

Tuesday

Review 1. Limitations of Simulations for ICL studies TBC

Review 2. Limitations of Observations for ICL studies. Anthony Gonzalez

Contributed talks:

The origin of the intra-cluster light in The Three Hundred simulations

Ana Contreras-Santos

We present a comprehensive study of the origin of intra-cluster light (ICL) using The Three Hundred project, a large sample of 324 hydrodynamical simulations of massive galaxy clusters. By identifying the ICL at $z = 0$ and tracing its particles back in time, we reconstruct when and through which physical processes the ICL assembles. We find that half of the ICL's present-day mass was already in place between redshift 0.2 and 0.5. Tidal stripping of galaxies after infall is the primary formation channel, with the bulk of the material contributed by massive galaxies (stellar mass above $10^{11} M_{\odot}$), groups, and clusters. Major mergers account for a median of roughly one third of the ICL mass, although there is large variation across clusters (15-55%). The infall redshift of the primary contributors is generally below redshift 1, with smaller fractions arriving at redshifts between 1 and 2. In contrast, in-situ star formation plays only a minor role and is likely linked to gas stripping in rapidly infalling satellites.

Preliminary ICL Surface Brightness and Colour Profiles from the HSC CAMIRA Catalog

Xingquan Liu.

Understanding the assembly history of brightest cluster galaxies (BCGs) and the intra-cluster light (ICL) requires accurate colour gradients in the ultra-faint halo. In this talk, I will present preliminary g, r, and i-band surface brightness and colour profiles for clusters in the HSC CAMIRA catalog. Using a custom photometry pipeline, we map the stellar population transition from the BCG core out to the extended ICL. I will discuss our initial findings on the ICL colours and what they might imply for the buildup of these massive systems.

On the Origin of Intracluster Light based on the High-resolution Simulation, NewCluster

Seyoung Jeon

Intracluster light (ICL) is a key component of galaxy clusters, with the potential to trace their dynamical assembly histories and the underlying dark matter distribution. Despite these prospects, its faint nature makes a consensus on its origin or population properties difficult to achieve, both in observations and simulations. In the hope of finding a breakthrough, we utilize the ongoing high-resolution cluster simulation, NewCluster. By classifying billions of particles in and around the cluster with a rigorous tracking procedure, we find that the majority of the ICL originates from satellites, including surviving and disrupted galaxies. Another notable finding is that the preprocessed component follows the density profile of dark matter better than the other components and has distinctive properties: old age, low metallicity, and enhanced α -element abundance. We further investigate the orbital dynamics, and our results demonstrate that the stripped fraction of satellites is primarily determined by the time since infall and the pericenter distance. By linking the demographic, chemical, and orbital properties of ICL stars to their origins, this work proposes a quantitative approach for tracing the assembly history of galaxy clusters from the ICL.

Numerical Insights into the Origin and Growth of Intragroup Light in Pre-Virialized Galaxy Groups

Betelehem Bilata Woldeyes.

Deep surface photometry reveals the presence in a good number of galaxy groups of a faint and diffuse baryonic component permeating the intragroup space. This intragroup light (IGL) is primarily formed by stars that are removed from their host galaxies through gravitational interactions and now drift freely, unbound to any particular galaxy.

A controlled numerical simulations of pre-virialized groups are used to study the formation and evolution of the diffuse IGL and investigate its potential to describe the assembly history of such systems of galaxies. We traced the growth of the IGL over cosmic time in these groups where the IGL begins to form in substantial amounts during the turnaround $z \sim 0.99$ and keeps growing with cosmic time showing a relatively higher IGL fraction in groups which hosts a massive dominant galaxy.

We analyzed the correlation between IGL and different group properties at $z=0$. We observed a negative correlation between the IGL fraction and the group's velocity dispersion, indicating that IGL formation efficiency is primarily influenced by internal group dynamics. Lower velocity dispersion may enhance IGL formation through increased gravitational interaction effectiveness. The sublinear correlation observed between the mass of IGL and the first-ranked galaxies, suggests that their growth is connected but doesn't have a one-to-one growth. To complement this result, by tracing back the progenitors of the diffuse stellar component and first-ranked galaxies, we found that despite their intertwined origins, they follow distinct growth histories, involving different populations of progenitors. These results indicates, the IGL and the first-ranked galaxies in the group form at a different time and also their formation mechanism can be different. Furthermore, comparing the density profile of the IGL and the total mass of the system at $z=0$, we found similarities in the profiles which suggests the IGL follow the dark matter distribution, even when these galaxy aggregations are not in dynamic equilibrium. In some of the groups the profiles might not agree for different projections due to the lack of symmetry.

Joint study of the diffuse stellar and gas content of galaxy clusters

Amaël Ellien

In this talk, I will present and review the results from my recent works on Euclid, JWST and UNIONS data, with an emphasis on the differences and synergies brought by a multiwavelength/multicomponents approach (ICL+ICM), and what powerful information it holds to understand galaxy cluster evolution.

Modelling and Disentangling Cirrus from Extragalactic Low Surface Brightness Light

Qing Liu

Diffuse Galactic cirrus is becoming one of the major foreground limitations in deep low-surface-brightness (LSB) imaging. Dust-scattered light from cirrus can produce filamentary, structured emission that overlaps in both angular scale and surface brightness with a variety of extragalactic LSB emission, including intracluster light (ICL), tidal debris, and stellar halos, making it a particularly challenging contaminant for next generation wide-field imaging surveys such as the Euclid Wide Survey. In this talk, I will give a brief review of Galactic cirrus in the context of LSB astronomy. I will summarize key observed properties of cirrus, including its broad-band spectral energy distribution and its non-Gaussian, filamentary morphology, and discuss how these information has the potential of being used to distinguish cirrus from genuine extragalactic diffuse light. I will then present a developing mock cirrus generation framework designed for Euclid data. The method combines physically motivated dust/SED priors with statistical modelling of cirrus morphology to generate realistic synthetic cirrus images that reproduce both intensity fluctuations and structured texture. These models can provide controlled training and test data for future

machine-learning based component separation of cirrus from extragalactic LSB emission, and offer a route toward more robust measurements of ICL in upcoming surveys.

Wednesday

Review 3. Stellar population properties of the ICL. Chris Mihos and Enrica Iodice

Review 4. ICL as a dark matter probe. Mireia Montes and Jaewon Yoo

Contributed talks:

The Metallicity of the ICL: Insights from the Euclid Quick Data Release

Jesse Golden-Marx

Colour provides key information to constrain the stellar population of the intracluster light (ICL). Using the new Euclid Quick Data Release (Q1) observations, we derive radial colour profiles (Y-H, J-H, I-H) of the brightest central galaxy (BCG) and ICL for 174 galaxy clusters from the DES-redMaPPer catalogue within the redshift range $0.1 < z < 0.75$ and halo mass $M_{\{200m\}} > 10^{(14.05)} M_{\odot}$. We use elliptical annuli to measure ICL light profiles as far out as 600kpc from the core of the BCG. By stacking our BCG+ICL images, we can detect a colour gradient that extends out to 600kpc for the first time, and find that the ICL is bluer and the BCG core is redder. Using stellar population synthesis models, we find that NIR colours are sensitive to metallicity, but not age. We find that the metallicity of the BCG is super-solar [$\log_{10}(Z/Z_{\odot}) > 0.1$], while the ICL is metal-poor [$\log_{10}(Z/Z_{\odot}) \sim -0.5$ to -1.0]. This measurement places the first statistical constraint on the metallicity of the ICL out to large radii. These observations strongly align with the metallicities of the ICL found in the IllustrisTNG and Hydrangea simulations for the inner 200 kpc and then start to diverge, becoming more metal poor. These results support our current understanding of BCG and ICL formation: BCGs form predominantly through mergers with massive galaxies or the cores of satellite galaxies, while the ICL grows via the tidal stripping of lower metallicity stars from the outskirts of massive satellite galaxies.

ICL in Nearby Clusters

Marilena Spavone

Intracluster light (ICL) and the extended stellar halos of cluster galaxies provide crucial insights into the formation and dynamical evolution of galaxy clusters. In this talk, I will present recent observations of ICL and stellar halos in a sample of nearby clusters, highlighting their fraction of intracluster light, and connection with cluster substructure. We investigate the processes contributing to the build-up of galaxies in the clusters, including tidal stripping, mergers, and disruption of dwarf galaxies. Current studies are limited by surface brightness sensitivity, sky subtraction uncertainties, and instrument field of view, which constrain the detection of faint outskirts. I will discuss how upcoming facilities and improved instrumentation will enhance our ability to trace ICL and stellar halos to lower surface brightness levels, providing a more complete view of cluster assembly in the local universe.

What can intracluster light tell us about dark matter?

Garreth Martin

Because ICL stars are essentially collisionless, much like dark matter itself, the ICL is a promising tracer of the underlying potential of galaxy clusters. Observations increasingly show that ICL morphology traces dark matter more faithfully than other baryonic tracers like X-ray gas. I will discuss the physical relationship between ICL and dark matter, what drives the differences in their

spatial distributions, and how we might use ICL observations to recover the properties of cluster dark matter haloes.

Intracluster Light as a Probe for Dark Matter: Exploring SIDM and CDM with C-EAGLE Sims

Jaewoon Yoo

We assess whether intracluster light (ICL) can serve as an observational discriminator of dark matter physics. The self-interacting dark matter (SIDM) model has gained increasing attention as a possible resolution to small-scale discrepancies between collisionless cold dark matter (CDM) simulations and observations, predicting distinct tidal interaction histories within galaxy clusters. We analyze Cluster-EAGLE zoom-in galaxy clusters re-simulated from identical initial conditions in both CDM and SIDM frameworks. The morphological similarity between dark matter and multiple baryonic tracers—gas, all stars, galaxies, and the combined brightest cluster galaxy plus ICL (BCG+ICL)—is quantified using the Weighted Overlap Coefficient, a contour-overlap statistic. We find that dark matter is traced most accurately by BCG+ICL, followed by gas, all stars, and galaxies. The BCG+ICL component remains a robust tracer even at high redshift, while gas initially traces dark matter poorly but improves over time, eventually approaching the performance of BCG+ICL. Notably, in the SIDM case the gas distribution more closely resembles dark matter than in CDM. This reflects the underlying physics: in CDM, collisionless dark matter behaves similarly to the collisionless BCG+ICL, whereas in SIDM, self-interactions introduce an effective collisionality, making dark matter evolve more like the gas component. Our results demonstrate the potential of ICL as a novel observational probe of dark matter physics and provide a first step toward using diffuse cluster light to constrain the nature of dark matter.

Intracluster light is a close tracer of the dark matter halo shape

Adela Fernandez

We explore whether the intracluster light (ICL) can be used as a tracer of the shape of the dark matter (DM) haloes in galaxy clusters. Establishing such a link would provide a new way to probe the shapes of DM directly from deep imaging, to ultimately help us better understand its nature. Using the Hydrangea simulations, we measure the three-dimensional and projected shapes of the ICL and DM with a shape tensor in concentric ellipsoidal shells. We find that the ICL and DM position angles are closely aligned, with major-axis misalignments below 10 degrees, and very similar axis ratios, though the DM is slightly rounder on average. We show that the satellite distribution is a less reliable tracer than the ICL, with large misalignment angles and a bias toward more elliptical shapes. These results indicate that the ICL can serve as a useful proxy for the ellipticity and orientation of DM haloes.

The shape of cluster haloes revealed by the intracluster light

Tutku Kolcu

The intracluster light (ICL) offers a uniquely luminous probe of galaxy cluster halo shape and orientation, but its extremely low surface brightness has historically made robust cluster-scale morphological measurements challenging. In this talk, I will present ICL ellipticity and position-angle measurements from Euclid's Quick Release (Q1) for nearly 200 clusters at $0.1 \leq z \leq 0.8$, selected from the eROSITA All-Sky Survey and the Dark Energy Survey. We quantify ICL morphology across five bands (VIS, Y, J, H, and coadded YJH) and find consistent shape parameters across filters, with the H band tracing the ICL to the largest cluster-centric radii. The ellipticity distribution peaks at $e \approx 0.5$ ($e = 1 - b/a$), in close agreement with halo ellipticities inferred from strong and weak lensing, supporting the view that the ICL traces the cluster's large-scale structure. Radially, BCG-dominated cores are relatively round ($e \approx 0.2$), while the diffuse

component becomes progressively more elongated, reaching $e \approx 0.5$ by $0.1R_{200}$ (~ 100 kpc). By stacking clusters in redshift bins, we extend ellipticity measurements to $\sim 0.4 R_{200}$ (350–400 kpc), where we observe a plateau beyond $\sim 0.1R_{200}$ with no detectable redshift evolution, challenging theoretical expectations.

To bridge observations and theory, we compare to Hydrangea simulations using two complementary ICL definitions: (i) a theoretical “unbound” ICL+BCG component, and (ii) fully forward-modelled mock observations that include subhaloes and realistic backgrounds. The unbound ICL is systematically rounder, while the forward-modelled distribution matches the observed distribution well—highlighting that forward-modelling is essential for direct comparisons when observational processing and measurement extraction are imperfect. Finally, we find strong alignment between the ICL and the BCG (85% within 30°) and show that ICL-based position angles can be measured for substantially more clusters than satellite-based estimates. Overall, our methodology provides a benchmark for testing hydrodynamical simulations and forthcoming Euclid data releases will enable substantially tighter statistical constraints.

The intracluster light fraction across redshift and cluster environment

Louisa Canepa

The intracluster light (ICL) is an important tracer of galaxy cluster assembly, being formed primarily due to galaxy interactions and mergers. Up to now, only small samples of clusters have been studied due to the ICL’s very low surface brightness and the challenges involved in carrying out measurements on a large scale. Using a novel machine learning method, we have measured the ICL fraction in 177 galaxy groups and clusters using images from the Hyper Suprime-Cam Subaru Strategic Program. In this talk, I will present the results of our analysis of this large sample, studying observational trends in redshift, halo mass, and cluster dynamical state. I will highlight the importance of accounting for observational effects when drawing our conclusions, and discuss what these trends reveal about the formation and evolution of the ICL and the galaxies within the cluster.

Euclid Q1: The evolution of the ICL fraction

Harry Gully

The intracluster light (ICL) is built up through a combination of tidal stripping, mergers involving the brightest cluster galaxy, and pre-processing prior to cluster infall. Measurements of the ICL fraction and its evolution with redshift can constrain the relative importance of these processes. However, existing measurements are largely restricted to narrow redshift intervals and employ heterogeneous data sets and methodologies. The inhomogeneity between studies, be it the ICL definition and measurement, or cluster samples themselves, makes the inference of evolution with redshift extremely challenging. In this talk, I will present a homogeneous analysis of the ICL fraction in a sample of ~ 300 galaxy clusters detected with SPT and Euclid, spanning $0.2 < z < 1.6$. By applying a uniform methodology to homogeneous observations, this work provides the first systematic view of the contribution of the ICL to the total cluster stellar light over such a broad redshift range, enabling direct comparisons between low and high redshift cluster populations.

Tracing Intracluster Light Across Halo Mass, Redshift, and Cluster Dynamical State with UNIONS

Syeda Lammin Ahad

Intracluster light (ICL) encodes the assembly history of galaxy clusters and the growth of brightest cluster galaxies (BCGs). In this talk, I will present results based on the low-surface-brightness optimized deep r-band imaging from the UNIONS survey, measuring ICL properties across ~ 5000 galaxy groups and clusters from the northern sky. I will show how the ICL fraction and spatial

distribution vary with host halo mass, redshift, and dynamical state, and discuss emerging trends linking diffuse stellar mass buildup to hierarchical assembly.

The Evolution of the Stellar Mass Function in Massive Galaxy Clusters from the Atacama Cosmology Telescope from $0.2 < z < 0.8$

Damien Cole Ragavan

The galaxy stellar mass function (SMF) is a valuable probe to further understand galaxy evolution, particularly in galaxy clusters. I present the recent findings of our study on the SMF and stellar mass growth in 568 galaxy clusters at $0.2 < z < 0.8$ from the Atacama Cosmology Telescope Data Release 5 (ACT DR5). By utilising deep photometric data from the tenth release of the Dark Energy Camera Legacy Survey (DECaLS DR10), we were able to measure the composite/stacked cluster SMF down to $M^* = 10^{9.5} M_{\odot}$. Our results indicate that massive galaxies are already established in clusters at $z \sim 0.8$. However, we do find a late build-up of low-mass galaxies in clusters at $z < 0.55$. We find that a Schechter+Gaussian model is better suited to account for the excess stellar mass observed at the high-mass end of the cluster SMFs. Furthermore, our measurements of cluster stellar mass fractions suggest a significant growth of stellar mass within clusters from $z = 0.8$ to $z = 0.2$. Finally, I introduce pathways for future work, which include comparisons to cluster simulations from the The300 Project. Implementing these methods on the ACT DR6 cluster sample using photometry from the Vera C. Rubin Observatory/LSST will be a logical way forward for this work.

Thursday

Review 5. Data processing Ignacio Truillo

Review 6. The problem of Cirrus Qing Liu and Amaël Ellien

Review 7. How to separate BCG from ICL Ilaria Marini and Sarah Brough

Contributed talks:

Euclid Image Post-processing for Intracluster Light Studies

Hua Gao

The Euclid survey provides images with extraordinary potential for studies of the low-surface-brightness (LSB) Universe. We develop a dedicated pipeline to minimise background variations while preserving the signal from LSB diffuse structures. In this talk, I will describe the post-processing steps to produce adequate coadd images for studies of ICL with Euclid. We develop effective methods to address residual detector systematics, including persistence, correlated noise, and unstable channels for NISP and bias jumps for VIS, respectively. In addition, we perform special background corrections including an atemporal background subtraction to remove systematic variations between detectors that persist among different exposures and a background matching correction to force agreement in background levels between detectors and exposures. Subtraction of bright stars is being developed at the moment. By injecting simulated clusters into the real Q1 images, we show that our approach preserves the faint outskirts of extended sources. On scales of several arcminutes, we can reliably detect surface brightness levels down to ~ 27.5 mag arcsec⁻² in YE, JE, HE, and ~ 29 mag arcsec⁻² in IE.

Preparation for the Study of Nearby Clusters with Euclid DR1

Mathias Urbano

The first data release of the Euclid space telescope mission will cover a large portion of the sky. It will include new observations of the Fornax Wall structures (especially the Fornax Cluster and the Dorado Group) in a unique combination of coverage, depth, and resolution, enabling the study not only of their diffuse components but also of their globular cluster (GC) counterparts. However, these wide fields (spanning multiple Euclid observations) require adaptations of image processing methods (especially, but not exclusively, on star subtraction) in order to extract precise photometric measurements of the diffuse components. The work presented will review the data preparation efforts and the first results of this study.

Detection of the BCG-ICL transition with deep imaging

Giulia Golini

Over the next decade, the synergy between the Vera C. Rubin Observatory LSST and the European Space Agency's Euclid mission will open a new window into the co-evolution of brightest cluster galaxies (BCGs) and diffuse intracluster light (ICL) across cosmic time.

Cosmological simulations suggest that the radial range of ~ 30 – 100 kpc marks the transition between early in-situ BCG formation and later ex-situ stellar mass assembly. Observationally isolating this boundary, however, has remained challenging.

Using deep Subaru Hyper Suprime-Cam imaging (~ 30.9 mag arcsec⁻²) for clusters at $0.1 < z < 0.5$, we identify two distinct transition radii: one at 30–40 kpc, corresponding to the “edge” of the BCG,

and a second at ~ 80 kpc, marking the onset of an ICL-dominated regime. Our multi-wavelength analysis allows to constrain the stellar populations across these regions, and the inner transition is independently confirmed in luminous red galaxies in lower-density environments.

To robustly detect these transition radii, we introduce a novel approach based on the second derivative of stellar mass density profiles of the BCG+ICL system, derived from multi-band imaging. These techniques will be crucial for studying the BCG+ICL evolution with LSST and Euclid.

Separating the stellar halo of the BCG from the ICL using deep photometry only

Carlos Marrero

A longstanding question in the study of galaxy clusters is whether the stellar halo of a brightest cluster galaxy (BCG) can be disentangled from the surrounding intracluster light (ICL) using deep photometry alone, without recourse to kinematics. Traditionally, this separation has relied on geometric or structural criteria, assuming distinct spatial components. However, there remains a radial regime in which the distinction between the outer halo and the ICL becomes ambiguous.

We address this issue through ultra-deep g- and r-band imaging of IC1101, the central galaxy of Abell 2029, reaching surface-brightness levels of $\mu \sim 30$ mag arcsec $^{-2}$. By jointly analysing surface-brightness, stellar mass surface density, and colour profiles, we identify radial transitions that allow us to partition the bound stellar halo from the diffuse ICL component. Among these diagnostics, we find that the radial colour profile—particularly abrupt variations in colour—is the most sensitive tracer of changes in the underlying stellar populations, and therefore the most promising photometric marker of the halo–ICL transition. IC1101 thus provides a case to evaluate how far deep imaging alone can go in disentangling stellar components in the most massive environments, and clarifies the limitations and potential of purely photometric approaches to ICL studies.

Kinematically-isolated ICL traces dark matter in galaxy cluster cores

Steven Bamford

In galaxy clusters, intracluster light (ICL) offers a novel tracer of dark matter, but is difficult to distinguish from the brightest cluster galaxy (BCG). We resolve this by using integral-field spectroscopy to kinematically isolate the ICL in AS1063 and map its spatial distribution and line-of-sight kinematics. Within 100 kpc, the ICL contains a stellar mass comparable to that of the BCG, exhibits a constant velocity dispersion, and follows a surface-brightness profile that matches independent estimates of the dark matter density distribution. Unique to our approach, we measure both spatial and kinematic offsets between the BCG and ICL, suggesting the BCG is oscillating around the cluster centre. Together, these results favour a cored dark matter density profile. This work introduces kinematically-isolated ICL as a potentially competitive probe of cluster halo cores and hence the nature of dark matter.

Tracing the evolution of the Intra-Cluster Light from low to high redshift

Paola Dimauro

Intra-cluster light (ICL) represents a significant fraction of the baryonic content within galaxy clusters, reflecting the complex interplay between galactic evolution, star formation, and gravitational interactions within these massive structures. It originates from stars torn from galaxies by various processes, including tidal interactions, mergers, and collisions within the dense cluster environment. Therefore, understanding the properties of the ICL, such as its spatial distribution, stellar population, and age, can shed light on the processes governing the formation and evolution of galaxies in densely populated environments. Furthermore, the ICL can serve as a tracer of the

underlying dark matter distribution, providing valuable constraints for cosmological models and the formation of large-scale structures in the Universe. Most theoretical models show that the ICL forms as a consequence of the processes that lead to cluster formation and evolution, becoming significant only at $z < 1.5$. For this reason, its detection at earlier epochs ($z \geq 2$) is extremely important, as it challenges our current understanding of galaxy formation and evolution. In this paper, we present the analysis of some ICL detections at $z > 2$.

Producing a catalogue of ICL from the Euclid Wide Survey

Nina Hatch

I will talk about my current work creating a catalogue of ICL properties from the Euclid Wide Survey. I will talk about our ongoing tests with DR1, and request feedback from the audience about how we can construct the catalogue so that it is most useful for their science goals in the future.