Abstract of workshop on galaxy evolution with Euclid

Annette Fergusson
The local universe with Euclid

The Milky Way and its immediate neighbours contain an archaeological record of 13 billion years of galaxy evolution across a broad range of luminosity and mass. These systems can be resolved into individual stars and star clusters, allowing their evolutionary histories to be reconstructed with a precision and accuracy unattainable in studies of more distant systems. In this talk, I will outline the potential of Euclid for major advances in understanding local galaxies and highlight the complementary roles of other facilities.

Jason Rhodes
Euclid from the US Perspective

The mid 2020s will usher in a Golden Age of optical/near infrared survey astronomy with the start of operations of Euclid, the Nancy Grace Roman Space Telescope, and the Vera Rubin Observatory's Legacy Survey of Space and Time. All three of these ambitious observatories have the understanding of dark energy as a primary science and design driver, but will provide data that will make fundamental contributions across a wide range of astrophysical topics, including providing an unprecedented joint data set for the understanding of the evolution of galaxies. I will discuss how Euclid is an integral part of NASA's contribution to this Golden Age of survey astronomy. I will make the case that for cosmology and galaxy evolution, the most powerful constraints on our knowledge of the universe will come from the eventual joint processing of data from these three telescopes and the analysis of the resulting joint data sets.

Sandor Kruk
The evolution of the internal structures of galaxies with Euclid

With the exquisite imaging of millions of resolved galaxies, Euclid will be transformative to galaxy morphology studies. So far, studies with the Hubble Space Telescope on the formation and evolution of galaxy structures such as bars and bulges have been limited by the availability of sufficiently large samples. With unprecedented statistics, Euclid will enable us to study the redshift evolution of galaxy structures and will resolve a number of fundamental unknowns related to galaxy formation and evolution: when the well-known Hubble sequence emerged, how commons structures such as bars form, the effects of bars on quenching star formation and fuelling AGN in host galaxies, and what determines the formation of features such as boxy/peanut bulges in galaxies. I will discuss these science cases as well as the ongoing efforts within the Euclid Morphology team and in Galaxy Zoo to develop new tools combining deep learning and citizen science to classify and study the detailed morphologies of galaxies, with the aim of creating the largest catalogue of galaxies with reliably classified structures.

Karina Voggel
The detectability of Extragalactic Globular Clusters and Relic Nuclei with Euclid.

Globular clusters exist in almost any galaxy no matter its luminosity. In recent years it was discovered that among high-mass Globular Clusters (GCs) there are many relic nuclear star clusters of stripped galaxies. These former Nuclear Star Cluster end up in the halos of massive galaxies when they are stripped of their surrounding stars by tidal forces. On the surface they look like normal GCs but many of these former nuclei contain 'hidden' SMBHs, a signpost of their past in the centers of a large galaxy. Nuclei and GCs are important tracers of the galaxy assembly process
Euclid with its combination of sky-coverage and spatial resolution will dramatically improve our ability to identify new GCs and relic nuclei in nearby galaxies. Euclids spatial resolution enables us to spatially resolve Globular Clusters in galaxies in the Local Universe out to at least 40Mpc. Our current estimates show that we will detect at least $\sim10^{5}$ new Globular Clusters in the 1000+ local Universe galaxies that are in the Euclid footprint. This will provide the most complete and homogenous catalogue of photometric information of globulars and stripped nuclei candidates and will allow us to reconstruct the big picture of their formation and how they trace galaxy assembly. I will present the current state of the Local Universe SWG on Extragalactic globular clusters (EGC, WP8) and the progress that has been made in testing the detectability of Globulars in Euclid data.

Marina Rejkuba
Resolving stellar populations in the nearest giant elliptical galaxy

Deep photometric observations of individual stars in nearby galaxies offer the possibility to reconstruct their star formation history. Observations over wide area in the low surface brightness have so far been undertaken for few targets due to challenge to get both the necessary depth and high spatial resolution that enables distinguishing between stars and background compact objects. In this presentation I will highlight results from the Hubble Space Telescope observations of extended stellar halo of Centaurus A, the nearest giant elliptical galaxy and what we have learned so far. I will use this to then highlight how Euclid can contribute to more comprehensive understanding of assembly history of large nearby galaxies.

Antoine Mahoro
properties of IR AGNs in COSMOS

We present a study on the stellar populations and stellar ages of a sub-sample of far-infrared AGN and non-AGN green valley galaxies analysed in Mahoro et al. (2017, 2019) at $0.6 < z < 1.0$ using the data from the COSMOS field. We used long-slit spectroscopy and derived stellar populations and stellar ages using the stellar population synthesis code “STARLIGHT” and analysed the available Lick/IDS indices, such as Dn4000 and HδA. We find that both FIR AGN and non-AGN green valley galaxies are dominated by intermediate stellar populations. The median stellar ages for AGN and non- AGN are logt = 8.5[yr] and logt = 8.4[yr], respectively. We found that the majority of our sources, whether AGN or non-AGN, appear to have

experienced both bursts and continuous star formation. The results obtained are in line with our previous results where we do not find that our sample of FIR AGN in the green valley shows signs of negative AGN feedback, as has been suggested previously in optical studies.

Junkai Zhang
3D intrinsic shapes of quiescent galaxies in observations and simulations

I will present a study of the intrinsic 3D shapes of quiescent galaxies over the last half of cosmic history based on their axial ratio distribution. To this end, we construct a sample of unprecedented size, exploiting multi-wavelength u-to-Ks photometry from the deep wide-area surveys KiDS+VIKING paired with high-quality i-band imaging from HSC-SSP. Dependencies of the shapes on mass, redshift, photometric bulge prominence and environment are considered. For comparison, the intrinsic shapes of quenched galaxies in the IllustrisTNG simulations are analyzed and contrasted with their formation history. We find that over the full 0<z<0.9 range, and in both simulations and observations, spheroidal 3D shapes become more abundant at M_* > 10^{11} Msun, with the effect being most pronounced at lower redshifts. In TNG, the most massive galaxies feature the highest ex-situ stellar mass fractions, pointing to violent relaxation via mergers as the mechanism responsible for their 3D shape transformation. Larger differences between observed and simulated shapes are found at low to intermediate masses. At any mass, the most spheroidal quiescent galaxies in TNG feature the highest bulge mass fractions and conversely observed quiescent galaxies with the highest bulge-to-total ratios are found to be intrinsically the roundest. Finally, we detect an environmental influence on galaxy shape, at least at the highest masses, such that at fixed mass and redshift quiescent galaxies tend to be rounder in denser environments.

Hao Fu
The role of the stellar mass-halo mass on galaxy mergers, satellite abundances and morphology

The role of mergers and star formation in regulating galaxy growth is still a matter of hot debate in astronomy. We present DECODE, a new Discrete statistical sEmi-empiriCal mODEl, designed to predict, in a full cosmological context, the merger and star formation histories, and their respective contribution in the total mass assembly of galaxies. DECODE starts by generating object-by-object dark matter haloes and their merger trees via input mass functions and accurate infall redshift probability distributions. Dark matter haloes are subsequently populated with galaxies and merger trees are converted into galaxy merger histories via input redshift-dependent stellar mass-halo mass (SMHM) relations, which is highly sensitive to the systematics in the galaxy stellar mass function (SMF). Star formation histories are computed assuming that themselves along with the merger history are the main components of the mass growth of a galaxy. The beauty of DECODE is the capability of following the evolution of each single galaxy without losing the flexibility and rapidity of a semi-empirical method. We show that only specific SMHM relations, namely those implied by SMFs characterized by significant redshift evolution, can simultaneously reproduce the local abundances of satellite galaxies and the time-dependent major merger rate. The same

models can also reproduce the local fraction of elliptical galaxies, on the assumption that these are strictly formed from major mergers, as well as the local mean bulge-to-disc distributions with the inclusion of a moderate amount of disc instabilities. We also find that SMHM relations implied by SMFs with weak redshift evolution only at low stellar masses are suitable to describe the star formation history of galaxies below 10^11 solar masses. Furthermore, we show how star formation histories predicted by our model based on mergers compare to those from SEDs. Finally, we use DECODE to generate inputs in several Euclid projects such as AGN mocks, star formation histories, satellite abundances and fraction of ellipticals.

Witnessing the Formation of Massive Galaxies in the (Sub)Millimeter Regime
Helmut Dannerbauer

In order to understand galaxy formation it is crucial to obtain sensitive observations of the emission of dust and molecular gas both of which constrain the on-going star formation or AGN activity and the future potential of the galaxy to grow. Constraining the growth of the ensemble of galaxies in the distant universe and not simply the most active ones, is one of the primary goals of current and planned (sub)mm facilities. To shed light on this topic, I will present our on-going observations of dust and molecular gas with a number of (sub)mm facilities such as ATCA, Herschel, APEX, IRAM or ALMA of one important star forming galaxy population in the distant universe: submillimeter selected galaxies (SMGs) at different environments. Finally, I will discuss the prospects of Euclid observations on the presented topic at high-density fields.

Fitsum Beyene
Galaxy structural parameters from 2D modelling of HST images

We have performed a detailed two dimensional photometric decomposition for early and late-type galaxies from the core and outskirt of the Coma Cluster. The sample is taken from the Hubble Space Telescope Advanced Camera for Surveys of the Coma Cluster in F814W and F475W passbands. We have studied 115 galaxies which are Coma Cluster members and 15 interlopers for comparisons. Depending on the morphology of the galaxies, we used up to three components to account for bulges (Sérsic), disks (Exponential), and bars (low-n Sérsic) using GALFIT. From the models generated by GALFIT, we obtained a number of structural parameters for the galaxies and their components such as: total magnitude (m), effective radius (re), sérsic index (n), eccentricity (q), among others. Combining these structural parameters with other data from the literature we revised the basic galaxy and black hole scaling relations. We have compared our results with other HST and ground-based Low-Redshift Optical Cluster Survey (LOCOS) data. Therefore, in this conference, we would like to make a presentation of the methodology followed to obtain the structural parameters of the galaxies and some of our results in the context of the formation and co-evolution of supermassive black holes (SMBHs) and the host galaxy.

Marziye Jafariyazani
Inferring spectroscopic features of galaxies from their broadband colors using Self Organizing Maps

Self-Organizing Maps (SOMs), an artificial neural network trained by unsupervised learning, has shown to be a powerful tool to extract knowledge from photometric observations of galaxies. In this talk, I will present how SOMs can be used to estimate spectroscopic features of large samples of galaxies from their broadband colors. I train SOMs with sets of colors from COSMOS2020 photometric catalogue and use measured spectroscopic features for a subsample of galaxies from surveys like LEGA-C and zCOSMOS to estimate features such as D4000 and line equivalent widths for the parent sample. Also, these trained SOMs will be used to evaluate the success of spectroscopic surveys to sample the full color space and to identify less-understood regions of parameter space in order to design new observational strategies. This technique will benefit Euclid and other future massive surveys where wide regions of sky will be observed in a limited wavelength range to extract physical properties of galaxies more efficiently.

Tadayuki Kodama
Rise and fall of star formation activities in clusters/protoclusters

I will review some recent researches on clusters/protoclusters and summarize current outstanding questions. I will also outlook how the Euclid survey can tackle these issues.

Filippo Mannucci
Detecting dual/lensed AGNS at small separations with Euclid and AO-assisted spectrographs

All cosmological models of structure formation predict the existence of a widespread population of dual SMBHs in-spiraling inside their common host galaxy with separations of a few kpc eventually merging and giving rise to intense gravitational waves emission. Many of these objects are expected to give rise to dual AGNs at sub-arcsec separations at z>1. The properties of these objects (distribution in separation, luminosity ratios etc.) would be crucial to test the cosmological models and the physics of in-spiraling. Unfortunately, identifying these systems is a difficult task: only 4 systems are confirmed with separations below 8 kpc at z>1. These rare systems (about 0.1% of the AGNs) can only be identified by very large-field, high spatial resolution surveys, and confirmed with AO-assisted or space-born spectrographs. Recently we proposed a new techniques based on digging the Gaia archive that provides hundreds of candidates with separations below 0.6 arcsec among the bright systems, down to g~20.5, confirming several of them with imaging (HST and LBT) and spectroscopy (VLT/MUSE-NFM and Keck/OSIRIS, Mannucci et al 2022). On-going VLT/MUSE-NFM observations will study 30 of these targets in the next semester. The realm of fainter objects below the Gaia detection threshold remains totally unexplored. As shown by a set of simulation we have performed, Euclid will be crucial to extend this search down to g~24.5 and separations down to ~0.15 arcsec, finding many candidates that will be studied spectroscopically with the ESO AO-assisted instrumentation, specifically ERIS and MUSE-NFM.

Song Huang
China 6.5m spectroscopic survey telescope - Euclid synergy

The Chinese astronomy community (led by Tsinghua University) is developing a new spectroscopic survey facility - the 6.5-meter MUltiplexed Survey Telescope (MUST). MUST will see its first light around 2030 at Lenghu, China, and will serve as a long-term platform for next-generation, large-scale cosmological and extragalactic surveys in the northern sky. MUST will have 10K-20K fiber positioners within its 7 square degrees FoV and the potential to observe with different spectrographs simultaneously. I will introduce the conceptual design and the current status of this ambitious project. There is a great potential for synergy between Euclid and MUST. MUST's target selection will benefit from Euclid's imaging data; in the long run, MUST's spectroscopic survey can enhance Euclid's scientific capability in extragalactic science. We welcome international partners in MUST.

Jun Toshikawa
A systematic protocluster search at z~3-5 by an optical wide-field survey

We conduct a systematic search for galaxy protoclusters at z~3-5 based on the optical wide-field imaging of the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP). In the Deep layer of the HSC-SSP, we measure the projected sky distribution of u-, g-, and r-dropout galaxies over an area of 25deg^2, and ~30-40 overdense regions with >4sigma significance are identified at each unit redshift between z~3 and z~5. By comparing with light-cone models, ~90% of >4sigma overdense regions are expected to include the progenitors of a >10^14Msun halo at z=0. We find that brighter dropout galaxies are more richly populating the protocluster candidates than coeval field environments, a trend which persists at all redshifts from z~3 to z~5. This result suggests that, in high-density environments like protoclusters, bright galaxies are formed more efficiently, due to a higher formation redshift and/or enhanced star formation. We contrast our findings with theoretical models, evaluate the spatial distribution of bright galaxies within overdense regions, and quantify the projected shapes of protocluster candidates selected from our observations and from mock light-cones to shed light on sample purity. Our protocluster study based on HSC-SSP serves as a pathfinder for future explorations with Euclid and Rubin-LSST.

Mariko Kubo
Exploring the infrared emission from protoclusters with Euclid

Euclid will be a powerful surveyor of clusters/protoclusters across cosmic time. With deep near-infrared imaging, Euclid will show the stellar mass assembly histories of clusters. Here I will discuss the capability of Euclid to explore 'obscured' starburst/AGN activities of protoclusters in the mid to far infrared. First, Euclid can detect the galaxies in protoclusters found as unresolved luminous infrared sources detected with e.g., Planck and Herschel. Furthermore, the infrared stacking analyses of clusters/protoclusters can show their average infrared emission; in our previous work, we showed the total infrared SED of a protocluster

by the stacking analysis of Planck/IRAS/AKARI/WISE/Herschel images of the large catalog of protocluster candidates at z~4 selected from Hyper Suprime-Cam (HSC) Subaru Strategic Program survey. Similarly, we will select candidate clusters/protoclusters with Euclid and also HSC, and constrain their average far-infrared emission, where no high sensitivity space telescope now, by stacking analyses to show the star-formation/SMBH growth history of clusters of galaxies.

Tjitske Starkenburg
Constraining galaxy formation with Euclid: stellar halos and tidal debris in external galaxies

Abstract: I will present predictions for the observability of extragalactic stellar halos and their tidal debris from accreted satellites with Euclid. Additionally, I will highlight how this low-surface brightness discovery space provides unique constraints on the assembly history of galaxies as well as galaxy formation at the low-mass end.
Stellar halos are amazingly rich records of their host galaxy,Äôs history. Built up out of mostly accreted satellites systems that then get stripped apart, the stellar halos, substructure, and satellites of our own Milky Way have governed our understanding of the Milky Way,Äôs hierarchical evolution but also of galaxy formation at the low-mass end. Upcoming facilities such as Euclid will greatly expand the low-surface brightness discovery space, and will be able to detect and observe stellar halo substructure for numerous galaxies in our nearby universe. Building on a variety of modeling techniques, I will illustrate the relevance of a galaxy,Äôs individual merger history for the formation of its stellar halo and the substructure within it. Moreover, I will highlight how the physics of low-mass galaxy formation affects stellar halo build-up, and how we can use Euclid observations to constrain this physics. Following the detailed evolution of accreted satellites, and the tidal debris that they form I predict the observability of satellites, stellar streams, and shells, in the Euclid surveys. I will then illustrate how varying the physical model for low-mass galaxy formation impacts my predictions for Euclid, and thus how data from the Euclid surveys can shed new light on low-mass galaxy formation. This work informs and facilitates the interpretation of observations by the next generation of telescopes, such as Euclid.

Helmut Dannerbauer
Exploring galaxy evolution through wide, deep near-infrared imaging via the ESO Public Survey SHARKS

Abstract: NIR imaging is a vital ingredient in multi-wavelength studies aiming to understand galaxies at both low and high redshifts. New wide-area surveys in the far-infrared and radio promise to revolutionize the field of research, but currently we lack equivalent deep, wide-area Ks-band imaging (at 2.2 micron) to link the radio/far-infrared sources to the optical and near-infrared. We are conducting the ESO Public Survey SHARKS (Southern H-ATLAS Regions Ks-band Survey) with the VIRCAM camera at the ESO 4 m VISTA telescope, comprising 300 square degrees of deep imaging at 2.2 micron (Ks-band). We note that the SHARKS data are complemented by an excellent existing multi-wavelength dataset including Spitzer, ALMA, ASKAP, LOFAR, Subaru HSC, DES and HST observations. Furthermore, in the future the SHARKS fields will be covered in the optical/NIR by LSST and Euclid, the later the scientific driver of

this meeting. The first data release of the survey, comprising 5% of the data, was published via the ESO database on 31 January 2022. We describe the strategy, the status and present the data products of the first data release. We show results based on the exploration of the SHARKS data, focusing on the evolution and formation of galaxies in the distant universe. Finally, we will give an outlook on the future exploration of the SHARKS data (in combination with multi-wavelength observations), especially in light of the Euclid mission.

Emmanuel Ríos-López
Study of scaling relations and host galaxy properties of AGNs using the SHARKS survey

Scaling relations involving galaxy properties such as luminosity, size, stellar mass, SFR, among others, are fundamental to understand the co-evolution between Supermassive Black Holes (SMBHs) and their host galaxies. Thus, we perform a photometric analysis to measure the structural parameters of galaxies using data from the ESO Public Survey SHARKS (Southern H-ATLAS Regions Ks-band Survey), a deep survey (Ks ~ 22.7 AB) covering ~300 square degrees in several fields previously observed by the infrared Herschel space observatory within the H-ATLAS survey. In addition, SHARKS fields overlap with several well-known optical, near, mid and far-infrared, radio surveys (such as HSC, DES, Spitzer, ASKAP and LOFAR) and will be observed by the Euclid mission and LSST. Furthermore, thanks to the SHARKS depth and along with multi-wavelength data, we are able to perform galaxy evolution studies across cosmic time and estimate the host galaxy properties of Active Galactic Nuclei (AGNs) identified through optical diagnostic diagrams. The results of this work are also presented in the evolutionary context of classical bulges and pseudobulges.

Simona Vegetti
Title: Strong gravitational lensing, a pathway to new physics

In this talk, I will review some of the most interesting applications of strong gravitational lensing, from the nature of dark matter to the properties of high-redshift galaxies. I will discuss the current status of the field and what we hope to achieve in the future with Euclid and the ELT.

Micol Bolzonella
Physical properties of galaxies in Euclid via Machine Learning

The wide area of the Euclid Survey will enable the possibility of grouping similar galaxies in many subclasses using their photometry, e.g. with Self Organising Maps, without losing statistical significance. On the other side, the large number of objects will also enable the possibility of picking outliers objects and characterise them statistically. The selection of out from the crowd objects by means of Machine Learning approaches is important to improve the statistics when recovering physical properties (by excluding them), and at the same time to pave the way to new discoveries. The physical properties of more conformist galaxies can be derived from single objects or from stacked high signal to noise SEDs to derive the evolution of similar galaxies. I will show how the above goals can be achieved in Q1 and DR1

datasets, using the properties of objects in Legacy Simulations (GAEA, MAMBO, Flagship, Horizon-AGN, and I will illustrate the official pipeline that will be used in Euclid to derive the physical properties of galaxies and AGN.

Chiara D'Eugenio
Gran Telescopio Canarias for the color-redshift calibration of the upcoming Euclid mission

Large scale surveys such as Euclid, NGRT and LSST will make use of large catalogs of machine-learning based photometric redshifts. These will used both for cosmology science and for legacy science, marking the impact that the accuracy of these state-of-the-art methods will have in the near future. I will present the results and the future perspectives of the GTC/OSIRIS observational programme as part of the wider C3R2 Survey, which aims specifically at testing and calibrating the color-redshift relation arising from galaxies' Euclid-like colors and their photometric redshifts by making use of high-quality ground-based spectroscopy.

Lucia Pozzetti
Search for rare overweight galaxies with Euclid:

The considerable sky coverage of Euclid spectro-photometric data, already at Q1-DR1 releases, will allow determining with unprecedented statistics the tail of the mass distribution function of galaxies above 10^11-10^12 solar masses at intermediate to high-redshift. Euclid data will allow us to determine the environment, halo-to-stellar mass relation, morphologies, sizes and physical properties of this rare population to determine when and where these giant galaxies form and assemble their stellar mass. We can compare these data with predictions from models of galaxy formations.

Pascal Oesch
Optical and Infrared Spectroscopy Follow-up for Euclid (Deep)

Abstract: The ESA/Euclid space telescope will open up our wide-area view of galaxies from low-redshifts into the reionization epoch thanks to unprecedented optical+NIR imaging. However, to fully utilize Euclid's samples for galaxy evolution science, we need to exploit possible synergies with existing and upcoming spectrographs. These include, for example ESO/MOONS to cover wide areas, or JWST for detailed analyses. As an example, I will discuss the synergy between MOONS and Euclid, which has the potential for an enormous leap forward in constraining the progress and topology of reionization through Ly-alpha detection statistics over unprecedented areas targeting the unique sample of luminous galaxies at z>6, where we expect star-formation and reionization to have started first in the Universe. Most importantly, this talk will be used as a starting point for a discussion about how a community-driven effort for spectroscopic follow-up of Euclid sources can best be organized.

Jean-Charles Cuillandre
Rubin-Euclid Derived Data Products: a platform for galaxy evolution studies

The Vera C. Rubin Observatory Legacy Survey of Space and Time (imaging) and the Euclid survey (imaging and spectroscopy) will each deliver groundbreaking astronomical datasets over this decade in the optical and near-infrared. Both surveys will map thousands of square degrees of sky from the ground and space respectively, with an overlap area of approximately 9000 square degrees at high galactic latitudes and 33 square degrees over two southern deep fields. The combination of Euclid's high spatial resolution imaging in the optical and near-infrared photometry with Rubin's densely sampled deep multi-band optical imaging will greatly enhance the science yield of both surveys. Such is the nature of the Rubin-Euclid Derived Data Products (DDPs) designed to realize the unique science goals enabled by joint processing at the pixel level. All interested Rubin and Euclid data rights holders were invited to contribute via an online discussion forum and a series of virtual meetings. Strong interest in enhancing science with DDPs emerged from across a wide range of astrophysical domains, galaxy evolution and AGNs representing the largest joint community, spawning a large bulk of the in the initial set of recommended DDPs.

Kim-Vy Tran
The AGEL Survey: Strong Gravitational Lenses in the DES and DECaLS Fields

We present spectroscopic confirmation of strong gravitational lenses as part of our ASTRO 3D Galaxy Evolution with Lenses (AGEL) survey. We confirm that 1) search methods using Convolutional Neural Networks (CNN) with visual inspection successfully identify strong gravitational lenses and 2) the lenses are at higher redshifts relative to existing surveys due to the combination of deeper and higher resolution imaging from DECam and spectroscopy spanning optical to near-infrared wavelengths. The AGEL lenses include deflectors at $z>0.5$ that are ideal for follow-up studies to track how mass density profiles evolve with redshift. Our results establish that CNN-based search methods are highly effective at identifying strong gravitational lenses in imaging and strongly support using CNNs in future surveys by EUCLID and LSST.

Asantha Cooray
Reionization in context: Multi-wavelength studies of primordial galaxies in the era of Euclid, SPHEREx and JWST.

In this talk I will summarize upcoming opportunities to identify and conduct detailed studies of the primordial galaxies responsible for reionizing the universe with Euclid and SPHEREx, with JWST, ALMA, and other ground-based facilities for follow-up. The talk will focus on the assembly of large samples of galaxies for statistical studies, aimed at establishing the reionization history and address key questions on the formation and growth of structure. With Euclid and SPHEREx other statistical studies such as intensity mapping focussing on some of the key spectral lines can also be pursued to constrain the faintest end of the galaxy luminosity and mass functions at z of 7-12. For the rare bright galaxies, ample opportunities exist for spectroscopic characterization with fasciitis such as JWST and ALMA.

Ryan Endsley
A wide-area view on reionization and massive galaxy formation: lessons learned from existing data at z~7 and future prospects with Euclid

Within the past few years, several deep wide-area optical+near-IR imaging surveys from the ground have reached (near-)completion, offering a first glimpse into the transformative reionization-era science offered by upcoming space-based facilities. In this presentation, we describe results from a systematic search and characterization of >100 UV-luminous (m~24-26) z~7 galaxies over the 7 deg^2 COSMOS+XMM area, discussing key open questions raised by this study and how Euclid data will soon help answer them. We identify a prominent photometric overdensity of Lyman-break z~6.8 galaxies over a 165 arcmin^2 area, and after conducting ultra-deep Lyman-alpha follow-up in this region, confirm a strong spectroscopic overdensity likely associated with a very large (R~3 physical Mpc) ionized bubble. We show that deep Euclid data will facilitate much clearer insight into the correlation between bubble size and galaxy overdensity by enabling the identification of very wide-area (~1000 arcmin^2) regions with ~2x the average z~7 surface density. Such regions will be excellent follow-up targets to characterize the first sites of structure formation in the Universe which likely trace the largest ionized bubbles (R~5-10 pMpc). Within the 1.5 deg^2 COSMOS field, we also identify an extremely red UV-bright z~7 galaxy detected in public mid-IR, far-IR, and radio data. ALMA Cycle 8 follow-up revealed an extremely luminous and broad [CII] line at z=6.853 which, when coupled with the full multi-wavelength data in COSMOS, suggests this object is an extremely massive (M* ~ 10^11 Msol) reionization-era galaxy that is not only undergoing rapid heavily-obscured star formation (~1300 Msol/yr) but also harbors a heavily-obscured hyperluminous radio-loud AGN powered by a ~1e9 Msol black hole. We discuss how deep Euclid surveys will be able to identify many more such UV-bright yet extremely red z~7-8 objects, offering a much better understanding of the incidence of heavily-obscured supermassive black hole growth and intense dust-enshrouded star formation in the most massive reionization-era galaxies.

Rui Marques-Chaves
The most UV-luminous starbursts at z~2-4: massive unobscured star formation in the early Universe

I will present recent results on a new sample of extremely UV-luminous star-forming galaxies at z=2-4 (M_UV ~ -23 to -24.5 AB) discovered within the public Baryon Oscillation Spectroscopic Survey (BOSS) database of the Sloan Digital Sky Survey (SDSS). These sources show apparent magnitudes rivaling those of QSOs, but without any hint of AGN activity or being lensed. Instead, they are characterized by extremely young (~ 10 Myr) stellar populations and compact morphologies (reff ~ 1 kpc). With stellar masses log(M*/Msun) ~ 9-10 and SFRs ~ 1000 Msun/yr, but almost un-obscured and dust-poor, these puzzling sources are among the most vigorous and efficient star-forming galaxies known, with specific star formation (sSFR) >50-100 Gyr^-1, that is a factor ~30 times higher than main-sequence galaxies at similar redshifts and stellar mass. Furthermore, the two highest-redshift sources show very large Lyman continuum (LyC) escape fractions, up to fesc(LyC)~90%, being the most powerful ionizing sources identified so far among the star-forming galaxy population, both in

terms of the intrinsic LyC photon production rate and LyC escape fraction. In this talk, I will highlight the unique rest-frame UV features detected in the high SNR spectra of these galaxies, including strong LyC emission, complex Lyman-alpha profiles, strong wind lines, and HeII 1640 emission, among others. I will also present near-IR spectroscopy of the rest-frame optical lines H-beta and [O III] 5007A and show that the large fesc(LyC) detected in these galaxies strongly affects the intensity of the nebular emission, as well as the overall SED. These extreme systems at z~2-4 are rare but might represent the very early stages of vigorous starbursts, possibly analogous to UV luminous star-forming galaxies at z>7 discovered recently. I will discuss the implications that these new sources may bring to galaxy formation and evolution, highlighting the importance of very wide surveys, such as EUCLID, to identify these rare systems and characterize their properties and number density in detail.

Stijn Wuyts
Structural evolution of star-forming galaxies since cosmic noon

I will discuss recent developments in our understanding of the geometry, structure and morphological transformation of star-forming galaxies from the peak of cosmic star formation to the present day. By combining resolved observations from multiple wavelengths and tracers, we can reconstruct where stars form and how stellar distributions assembled, while simultaneously gaining insights into the evolving 3D spatial distributions of stars and dust. Number statistics are key in such analyses, allowing us to treat samples of galaxies with similar global properties as ensembles observed from random viewing angles. I will outline how imaging and slitless spectroscopy from space together with wide-area surveys from the ground provide us with a taster of the multi-component structural evolution studies that will be enabled by Euclid.

Pratika Dayal
The emergence of galaxies in the epoch of reionization and their large-scale effects: advances and implications

Galaxy formation in the first billion years mark a time of great upheaval in our cosmic history: the first sources of light in the Universe, these galaxies ended the 'cosmic dark ages' and produced the first photons that could break apart the hydrogen atoms suffusing all of space starting the process of cosmic reionization. At the forefront of astronomical research, the past few years have seen cutting-edge instruments provide tantalising glimpses of such galaxies chaotically assembling in an infant Universe. I will show how this data has provided an unprecedented opportunity to pin down the reionization state of the Universe, understand the physical properties of early galaxies, and study the key physics driving their formation and evolution. Time permitting, I will try to give a flavour of how 21cm emission from the first billion years can provide a powerful testbed for Dark Matter models beyond "Cold Dark Matter".

Preetish Mishra
Stellar mass dependence of galaxy size-halo radius relation revealed by Subaru-HSC weak lensing measurements

Classic galaxy formation models predict a fundamental link between galaxy size and halo virial radius. Several past studies (Kravtsov 2013, Sommerville et al. 2018) have reported a single linear relation between halo radius and sizes of galaxies of different mass and morphologies. However, these studies have employed abundance matching ansatz to map observed galaxies onto simulated dark matter haloes which involves various assumptions regarding galaxy-halo connection. In this work, we re-examine the relation between sizes of galaxies and dark matter haloes using weak gravitational lensing which provides a direct way of probing dark matter distribution around luminous galaxies. Our sample consists of ~270,000 galaxies more massive than logM*=9 and within z<0.3 drawn from Subaru-HSC survey PDR2. We measure the galaxy half-light radius by fitting a single Sersic light profile to galaxy images and find galaxy size-stellar mass relation. We divide our sample galaxies into bins of stellar mass and obtain corresponding stacked weak lensing signals. We model the signals to infer stellar mass-halo mass relation. Finally, we combine galaxy size - stellar mass relation and stellar mass - halo mass relation to map galaxy sizes onto dark matter haloes. We find that the galaxy size - halo radius relation is not linear and depends on the stellar mass of galaxies. The ratio of galaxy size/halo radius decreases by a factor of two as one moves from low mass dwarf/disk galaxies to high mass early-type galaxies. These qualitative trends do not change even if we use different stellar mass - halo mass relations from previous works. Our results set the low redshift benchmark on the connection between galaxy structure and dark matter halo using deep and high-resolution imaging surveys. Similar work at higher redshifts using space-based missions like Euclid will further enhance our understanding of galaxy formation and evolution.

Belén Alcalde Pampliega
Hidden below the dust: the serendipitous discovery of an extremely bright lensed SMG behind the Lupus-1 molecular cloud.

In the last decades, remarkable progress has been made in the discovery, quantification, and characterization of the population of submillimeter galaxies (SMGs), thanks to extensive surveys in the far infrared (FIR) and in the submillimeter (submm). Due to their apparent high luminosity, commonly aided by gravitational magnification, the brightest SMGs provide a unique opportunity to better understand galaxies at early epochs.
We present the serendipitous discovery of J1545, an extremely bright z~6 extragalactic source detected toward the Lupus 1 molecular cloud. Brown dwarfs and SMGs can be difficult to distinguish due to their point-like appearance and very similar fluxes and colors in the mid-IR to (sub)mm regime. However, recent ALMA continuum observations have revealed an arc-like elongated shape that overlaps with the coordinates of a SMG candidate that was initially thought to be a prestellar core. According to the best-fitting models, J1545 most likely corresponds to a highly magnified SMG at z=4-6. Unlike 'normal' SMGs, extremely bright SMGs (i.e., S1.1mm > 30mJy) like J1545 are exceptionally rare due to their extremely high LIR. Therefore, J1545 (S1.1mm > 43.9mJy) can be considered a unique laboratory to study the most extreme phases of galaxy formation and evolution, and how galaxies can assemble their mass in the early Universe.