistical techniques such as spectral line stacking. We have obtained MeerKAT 32k L-Band observations covering a cosmological volume of 52 x 52 Mpc^2 (at $z \sim 0.43$), enabling the exploration of these new HI windows in an effort to push to higher redshifts and begin to answer questions such as "nature" vs "nurture" for galaxies halfway to cosmic noon.

In this talk, I will present preliminary results from the observations made using MeerKAT of the cluster A2626. I will explore the large scale structure and galaxies identified at higher redshift behind this cluster, at $z \sim 0.43$, where we believe there to be a filament-like overdensity. I will show a first-pass characterisation of the environment, looking at filament finding techni

Burst, quench, repeat: the physical drivers of extreme galaxy properties at Cosmic Dawn

Authors

Will McClymont (1)

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Abstract

Recent JWST observations suggest that the first galaxies are incredibly compact, extremely bursty, and host peculiar chemical abundances. I use the high-resolution THESAN-ZOOM cosmological simulations, which combine a cutting-edge ISM model with on-the-fly radiative transfer, to understand these properties. I connect galaxy environment to short-timescale ISM evolution by showing that burstiness is driven by increasingly stochastic and rapid gas inflows from the IGM and mergers with increasing redshift. This bursty star formation naturally causes distinct morphological features (e.g., extended H-alpha relative to stellar continuum), produces a population of mini-quenched galaxies, and even generates nitrogen-rich galaxies by preferentially ejecting oxygen-rich gas, reproducing JWST observations without requiring exotic stellar yields. In summary, the tempo of IGM inflow leaves fingerprints on the morphology, star formation histories, and chemical abundances of high-z galaxies.

Environmental Dependence of Galaxy Properties in COLIBRE

Authors

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Abstract

Using a joint empirical and theoretical approach, we aim to assess how a galaxy's environment affects its evolution. Using data from the DESI Bright Galaxy Survey, we empirically explore how galaxy properties—such as brightness, colour, and morphology—change depending on their surroundings in the cosmic web (voids, filaments, clusters, etc.). We will then compare these trends with predictions from the hydrodynamical COLIBRE simulation suite to shed light on the physical processes behind them. By studying galaxy formation histories and testing different simulation parameters, we assess whether these trends are driven by dark matter halo mass, biases in halo mass assembly, or baryonic physics. In this talk, I present preliminary results quantifying the role of halo mass in driving environmental trends in the COLIBRE simulations, and highlight those that require additional physical processes.

Environmental effects on the chemical properties of baryons across halo mass in IllustrisTNG-Cluster simulations

Authors

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Abstract

The chemical evolution of baryons is shaped by the interplay between internal processes and the environment in which galaxies reside. In this work, we investigate how environmental effects influence the chemical properties of baryons across a wide range of masses using the IllustrisTNG-Cluster simulations. This suite of cosmological magneto-hydrodynamical simulations provide a large statistical sample of galaxies in clusters with a mass resolution high enough to study baryonic processes in dense environments and their surrounding regions.

We analyze the dependence of gas-phase and stellar metallicities, as well as baryonic content, on both halo mass and environment, considering metrics such as cluster-centric distance, central-satellite classification and local density. We also investigate the role of active galactic nucleus (AGN) feedback in shaping the chemical properties of baryons, examining how its impact depends on the virial mass of the host halo and the location of the host galaxy within the cluster environment.

This work aims to provide a comprehensive characterization of the combined role of halo mass, environment, and AGN feedback in shaping the chemical properties of baryons.

Contrasting Importance of Local Density vs Large Scale Environment on Galaxy Evolution

Authors

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Abstract

The evolution of galaxies is strongly influenced by their surrounding environment, from the interactions with neighbouring systems to their position within the cosmic web. By transitioning from a star-forming to a passive state, the star formation rate (SFR) of galaxies is suppressed in a process referred to as quenching. Specifically, this analysis focuses on environmental quenching, which is driven by external factors. On the one hand, galaxies interact with each other through merger events and close encounters. These processes are correlated with local density. On the other hand, galaxies move through the large-scale structure (LSS) of the Universe and the different environments that compose it: clusters, filaments, groups and voids. Each environment is characterised by distinct densities and geometries, which can exert additional physical effects.
In this work, we aim to disentangle the relative importance of local density and the LSS in the environmental quenching of simulated galaxies. Building on the observational framework of O'Kane et al. (2024), we classify galaxies into six environmental categories to explore their baryonic properties, focusing first on their SFR. We tackle this issue analysing the numerical simulations available within The Three Hundred Project: a suite of zoom-in simulations that provide extensive information on galaxy clusters and their surrounding environments. Numerical simulations offer large samples of galaxies and controlled conditions to explore in detail their baryonic properties and temporal evolution in each environment. We show here our preliminary results analysing the hydrodynamical simulations from the GIZMO-SIMBA run.
We recover the observational trend reported by O'Kane et al. (2024), finding an excess of massive galaxies in groups relative to clusters. We explore whether this reflects enhanced merger activity or environmental effects tied to groups and/or clusters. We also address key challenges in the comparison with observations, including differences in SFR estimations and the impact of projecting three-dimensional environments into two-dimensional classifications.

Future stages will include contrasting results between hydrodynamical and semi-analytic models using SAG (Semi-Analytic Galaxies). With this ongoing project, we aim to gain more insight into how local and large-scale structures jointly shape the evolution of galaxies.

IMF variations across the DESI BGS galaxy populations

Authors

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Abstract

There is growing evidence that the stellar initial mass function (IMF) varies across galaxy populations, suggesting that star formation may depend on the local physical environment rather than following a universal form. Understanding how galaxy-scale conditions influence the IMF is therefore essential for interpreting measurements of stellar mass, star formation rates, and chemical enrichment. The large, homogeneous spectroscopic dataset provided by the Dark Energy Spectroscopic Instrument (DESI) enables a statistical investigation of IMF variations across a wide range of galaxy environments.
We analyse star-forming galaxies in the DESI Year 3 sample over the redshift range $0 < z < 0.5$, combining Balmer emission-line measurements with broadband optical colours to constrain IMF-sensitive diagnostics through comparison with stellar population synthesis models. The size of the DESI sample allows us to probe IMF behaviour across diverse galaxy environments characterised by stellar mass, star formation rate, gas-phase metallicity, and star formation surface density.
We find systematic trends in the inferred IMF slope with galaxy environment, with the strongest correlations linked to star formation activity and gas-phase metallicity. Galaxies with higher star formation intensity and denser interstellar medium conditions show evidence for systematically different IMF slopes compared to more quiescent systems. These trends support scenarios in which local interstellar medium properties regulate the relative production of high- and low-mass stars. The persistence of these correlations across the explored redshift range suggests that internal galaxy environment, rather than cosmic time alone, plays a primary role in driving IMF variations.
These results demonstrate that IMF variations are closely connected to galaxy environment and highlight the importance of incorporating environmentally dependent IMFs into models of galaxy evolution.

Quantifying star formation in galaxy mergers across mass ratios: TNG50 and idealized models (Online)

Authors

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Abstract

In this work, we use idealized hydrodynamic simulations with the AREPO code to investigate how the SFR is affected by mergers with different mass ratios (1:1 to 5:1) and orbital inclinations (0, 30, 45 and 60 degrees), without the cosmological background. The results are compared to equivalent merger events identified in the complete cosmological simulation IllustrisTNG (TNG50).

In the idealized simulations, major mergers (ratios 1:1 to 3:1) produce the largest increases in SFR, reaching +62% under certain conditions (head-on collision, ratio 1:1), while minor mergers (4:1 to 5:1) generate more modest increments, from +7% to +19%. These bursts of star formation are short-lived (less than 0.3 Gyr) and have a limited impact on the total stellar mass of galaxies (an increase of 5 to 15%).

When compared to the galaxies in TNG50, we observe the cosmological background provided by TNG50 considerably amplifies the efficiency of mergers. Considering the cosmological scenario, the average SFR increases 9.3 times (830%) compared to an isolated galaxy in TNG50, versus 6.7 times (570%) in idealized simulations, without the cosmological background. Considering smaller mergers (4:1 and 5:1), the background outperform their idealized counterparts by factors of 2.0 to 2.5 times. These results indicate that the gas accretion and previous interactions, play a crucial role in amplifying star formation, especially for low mass ratio mergers.

Likelihood-Free Inference for Inferring Galaxy Physical Properties from Images

Authors

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Abstract

Next-generation photometric surveys will observe orders of magnitude more galaxies than can be spectroscopically characterised, requiring robust methods to infer physical properties with reliable uncertainties. We introduce a likelihood-free inference framework that directly maps galaxy images to posterior distributions over physical parameters. Galaxy evolution studies rely on measurements of physical properties across cosmic time, with redshift playing a central role in both astrophysical and cosmological analyses. However, the mapping from photometric observations to these properties is highly degenerate, and capturing the resulting uncertainties in a consistent and scalable way is nontrivial. We address this by leveraging deep learning models to extract information directly from imaging data, reducing reliance on hand engineered colour features and enabling the model to learn complex morphological and photometric relationships. These learned representations are used as summary statistics and used to train a neural density estimator, an approach often used in Simulation Based Inference. Our method recovers the full joint posterior distributions from purely observational data. This combination of representation learning and neural density estimation enables flexible, data driven posterior estimation that captures degeneracies without imposing restrictive model assumptions, providing a scalable pathway for uncertainty-aware inference in large galaxy surveys.

What do we mean by Stellar Mass? The impact of the stellar pre-main sequence on stellar population synthesis

Authors
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Abstract
Stellar population synthesis models are an essential tool with which galaxy physical parameters are extracted from observations. However they are built on assumptions designed for use in the local Universe, and not always appropriate to high redshift galaxies. Here we consider the impact of including the hitherto-neglected stellar pre-main sequence delay timescale on the interpretation of composite stellar populations at ages of <1 Gyr. We find that doing so has an impact on the optical luminosity of very young stellar populations of up to ~10 per cent, although smaller changes in observed light (<5 per cent) are expected in most use cases. However the impact on the inferred stellar mass and mass-to-light ratios is significant (a factor of 2 or more), depending on how those properties are defined. We demonstrate that the short time scales for star formation in the distant Universe require a clearer definition for the stellar mass in a population, and will impact assumptions about the inferred shape of the stellar initial mass function from observations.

Panchromatic modelling of resolved high-z galaxy observations using Bayesian Neural Networks

Authors

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Abstract

Galaxy growth has traditionally been explored through two complementary perspectives: the build-up of stellar mass inferred from galaxy integrated SED modelling, and the growth in size captured by high-resolution imaging. While these approaches have driven major advances in our understanding of galaxy evolution, both tend to gloss over the fact that both dust attenuation and stellar populations may vary spatially, which has been known to influence colour gradients in galaxies since the Hubble Space Telescope era and therefore limiting the physical realism of inferred properties. Meanwhile, deep multi-wavelength surveys on high-redshift galaxies provide increasingly rich datasets across the UV to mm, but the data exhibits different spatial resolutions, resulting in a mixture of highly resolved, marginally resolved and unresolved data. To address these limitations, we developed a novel modelling technique aimed at maximally exploiting all of this rich yet varied information without sacrificing unresolved or poorly resolved bands, and without sacrificing resolution where available. Our modelling approach simultaneously and self-consistently models a galaxy's spectral energy distribution and its spectral distributions of global structural parameters: the wavelength dependent galaxy size, light profile and projected axis ratio using a computationally efficient machine learning emulator trained on a large library of toy model galaxies processed with 3D dust radiative transfer and mock observed under a range of viewing angles. The toy models vary in their stellar and dust geometries, and include radial stellar population gradients allowing for informative extraction of these properties during inference. The emulator reproduces the spectral distributions at an accuracy of $\sim$ 0.05 dex or less across the dynamic range of input parameters, and across the rest-frame UVJ colour space spanned by observed galaxies out to $z = 3.5$. This framework enables physically realistic inference for galaxies around cosmic noon, and we demonstrate its application to TNG50 star forming galaxies and observations from the COSMOS and GOODS-South fields.

Peculiar Velocities from DESI: A New Resource for Studying the Local Universe

Authors
Caitlin Ross (1)

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Abstract
Peculiar velocities provide a unique link between galaxy properties and the underlying large-scale structure, offering insight into how galaxies evolve within the cosmic web, beyond the capabilities of traditional redshift surveys. The Dark Energy Spectroscopic Instrument (DESI) Peculiar Velocity Survey is measuring distances and peculiar velocities for over 186,000 nearby galaxies using the Fundamental Plane and Tully–Fisher relations, enabling detailed studies of galaxy environments and mass assembly in the local Universe. In this talk I will present an overview of the DESI Peculiar Velocity Survey and its available data products, with a focus on the Fundamental Plane sample from Data Release 1. The first release contains peculiar velocity measurements for nearly 100,000 early-type galaxies, making it the largest sample of its kind. I will describe how the catalogue is constructed, its calibration, selection properties, and current limitations, and outline the types of science applications for which these data may be useful, including studies of galaxy environment, large-scale flows, and the relationship between galaxies and the underlying matter distribution. I will also discuss ongoing improvements being made to the analysis pipeline for future releases. These developments will enhance the utility of DESI peculiar velocity data for a broad range of galaxy evolution and large-scale structure studies.

Environment as the Origin of Plateau and Scatter in the Stellar Mass-Metallicity relationship

Authors

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Abstract

Below $M_\star\sim10^5\ \mathrm{M_\odot}$, dwarf galaxy satellites of the Milky Way (MW) depart from the canonical stellar mass--metallicity relation (SMZR), producing a `plateau' with markedly increased scatter. The origin of this feature is unresolved. We use data for Local Group dwarfs and the high-resolution radiation--hydrodynamical EDGE2 (Engineering Dwarfs at Galaxy formation's Edge 2) simulations to explore the origins of this plateau. We find that strong tidal stripping can displace individual systems (producing clear outliers) but is rare and insufficient to explain the full plateau population. Instead, we find isolated EDGE2 dwarfs naturally develop a large intrinsic scatter at low stellar mass ($M_\star\lesssim10^5\ \mathrm{M_\odot}$) driven by three coupled processes: (i) variations in central dark-matter density that set early star-formation and enrichment rates, (ii) merger-driven or inflow-induced dilution that temporarily lowers the mass-weighted metallicity, and (iii) differential metal retention controlled by confinement in dense filamentary circumgalactic environments. Rapid self-enrichment to ${\rm [Fe/H]} \sim-3$ within $\lesssim100$\,Myr establishes a lower metallicity floor in the plateau region, while early quenching (by reionisation for the lowest-mass systems or by infall for larger dwarfs) freezes galaxies in at different enrichment stages. We show that, together, these effects naturally populate the observed plateau without any need for additional physics. Our results imply that the plateau is an imprint of early dwarf formation and should be present in all environments.

Connecting observations and simulations of Small Magellanic Clouds

Authors

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Abstract

Using the near-infrared Calcium Triplet lines, we derive metallicities for a sample of over 3,500 red giant stars in the field of the Small Magellanic Cloud. We measure a median metallicity of [Fe/H] = -1.05 ± 0.01 dex and identify a negative metallicity gradient of -0.064 ± 0.007 dex per degree, consistent with an outside-in evolutionary scenario.
We also detect significant azimuthal variations in metallicity, with shallower gradients in the eastern and southern regions and steeper gradients toward the north and west. These patterns are consistent with the effects of tidal interactions with the Large Magellanic Cloud.
To test this scenario, we compare our observations with an N-body model of the Small Magellanic Cloud–Large Magellanic Cloud–Milky Way interaction, assuming an NFW dark matter halo and a Plummer stellar distribution. The simulated chemical gradients and structural features show good agreement with our observational results, supporting a tidal origin for the observed asymmetries.

The Missing Geometric Dichotomy: Chemical Structure in Simulated Milky Way-like Galaxies

Authors
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Abstract
In the Milky Way and other spiral galaxies, stellar populations encode the fossil record of past star formation, gas accretion, and merger events through their chemistry and kinematics. One of the clearest manifestations of this record is the so-called double-disc dichotomy: the coexistence of chemically and geometrically distinct thick and thin discs. This paper investigates a simulated galaxy from the Auriga simulations that demonstrates it is possible for a chemical dichotomy to exist without a geometric bimodality. Rather than forming in the classic two-phase scenario characterised by an early turbulent phase followed by quiescent settling, the galaxy experienced prolonged late-time gravitational perturbations from nearby companions. This activity triggered bursts of star formation leading to chemically distinct stellar populations whilst simultaneously hindering the disc from settling into two distinct geometric components. A subsequent merger dynamically heated and radially redistributed stars, effectively "puffing up" the disc into a single thickened structure and erasing a clear geometric dichotomy. These results demonstrate that chemical dichotomies can outlive geometric signatures of mergers and secular evolution, providing a more robust tracer of past dynamical events. As next-generation spectroscopic surveys expand beyond the Milky Way, identifying galaxies with mismatched chemical and geometric structures may offer a new avenue for probing merger histories and gas accretion in dynamically active environments.

Are dusty quasars in an evolutionary phase?

Authors

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Abstract

The most rapid SMBH growth in the Universe has occurred in luminous quasi-stellar objects (QSOs), making them the perfect laboratories for observing galaxy–SMBH evolution. When we have an unobscured view of the accretion disc, which peaks in the UV, QSOs display very blue UV–optical colours. However, there exists an important population of QSOs, obscured by dust, which are typically uncharacterised by optical spectroscopic surveys. These dusty QSOs could represent an important short-lived transitional phase in the evolution of galaxies (a "blow-out" phase). Utilising data from DESI we can now, for the first time, explore a statistically significant sample of these reddened QSOs. Combining DESI spectra with radio data from the LoTSS DR2, we find a striking positive relationship between the amount of dust extinction and the radio detection fraction in DESI QSOs. This demonstrates an intrinsic connection between opacity and the production of radio emission in QSOs which may be due to outflow-driven shocks. In our latest work, we test this scenario by exploring the radio spectral slopes and ionised outflow properties of dusty QSOs, finding evidence that dusty QSOs might reside in a short-lived blow-out phase.

Extracting dark matter profiles from stellar and gas kinematics in Virgo spiral galaxies.

Authors

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Abstract

To better understand the interactions between dark and baryonic matter and the co-evolution of their distributions we created dynamical models to constrain the inner slope in a generalised NFW (gNFW) profile as such to better understand the dark halo distribution. To this end we present a dynamical modelling method of combining both the stellar and gas kinematics to constrain the dark matter profile of a late-type galaxy within a cluster environment. This method is applied to the late-type galaxy NGC4501, using IFU data from MAUVE -MUSE(Multiphase Astrophysics to Unveil the Virgo Environment) survey, DECALs (Dark Energy Camera Legacy Survey) imaging, and molecular hydrogen and HI data from the MAUVE-ALMA and VIVA (VLA Imaging of Virgo in Atomic gas) surveys for the gas kinematics and their contribution to the overall gravitational potential.
Using the gNFW dark matter profile with this method to constrain the dark halo parameters both and analyse the influence of the gas component of the baryonic distribution as well as analysing the effect of including gas kinematics as tracers.

Which Galaxies Enrich the Intergalactic Medium?

Authors

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Abstract

The need for energetic feedback to regulate star formation is reasonably uncontroversial. However, it is naive to assume this is a settled debate; the nature, strength and appropriate model implementation of both SNe and AGN feedback yet remain unsettled.

The metal-enrichment of the IGM is also a well-studied phenomenon, offering a reasonable constraint of the impact galaxies must have on their environment (Booth+12). Such impacts require that the same feedback mechanisms which regulate star formation also eject metal enriched ISM gas from the high-density galactic environment in which synthesis occurs and out into the IGM where these metals remain as a fingerprint of sorts.

The most up-to-date hydrodynamical simulations require that low-mass galaxies feature large-scale and highly mass-loaded winds as a direct consequence of their comparatively shallow potential wells. While we would anticipate mass-loading factors in the range 10 to 100, the observational literature lacks consensus on strong evidence for the existence of such outflows from low-redshift galaxies with some studies quoting values several orders of magnitude lower (Marasco+23). Criticisms of theoretical predictions that arise from such results, citing lack of resolution or poor subgrid treatments of key physics in simulations, do little to address the logical need for metals to reach the IGM. For this reason, we ask whether modern simulations which successfully reproduce the observed galaxy population are able to approach a reasonable IGM enrichment without contributions from low-mass galaxies.

I will present our results from the EAGLE simulations, including our analysis of which galaxies make significant contribution to IGM enrichment. Additionally, I will show the best estimate of the mass and volume-filling fractions of metals in EAGLE along with how this is broken down by galaxy mass and how this is dependent on the implementation of feedback physics. I will use these results to comment on the mass-range of galaxies and feedback prescriptions necessary to reproduce the IGM enrichment observed from QSO observations.