



COSMIC CARTOGRAPHY *with Roman*

July 14 – 18, 2025

Roman Symposium Booklet



STScI

ROMAN



SPACE TELESCOPE



The Nancy Grace Roman Space Telescope, planned to launch in late 2026, will be capable of surveying the sky 1000 times faster than the Hubble Space Telescope with similar sensitivity and resolution. A combination of near-infrared imaging and spectroscopic surveys, designed by Roman's community-defined Core Community Surveys and General Astrophysics Survey programs, will generate unique data-sets and large-area maps of the sky that will catalyze scientific discovery across all of astrophysics. Roman's accurate mapping of stars, galaxies, and galaxy clusters will offer the unique ability to map our Universe, both the seen and the unseen.

This symposium aims to focus on the intersection of dark energy and dark matter with galaxy formation and evolution. It will explore the novel research that is possible only with large cosmic surveys and simulations and discuss how the community will be able to optimize scientific output with Roman in the future. Topics of discussion will include, but are not limited to, the expected impacts from Roman observations of galaxy clustering (including BAO/RSD), weak lensing, galaxy clusters, supernova cosmology, stellar streams, and dwarf galaxies. It will strive to foster synergies between contemporaneous experiments to Roman, such as Euclid, Rubin, DESI, Simons Observatory, and SPT. The schedule will feature invited talks, contributed talks, posters, discussion panels, and fun social activities.



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Monday, July 14, 2025

Tuesday, July 15, 2025

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COSMIC
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Roman Symposium Abstracts



Invited Talks

Breaking astrophysical barriers for next-generation cosmic shear: multi-wavelength constraints

Alexandra Amon
Princeton University

There is no consensus on how baryonic feedback shapes the non-linear matter power spectrum from hydrodynamical simulations. This uncertainty results in a critical loss of constraining power for weak lensing surveys. Key to leveraging the power of Roman and LSST is confronting the uncertain astrophysical landscape. In this talk, I make the case for using flexible models to jointly analyze cosmic shear with probes of the gas around halos. At the redshifts and halo masses relevant to cosmic shear, I will present a consistent picture of the gas distribution, as seen by X-ray, kSZ, and galaxy-galaxy lensing, which will provide informative priors for next-generation lensing.

Supernova Cosmology Overview with NASA's Roman Space Telescope

Dillon Brout
Boston University

The Nancy Grace Roman Space Telescope will enable a leap forward in type Ia supernova (SN) cosmology with tens of thousands of well-characterized SNe out to the highest redshifts ($z \sim 3$) and that address the most important systematics plaguing current measurements. In this talk, I will give an overview of the state of SN cosmology, the Roman SN survey design, and exciting possibilities for cosmological constraints of dark matter and dark energy from a dataset with systematics controlled at the sub-percent level.

Detecting microhertz gravitational waves from supermassive blackholes with Roman

Tzu-Ching Chang
JPL

Relative astrometry of stars observed in galaxy redshift surveys has emerged as a promising technique to detect gravitational wave (GW) signals from supermassive black hole mergers. This technique can be sensitive to blackholes with masses around $10^7 M_{\odot}$, allowing us to uniquely probe the microhertz GW regime and bridging the frequency gap between current pulsar timing arrays and future LISA mission. The Roman Space Telescope's Galactic Bulge Time Domain Survey, with its high-cadence observations, precise astrometry, and vast stellar sample, offers an exciting opportunity to detect both individual GW sources and the stochastic background. In this talk, I will present our development of a GW signal estimator tailored for this approach, along with strategies to model and mitigate dominant systematic effects, such as spacecraft-induced motion from active control systems and differential velocity aberration, that could impact the measurements.

Cosmology and cross-correlations with ACT and SO

Martín Crocce

Institute of Space Sciences, ICE, CSIC

I will present the current status of cosmology results from the final 6 years of the Dark Energy Survey (DES). DES has surveyed 5000 square degrees of the southern sky in five photometric bands (grizY), which is contained within the public DES Data Release 2 (DR2), leading to over 150 million galaxies with measured shapes for weak lensing analysis, 16 million red galaxies for baryon acoustic oscillations (BAO) studies and over 1600 Type Ia SNe. I will summarize the current status of the legacy 3x2 analysis, which combines galaxy clustering and weak gravitational lensing using DES Y6, covering methodological, theoretical, and data updates. And legacy results from geometric probes: BAO, SNe Ia and their combination.

Cosmology and cross-correlations with ACT and SO

Jo Dunkley

Princeton University

I will talk about the current status of ground-based CMB from Chile, with observations that overlap large scale structure surveys. I will talk about results obtained by the Atacama Cosmology Telescope, and about the start of data-gathering for the new Simons Observatory. I will highlight the extensive cross-correlation science that can be done with data from these high resolution wide-area surveys, through measurements of gravitational lensing of the CMB, and of the galaxy cluster and gas distributions via the Sunyaev Zel'dovich effects.

Challenges and opportunities for testing cosmology in the Roman era

Agnès Ferté

SLAC

As wide galaxy surveys of the previous generation such as the Dark Energy Survey are finishing their cosmological analyses, challenges in exploiting their cosmological information have arisen. I will highlight some of these limitations in the theoretical description and cosmological inference of weak lensing and clustering, which the new generation of surveys such as Roman or the Rubin Observatory's LSST will face. I will then present the opportunities that new tools and probe combinations will offer in the coming experimental landscape to test dark energy and gravity with the highest precision.

Unveiling Dark Matter with Dwarfs and Stellar Streams in the Era of Roman & Rubin

Peter Ferguson

University of Washington

Low-mass satellite dwarf galaxies and stellar streams—the tidally disrupted remnants of galaxies and star clusters—serve as powerful probes of dark matter structure in the nearby universe. The satellite populations of more massive galaxies in the local volume and perturbations to stellar streams provide a unique window into dark matter behavior at and below the threshold of galaxy formation, offering constraints on fundamental dark matter properties that complement traditional galaxy-scale measurements. Over the past few decades, large astronomical surveys including SDSS, DES, and Gaia have revealed tremendous substructure in the local volume, allowing us to constrain the galaxy-halo connection at the low-mass end, but the upcoming Roman and Rubin surveys will be transformative for near-field cosmology. In this talk, I will discuss how these next-generation cosmological surveys will enable us to leverage the full population of dwarf galaxies and perturbed stellar streams to probe the fundamental nature of dark matter.

Cosmological Simulations and the Galaxy--Halo Connection in the Roman Era

Andrew Hearin

Leiden University

Weak gravitational lensing has emerged as a key cosmological probe to study the nature dark energy, as it allows for a direct mapping of the matter distribution in the Universe. I will review the current status of the field, highlighting some recent results and introduce Euclid, ESA's mission to study the dark Universe. Although surveys like Euclid and Roman will dramatically improve the data for weak lensing studies, progress in modelling the signal is paramount to extract the cosmological information. This relies on improving our understanding of the processes that change the matter distribution on small scales. I will highlight the problem and discuss ways to mitigate this.

Mapping the Universe with weak lensing

Henk Hoekstra

Argonne National Lab

The character of cosmological survey data in the Roman era will be qualitatively unlike the measurements of the past 20 years. The spatial extent of near-future datasets is such that multi-wavelength information from thousands of square degrees of overlapping sky will become available for the first time. Cosmological simulations coupled with forward models of the galaxy--halo connection provide critical tools to help ensure that our theoretical predictions will meet the quality of the data. In this talk, I will review recent advances in large cosmological simulations and the galaxy-halo connection, and discuss where the state of the field will be upon arrival of Roman data.

Trustworthy Machine Learning for Scientific Discovery with Roman Surveys
Michelle Ntampaka
STScI

Modern machine learning techniques enable powerful data analysis strategies that were not feasible even a few years ago, and could lead to transformative scientific discoveries with Roman data. But can we trust the black box? In this talk, I will highlight opportunities and challenges for creating credible ML methods to interpret cosmological observations. I will expand on ML interpretability and domain adaptation as keystones for building models that give trustworthy results. And I will show examples of how machine learning can be used, not just as a tool for getting “better” results at the expense of understanding, but also as a partner that can point us toward physical discovery.

Exploring Cosmic Acceleration: the 3 years of the DESI data
Hee-Jong Seo
Ohio University Dept. of Physics and Astronomy

The Dark Energy Spectroscopic Instrument (DESI) is soon entering its fifth and final year of a five-year redshift survey, targeting 40 million extragalactic sources across 14,000 square degrees of the northern sky, reaching redshifts up to 4, using the Mayall 4-meter telescope at Kitt Peak National Observatory. One of its primary goals is to measure the cosmic expansion history precisely and accurately through baryon acoustic oscillation (BAO) measurements. In this talk, I will summarize the results from the DESI First and Third Year BAO analyses, assess the relevant systematics, and discuss their intriguing cosmological implications, including evidence for time-evolving dark energy.

Precision Cosmology with Optical Clusters - projects and prospects with ongoing and future surveys
Tomomi Sunayama
Academia Sinica Institute of Astronomy and Astrophysics

Over the next decade, large-scale galaxy surveys will map billions of galaxies, enabling high-precision measurements of cosmic structure. Galaxy clusters have the potential to be among the most powerful cosmological probes, yet their full potential remains unrealized due to significant systematic uncertainties. Optical cluster detection, while capable of identifying lower-mass clusters than other methods, is particularly susceptible to systematics. However, its advantage lies in the improved precision of cluster mass measurements through weak lensing. In this talk, I will explore the opportunities and challenges posed by upcoming galaxy surveys and discuss strategies to make optical clusters reliable cosmological probes. I will also highlight insights from Subaru HSC and the prospects for the Roman Space Telescope.

Contributed Talks

Validating Injected SNe Ia in the Roman OpenUniverse Time-Domain Survey Simulations

Lauren Aldoroty

Duke University

NASA's Nancy Grace Roman Space Telescope (Roman) will provide an opportunity to study dark energy with unprecedented precision using several probes. Type Ia Supernovae are a key part of dark energy studies; as standardizable candles, they are used to construct the cosmological distance ladder. However, there are only approximately 20 SNe Ia with sufficiently well-sampled light curves above $z > 1$. Roman will change the landscape of SN Ia-driven dark energy studies by discovering enough SNe Ia at $z > 1$ to render statistical uncertainties insignificant. In order to make the best use of these observations, photometric measurements should be repeatable and precise between images. Roman's expected photometric precision is $< 1\%$, and a factor of 10 better than HST. In this talk, we present our difference imaging analysis pipeline and initial photometric results from SNe Ia in the OpenUniverse simulations (OpenUniverse et al. 2025), using the Saccadic Fast Fourier Transform method (Hu et al. 2022).

Optimizing Roman Photometric Redshifts for HLIS

Brett Andrews

University of Pittsburgh

Photometric redshifts (photo- z 's) are crucial for the main cosmology, galaxy evolution, and transient science drivers of Roman. The transformative nature of the Roman dataset presents both new challenges but also new opportunities for photo- z estimation. First, I will describe our photo- z forecasts that helped guide the HLIS survey design recommendations, especially the filter choices across the medium and wide tiers. These efforts assumed a fair spectroscopic redshift dataset for training and calibration, but that assumption is not currently achieved in deep imaging surveys. To address this need, our group is pursuing a multi-faceted approach to obtain additional spectroscopy, develop better re-weighting/interpolation methods, and implement an independent cross-check on the redshift distributions using clustering redshifts. Finally, I will discuss our efforts to understand whether deep learning models can leverage the information in high-resolution space-based imaging to achieve better photo- z 's than is possible with photometry alone.

J-ATLAS: Javalambre Andromeda and Triangulum Legacy Astrophysical Survey

Borja Anguiano

Centro de Fisica del Cosmos de Aragon (CEFCA)

In cold dark matter (CDM) structure formation models, dark matter halos form the “skeleton” on which the baryonic components of galaxies form, grow, and evolve. A key component of this process is the hierarchical assembly of subhalos to form larger structures. Halo stars can have multiple, distinct origins: through accretion of satellite galaxies, via in situ formation, or by being dynamically kicked out of the inner galaxy. Each mechanism for contributing halo stars imparts a specific expected age and chemical pattern distribution. The Andromeda (M31) and the Triangulum (M33) galaxies offer the ideal combination of an external perspective and relative proximity that lends it more easily to a detailed, but global view. The J-ATLAS survey adds new dimensions critical to piecing together the evolution of M31 and M33’s: the age distribution and chemical enrichment history of halo field stars and satellites. Thanks to the 56 J-PAS narrowband filters covering the optical down to $m \sim 23$ mag, we will complement previous broadband efforts (e.g., PanDAS) and be able to exploit a large database to constrain the intermediate-age fraction through studies of red and asymptotic giant branch (RGB/AGB) stars in the M31 and M33 disk, halo, and satellite galaxies. Adding constraints on the stellar age distribution and chemical enrichment history in the M33/M31 halos, we can test halo formation models within the context of Λ CDM in unprecedented detail. The analysis of low-resolution photo-spectra for M31 and M33’s stellar members using SED-fitting tools will generate a unique catalog containing stellar parameters and individual abundances for millions of objects. The synergies between J-ATLAS and the RomAndromeda (Roman Survey of the Andromeda Halo) will enable chemo-dynamical studies thanks to the combination between our stellar abundances and the high-fidelity proper motions from Roman.

Chromatic Effects on the PSF and Shear Measurement for the Roman High-Latitude Wide Area Survey

Federico Berlfein

Carnegie Mellon University

Weak gravitational lensing is a key cosmological probe that requires precise measurement of galaxy images to infer shape distortions, or shear, and thereby constrain cosmology. Accurate estimation of the Point Spread Function (PSF) is crucial for shear measurement, but the wavelength dependence of the PSF introduces chromatic biases that can systematically impact shear inference. One such effect arises from spectral energy distribution (SED) differences between stars, used for PSF modeling, and galaxies, used for shear measurement. We investigate these biases for Roman's weak lensing (Y106, J129, H158, F184) and wide (W146) filters. We find that these biases exceed the mission's tolerance limits, but we demonstrate that first-order corrections can mitigate biases in the weak lensing bands, with higher-order corrections needed for the wide filter. We demonstrate that both analytical color-based and machine-learning methods effectively reduce biases, providing opportunities to ensuring precise weak lensing measurements with Roman. We also discuss the impact of different survey strategies, assumptions about galaxy spectral energy distributions, and the coaddition process on these chromatic biases and correction methods.

Tracking the Evolution of Dwarf Galaxies using Large Cosmic Surveys

Nushkia Chamba

NASA Ames Research Center

Star formation is one of the main channels of dwarf galaxy growth and evolution. However, often excluded in growth studies are the faint, diffuse "edges" of galaxies, i.e. the maximum radial location where in situ star formation significantly dropped in these galaxies. In this contribution, we discuss how large, deep cosmic surveys such as from the upcoming Roman and Rubin, can be used to detect the faint edges of dwarf galaxies and track the impact of the environment on their growth and formation. Using deep imaging from the VLT, we demonstrate that: (1) Fornax Cluster dwarf galaxies are up to 50% more truncated than nearly isolated galaxies, reflecting the dramatic impact of environmental processes such as cluster tides and ram pressure; (2) the stellar and cold gas size distributions of nearly isolated dwarf galaxies show large variation and is fully compatible with hydrodynamical simulations of stellar feedback. Our results highlight the importance of deep, wide and large multi-wavelength cosmic surveys for tracing the key physical processes responsible for the evolution of dwarf galaxies.

Cosmology with weak-lensing-selected galaxy clusters in Roman: Demonstration with Subaru HSC

Kai-Feng Chen

Massachusetts Institute of Technology

Roman HLWAS will enable the detection of galaxy clusters directly on weak-lensing maps that are nearly independent of any baryonic assumptions. Large samples of these weak-lensing-selected clusters provide unique astrophysical opportunities as their selection depends solely on gravity. Cosmological constraints derived from these clusters will also complement those derived from the cosmic shear power spectrum and produce crucial consistency tests within the weak-lensing data. In this talk, I will demonstrate the power of these samples by presenting cosmological constraints derived from weak-lensing-selected clusters in the Hyper Suprime-Cam (HSC) Subaru Strategic Program. HSC is one of the deepest weak-lensing surveys currently available, and competitive cosmological constraints are derived with only 500 square degrees of data. I will discuss the detailed modeling we performed to characterize the selection effect and the mass—observable relation of these clusters, which can be directly applied to Roman. Our results are an important step toward utilizing these cluster samples in HLWAS.

Mapping the Structures of Dust Tori of AGNs with Roman HLTDS

Hojin Cho

Texas Tech University

The optically thick anisotropic medium around an active galactic nucleus (AGN), or the "dust torus," is considered to be responsible for various AGN phenomena, including type-1/type-2 dichotomy and changing-look AGNs. In addition, the properties of the dust torus likely evolve over a galaxy's lifetime, if AGN are associated with distinct phases of galaxy evolution. However, the structure of AGN dust tori, the physical processes that shape them, and the cosmic evolution of dusty medium in AGN are poorly understood. While a census of dust tori geometry would offer a new perspective on the evolution of AGNs and their connection to galaxy evolution, only a handful of dust tori have their structure mapped due to observational challenges. In this presentation, I demonstrate the capability of the Roman Space Telescope High-Latitude Time Domain Survey (HLTDS) to survey the population of AGN dust tori structures. We developed a code to model infrared dust reverberation signals that Roman will observe, which allows us to infer the geometry and physical characteristics of dusty tori. Simulations of AGN light curves in the HLTDS show that we can recover the structures of AGN dust tori, including their size, inclination, covering factor, and curvature. During its 2-year mission, we expect the HLTDS to map the structures of dust tori for at least $\sim 30k$ AGNs brighter than the 22nd magnitude. This sample will allow us to explore the distribution of dust tori geometric parameters and the connection between AGN activity and host galaxy evolution.

The Roman View of Strong Gravitational Lenses

Tansu Daylan

Washington University in St. Louis

Galaxy-galaxy strong gravitational lenses can constrain dark matter models and the Lambda Cold Dark Matter cosmological paradigm at sub-galactic scales. Currently, there is a dearth of images of these rare systems with high signal-to-noise and angular resolution. The Nancy Grace Roman Space Telescope, scheduled for launch in late 2026, will play a transformative role in strong lensing science with its planned wide-field surveys. With its remarkable 0.281 square degree field of view and diffraction-limited angular resolution of 0.11 arcsec, Roman is uniquely suited to characterizing dark matter substructure from a robust population of strong lenses. We present a yield simulation of detectable strong lenses in Roman's planned High Latitude Wide Area Survey (HLWAS). We simulate a population of galaxy-galaxy strong lenses across cosmic time with Cold Dark Matter subhalo populations, select those detectable in the HLWAS, and generate simulated images accounting for realistic Wide Field Instrument detector effects. For a fiducial case of single 146-second exposures, we predict around 93,000 detectable strong lenses in the HLWAS, of which about 500 will have sufficient signal-to-noise to be amenable to detailed substructure characterization. We investigate the effect of the variation of the point-spread function across Roman's field of view on detecting individual subhalos and the suppression of the subhalo mass function at low masses. Our simulation products are available to support strong lens science with Roman, such as training neural networks and validating dark matter substructure analysis pipelines.

Deep Spectroscopy with DESI for Photometric Redshift training and calibration

Biprateep Dey

University of Toronto

The Roman Space Telescope and the Rubin Observatory will rely heavily on photometric redshift (photo- z) estimates for cosmological measurements, transient localization, and galaxy evolution studies. The accuracy of these photo- z 's is paramount and depends critically on the availability of unbiased spectroscopic training samples matching the depths of the photometric data sets. Deep spectroscopic observations can significantly enhance the performance and characterization of photo- z estimates, ensuring that we can fully utilize the rich imaging data obtained from these next generation surveys. However, collecting a large unbiased spectroscopic data sets of faint galaxies remain a big challenge. We will present results from new on-sky tests demonstrating the remarkable efficiency of the Dark Energy Spectroscopic Instrument (DESI) in measuring redshifts of faint galaxies. Our findings show that DESI can achieve redshift measurement efficiency comparable to or exceeding those of frontline instruments on current large telescopes with only a modest increase in observing time. Given its high multiplexing capabilities, DESI emerges as a powerful tool to provide the definitive spectroscopic sample for targets down to the depths anticipated of Roman and Rubin data sets. Extrapolating from our results, we will discuss the compelling prospect of collecting magnitude limited spectroscopic samples with DESI at depths similar to early data from Rubin and Roman. This synergy between Roman, Rubin, and efficient spectroscopic facilities like DESI paves the way for unprecedented advancements in cosmic cartography and our understanding of the universe.

Constraining cosmology with peculiar velocities

Chaimongkol Duangchan

Leibniz-Institut für Astrophysik Potsdam (AIP), Germany

Peculiar velocities can be used to study structures and make maps of the Universe, since galaxies gravitate towards mass concentrations. They can also be studied to constrain cosmological parameters such as the expansion rate (Hubble's constant) and the bulk flow, the average motion of matter in a sphere centred on the Milky Way. To address these issues, we analyzed the Cosmicflows-4 catalogue, the most extensive catalogue of galaxy peculiar velocities, reaching a redshift $z=0.1$. Specifically, without assuming any cosmological model, we computed the bulk flow and expansion rate, directly from measurements of peculiar velocities - despite their inhomogeneous sampling and large errors. Our method accurately recovers cosmological parameters within a radius of 125 Mpc/h that can then be compared with the predictions from Λ CDM. We find a general agreement between Λ CDM and the observations. Additionally, we find that the bulk flow is closely aligned with the Local Group's movement relative to the CMB dipole, another success. Lastly, our analysis suggests a Hubble constant value of approximately 74.8 km/s/Mpc, exacerbating (or independently confirming) the existing "Hubble tension", however for the first time accomplished with the largest set of peculiar velocities in existence.

Science operations of the ESA Euclid cosmology mission

Xavier Dupac

European Space Agency

Science operations of the ESA Euclid cosmology mission --- Xavier Dupac, on behalf of the Euclid Survey Operations group. Euclid is the ESA space telescope dedicated to cosmology, launched in 2023. It is performing a large survey of galaxies over 14000 sq. deg. of the Extragalactic sky (Wide Survey) as well as a Deep Survey of three areas of the Extragalactic sky (53 sq. deg., 2 mag. deeper than the Wide Survey), and Auxiliary Fields for calibration purposes. The design of the survey is performed by the Euclid Consortium, while survey operations are performed by the Science Operations Centre at ESA-ESAC. In this presentation, I will focus on the science operation aspects of the Euclid survey, including planning and monitoring of the survey, planned and actual reactions to contingencies and under-performance, re-scheduling and other modifications of the planned survey. In-flight findings such as straylight affecting the visible instrument and ice depositing on parts of the telescope have had a significant impact on the post-launch re-design of the survey. I will also present the organizational aspect of this activity, which involves many actors of the Euclid Ground Segment.

Utilizing Roman to Study the Onset of Galaxy Clusters with Gravitational Lensing

Kyle Finner

California Institute of Technology / IPAC

The formation of the first galaxy clusters in the universe occurs roughly at cosmic noon. Studying the first galaxy clusters offers a view into early galaxy formation and the gravitational collapse of dark matter. The redshift of light makes infrared observations necessary for studying high- z clusters. In this talk, we will discuss the value of detailed study of galaxy clusters in the redshift range of 1 to 2.5. Using recent JWST observations of XLSSC122, an evolved galaxy cluster at $z=2$, we will demonstrate that weak and strong gravitational lensing is viable at high- z and can produce tight constraints on the mass distributions. We will describe how Roman will be an excellent observatory for efficiently studying galaxy clusters in the early universe.

Measuring and modeling intrinsic alignments with the Physics of the Accelerating Universe Survey

David Navarro Girones
Leiden Observatory

The intrinsic alignments (IA) of galaxies accounts for the preferred orientation of galaxies due to local gravitational interactions with the surrounding large-scale structure, being one of the main systematic effects in weak gravitational lensing studies. In this talk, I present the measurement and modelling of galaxy clustering (GC) and IA using data from the Physics of the Accelerating Universe Survey (PAUS), a narrow-band imaging survey that provides exceptional photometric redshifts (photo-z) and covers a luminosity range similar to upcoming stage-IV surveys. Our measurements cover an area of 51 deg. sq., with photo-z in the range $0.1 < z < 1$ and magnitude limit in the i-band up to 22. We find a strong correlation between galaxy color and IA, with red galaxies presenting a clear IA signal and blue galaxies showing no significant detection. Additionally, we observe an increase of IA with both luminosity and stellar mass, extending the results from previous analyses towards less luminous and massive objects. No clear evolution with redshift is detected, in accordance with previous literature. The fits to the IA parameters performed in our study will provide informative priors to stage-IV surveys, such as Roman, Euclid and LSST, enabling a precise modeling of this effect and ensuring unbiased cosmological analyses.

Multi-survey simulations to develop new algorithms: application to shape measurement

Axel Guinot
Carnegie Mellon University

The era of Stage-IV photometric surveys has started with the first Quick Release of Euclid's data, the first light of the Rubin Observatory around the corner, and the launch of Roman next year. As each of those surveys will individually provide unprecedented constraints on dark matter and dark energy, making use of the complementarity of the different observations will improve our understanding of the dark Universe even more. To achieve this goal, we will need to prepare and test algorithms on accurate multi-survey simulations and develop new analysis tools to overcome observational systematics. During my talk, I will present our simulated Euclid-like images that will be added to the recently released Roman-Rubin simulation based on the OpenUniverse2024 effort. I will also demonstrate how those simulations are critical to developing new processing tools. I will present a new approach, metacoaddition, derived from metacalibration, that could be used to process under-sampled images such as Roman or Euclid. Preliminary results show that this method could achieve the precision needed by Stage-IV surveys to be within their requirements to constrain the equation of state of dark energy.

LtU: Simulation-Based Inference and the Role of Accelerated Mocks in Cosmological Inference

Matthew Ho

Columbia University in the City of New York

The Learning the Universe collaboration is developing an accelerated mock pipeline for simulation-based inference of cosmological models, combining state-of-the-art machine learning techniques with modern cosmological simulations. By integrating high-resolution simulations, fast emulators, and inference techniques, our approach enables the efficient and precise extraction of cosmological information from large-scale structure surveys. In this talk, I will present our methodology and highlight its application to the SDSS BOSS CMASS spectroscopic galaxy sample, demonstrating its effectiveness in constraining cosmological models with field-level information. I will also discuss how lessons learned from developing this framework can inform future analyses of Roman data by refining inference techniques and improving computational scalability.

3Dx2D: Combining spectroscopic and imaging measurements with Roman

Yu-Hsiu Huang

University of Arizona

We present forecasted constraints from the joint analysis of 3D galaxy clustering and 2D kinematic lensing with data from the upcoming Roman High Latitude Wide Area Survey (HLWAS). This combination of observables breaks the degeneracy between the growth rate of structure and the amplitude of matter clustering, offering a novel approach to testing general relativity and dark energy models through direct measurement of the growth rate. Assuming the medium-tier depth of Roman HLWAS, we perform a simulated likelihood analysis using CosmoLike to assess the survey's ability to constrain the growth rate and other key cosmological parameters. Our results highlight the potential of this joint imaging and spectroscopic dataset to test Λ CDM and more general dark energy physics.

Deep Learning Photometric Redshifts for Roman
Ashod Khederlarian
University of Pittsburgh

Photometric redshifts (photo-z's) will be essential for studying cosmology, galaxy evolution, and transient science with Roman. State-of-the-art deep learning methods leverage pixel-level information from images to achieve the best photo-z's for low-redshift galaxies, but their performance at higher redshifts relevant to Roman science remains untested due to limited training data. In this talk, I will discuss our efforts to deploy deep learning photo-z algorithms on high-redshift galaxies using Hubble Space Telescope CANDELS imaging and redshift labels from spectroscopic, grism, and COSMOS2020 photometric catalogs. Our results show that a semi-supervised deep learning approach which makes use of unlabeled images outperforms fully supervised methods and traditional photometry-based estimates (both of which require redshift labels for all objects used in training). For galaxies brighter than $m_{\{H\}} < 22$, our method reduces bias by 87%, normalized median absolute deviation by 20%, and fraction of outliers by 47% compared to photometry-only predictions. Additionally, we demonstrate that our approach consistently improves photo-z estimates across varying amounts of labeled data, with no signs of plateauing--this is crucial as we scale from CANDELS to Roman's vastly larger datasets. With space-based imaging from wide- and deep-field surveys, semi-supervised deep learning will allow us to take advantage of the information available from the full set of hundreds of millions of galaxies, enabling the most accurate photo-z estimates for both faint and bright sources.

Cosmology from Non-Linear Redshift-Space Clustering and Gravitational Lensing
Johannes Lange
American University

Extracting cosmological information from large-area maps of the sky typically involves analyzing structures on linear and quasi-linear scales. While predicting the galaxy and matter distribution on these scales is less challenging, pushing the analysis to smaller non-linear scales is a promising way to maximize the science return from the Nancy Grace Roman Space Telescope. Recent work has shown that analyzing the non-linear distribution of galaxies and matter via advanced simulation-based modeling leads to significantly more stringent constraints on the growth of cosmic structure. In this talk, I will present results from a recent analysis of redshift-space clustering and gravitational galaxy-galaxy lensing of luminous red galaxies in the BOSS survey. Furthermore, I will present new insights from the analysis of simulated mock catalogs, including next-generation simulations such as FLAMINGO. Finally, I will outline ongoing studies of mock catalogs aimed at ensuring that cosmological constraints from the non-linear structure observed by Roman will be robust and reliable.

Probing Galaxy Evolution within Galaxy Overdensities Using the CANDELS-Herschel Environmental Spectr

Jitrapon Lertprasertpong
Rochester Institute of Technology

The study of galaxy evolution in dense environments, particularly within galaxy clusters, across cosmic time, is one of the primary goals of the Nancy Grace Roman Space Telescope. In the local universe, galaxies show a decline in star formation rates (SFR) within high-density regions, as observed in the SFR-density relation. However, at redshift $z > 1.0$, this trend becomes less clear, as several studies show conflicting results. These discrepancies largely stem from the limited availability of spectroscopic redshifts and the challenges of measuring SFR in dusty star-forming systems. To address these issues, we leverage spectroscopic redshifts (spec- z) from the CANDELS-Herschel Environmental Spectroscopic Survey (CHESS) to enhance the spectroscopic completeness of galaxies at redshift range $0.5 < z < 1.7$. By combining these new spec- z with existing archival spectroscopic redshifts, we construct improved overdensity maps and identify protostructures using the Voronoi Monte Carlo method. Furthermore, we incorporate Herschel far-infrared data into the CANDELS multiwavelength photometry to reconstruct spectral energy distribution (SED) of dusty star-forming galaxies. Utilizing the Code Investigating GALaxy Emission (CIGALE) to analyze these SEDs, we obtain new SFR estimates for our target galaxies. This study presents new spectroscopic redshifts, improved overdensity maps, and updated SFR measurements for galaxies across all five CANDELS fields. Ultimately, by reconstructing the SFR-density relation at $z > 1.0$, we provide new insights into how the local environments influence galaxy evolution. These results will serve as valuable targets for future Roman Space Telescope observations and demonstrate how Roman's wide-field grism spectroscopy can improve our understanding of galaxy evolution in galaxy clusters.

Cosmic Cartography at the Cosmic Extremes: Mapping the 100 Mpc-scale Cosmic Himalayas at Cosmic Noon

Yongming Liang

National Astronomical Observatory of Japan (NAOJ)

We report the discovery of the Cosmic Himalayas, an extraordinary quasar overdensity at $z = 2.16\text{--}2.20$, characterized by 11 luminous quasars clustered within a $(40 \text{ cMpc})^3$ volume. This structure is the most significant quasar concentration (17σ) identified within the $10,000 \text{ deg}^2$ SDSS/eBOSS footprint, notably diverging from typical cosmic structure patterns. Intriguingly, this quasar overdensity is spatially offset by approximately 25 cMpc from two galaxy-rich nodes identified via Subaru/HSC narrowband imaging, and it resides along an ionization boundary in the intergalactic medium, traced through 3D Ly α tomography. These spatial discrepancies underscore the limitations of optical surveys and highlight a substantial, yet hidden galaxy population. Given its extensive scale ($\sim 100 \text{ cMpc}$) and favorable redshift, the Cosmic Himalayas provides an optimal and extreme testbed compared to standard core community survey fields for the Nancy Grace Roman Space Telescope. Roman's wide-field, high-resolution near-infrared imaging will allow detailed morphological analyses of galaxies, enabling studies of mergers, interactions, and structural evolution, particularly in relation to the environments of the identified quasars. Additionally, Roman's grism spectroscopy will uniquely identify galaxies obscured at optical wavelengths and map their spatial distributions using key rest-frame optical emission lines ([O II], H β , [O III]) across a cosmological scale. By exploiting Roman's capabilities, we will significantly advance our understanding of galaxy-quasar interactions, feedback processes, and the complex assembly history of large-scale structures at the epoch of peak cosmic growth.

Cartography at Cosmic Dawn

Sangeeta Malhotra

NASA Goddard Space Flight Center

Cosmic cartography at cosmic dawn constitutes determining the regions of newly ionized and residual neutral gas. The visibility of Lyman alpha galaxies offers a local, scalable test for ionized gas during the central stages of reionization. Lyman alpha surveys at redshifts $z=7.0$ (the LAGER survey) and $z=7.3$ (the ongoing CIDER survey), conducted with wide-field CCD imaging using the 3 deg^2 Dark Energy Camera show substantial inhomogeneities in the distribution of Lyman-alpha galaxies. Recently, JWST has shown the presence of strong Lyman-alpha emitters up to redshift 13, but over small survey areas comparable to a single ionized bubble size in the epoch of reionization. Roman's wide field of view and near-IR wavelength coverage opens the way to survey large volumes from $z=7$ to $z>13$, using deep slitless spectroscopic surveys. I will discuss parameters of a General Astrophysics Roman survey that would obtain a statistically powerful sample of neutral and ionized regions, spanning the early, central, and late phases of reionization. Moreover, by comparing the galaxy populations inside and outside the inferred ionized bubbles, Roman will yield new information on the populations of galaxies driving reionization.

Dwarf Galaxies Across Cosmic Distances with DESI

Viraj Manwadkar
Stanford University

The Dark Energy Spectroscopic Instrument (DESI) is obtaining optical spectra at an unprecedented rate across ~ 14000 deg² of the sky. Pushing more than 4 magnitudes fainter than SDSS, DESI has obtained spectra with redshifts for 13.1 million galaxies in the first year of its five-year survey. From this, we identify ~ 300 k dwarf galaxies with stellar masses between $1e6$ to $1e9$ Msun at redshifts $0.001 < z < 0.4$. For nearby irregular or semi-resolved dwarf galaxies, where photometry will be fragmented, we remodel their photometry non-parametrically using the Scarlet framework. This catalog is further supplemented with information on environment (satellites, voids, pairs), incompleteness, anomaly scores in image and spectroscopic space, and stellar continuum and emission line properties from DESI's FastSpecFit Value Added Catalog. I will also present how this catalog—and future DESI data releases—will enable multi-wavelength synergies with Euclid, Rubin, Roman, UVEX etc. opening new frontiers in the study of low-mass galaxy formation and dark matter.

Clearing the Cosmic Fog: Circumgalactic Dust and Precision Distance Estimates with Roman

Jacqueline McCleary
Northeastern University

The circumgalactic and intergalactic media contain vast amounts of dust, comparable to the amount found within galaxies themselves. This dust presents a significant systematic uncertainty for precision cosmological distance measurements with supernovae, yet it is diffuse enough that it is difficult to measure directly. Moreover, the cosmic dust content appears to evolve with redshift. To help address this challenge, we have recently developed a new technique to detect circumgalactic dust halos: a maximum-likelihood estimator for dust-induced extinction. Our method is adaptable to nearly any photometric dataset and can incorporate a variety of dust reddening prescriptions, making it easy to apply to different galaxy types and redshifts. Applying this method to archival data, we have identified dust halo profiles extending beyond 10 Mpc, with distinct differences observed between star-forming and quiescent galaxy populations. Roman's wide field and deep imaging (as part of its High Latitude survey) will furnish extensive galaxy catalogs, enabling this analysis with no additional observations. By binning supernovae according to projected galaxy type and density along their line-of-sight, we may quantify the degree to which circumgalactic dust from interloping galaxies affects supernova distance estimates. By integrating our maximum likelihood technique into Roman's observational framework, we can produce detailed, large-area maps of circumgalactic dust opacity, simultaneously refining cosmological distance measurements and revealing new insights into the baryonic structure of the Universe.

Where spectroscopic and imaging surveys connect: Demographic modeling of galaxy intrinsic alignment

Jamie McCullough
Princeton University

Cosmological precision from weak lensing measurements is limited by our ability to model astrophysical effects — how galaxies intrinsically align with one another, baryon feedback, and uncertainty in the relation between galaxy colors and distances. Massively multiplexed spectroscopic surveys provide an orthogonal dataset for understanding these phenomena — for example, through direct measurements of intrinsic alignments and their dependencies on galaxy properties (e.g., luminosity, color). With the advent of the most comprehensive weak lensing surveys like Roman, Euclid, and Rubin, we propose a new approach for intrinsic alignment (IA) modeling that is tailored to the properties of the source galaxy population, leveraging relations between galaxy color-redshift-age-mass, as well as the deep-to-wide field inference pioneered in photometric redshift calibration. I will discuss mitigation strategies for intrinsic alignments via source sample selection (case study with the Dark Energy Survey, DES Y3), how that picture changes with direct measurements of IA from pairing modern imaging surveys with spectroscopy (DESI Y1), and a novel, data-driven approach to modeling IA that enables next-generation experiments to produce the tightest, unbiased constraints on dark energy and large-scale structure.

Enhanced Astrometry by Combining Telescopes

Kevin McKinnon
University of Toronto

Roman will provide deep astrometric images across the sky that will enable high precision stellar motions for the faintest stars in the Milky Way (MW), the Local Group, and beyond. These faint stars are key to Near-Field Cosmological studies: they will unlock the properties of the MW stellar halo in high angular and distance resolution, reconstruct the Local Group's precise history, and uncover more of each known stellar stream as well as new streams at larger distances. However, the best possible astrometry will come from harnessing the strengths of all telescopes, surveys, and datasets simultaneously. Towards this end, I developed the BP3M (Bayesian Positions, Parallaxes, and Proper Motions) pipeline, which measures significantly improved astrometry for stars shared between Gaia data and deep/long-exposure Hubble Space Telescope (HST) images. For deep/long-exposure HST regions with multiple epochs of observations, this technique yields proper motions for stars up to 4 magnitudes fainter than Gaia alone. Tests with nearby dwarf spheroidal galaxies demonstrates that BP3M delivers proper motions up to 50 times more precise than Gaia alone for stars with $G > 20.5$ mag. In this talk, I will discuss the generalizable statistics underpinning BP3M and their application to future Roman data. I will also present a tool for simulating Roman astrometry in combination with other surveys. Finally, I will highlight some of the exciting applications of BP3M in the context of Local Group dynamics (e.g. the distant MW stellar halo, stellar streams, and MW/M31 satellite kinematics) and discuss the anticipated improvements from Roman.

Photometric redshifts for Rubin-era weak lensing

Justin Myles

Princeton University

The large galaxy surveys coming online promise to deliver extraordinary datasets to answer open questions about the nature of dark matter and dark energy, but these surveys face science-limiting challenges arising from uncertainty in the galaxy color-redshift relation. The key challenge of calibrating redshift distributions for weak lensing galaxy ensembles is central to harvesting the cosmological information in these datasets. Optimal redshift calibration will require leveraging the complementarity of datasets from different surveys. I will discuss a project within the Rubin LSST Dark Energy Science Collaboration to characterize LSST redshift uncertainty as a function of available spectroscopic and overlapping near-infrared data from complementary telescopes like Euclid and Roman. The dearth of spectroscopic calibration samples at LSST depth, in particular, looms large as a limiting problem for redshift calibration. To quantify the impact of this issue, I will share forecasts on LSST Y1 using the SOMPZ redshift calibration method applied to simulations and discuss the performance of this method at the faint end. Due to insufficient spectroscopic calibration data, LSST Y1 may face a choice between adopting broad redshift uncertainty priors or limiting the depth of the source galaxy sample. I will discuss the relative merits of these options.

Unveiling galaxy evolution with Roman's WFI: Insights from JWST slitless spectroscopy programs

Kalina Nedkova

Johns Hopkins University

Roman's Wide Field Instrument is poised to answer key outstanding questions in galaxy evolution, including the history of reionization and the chemical evolution of galaxies. With its unparalleled wide-area mapping capabilities and slitless grism spectroscopy at 1–2 microns, Roman will provide large, unbiased samples of galaxies by obtaining spectra for every object in its field of view without pre-selection. This approach ensures a representative sample of typical galaxies across large areas of the sky, significantly reducing the impact of cosmic variance. Moreover, it removes slit losses and the possibility of missing Lyman- α emission due to slit placement, which are crucial for reliably studying the Epoch of Reionization (EoR). In preparation for Roman's groundbreaking surveys, I will present recent results from PASSAGE, a pure-parallel JWST NIRISS program leveraging wide-field slitless spectroscopy. I will share measurements of gas-phase metallicity for large galaxy samples from independent fields that are minimally impacted by field-to-field variation and constraints on the neutral hydrogen content in the Universe during the EoR from an unbiased Lyman- α emission search. These data and results highlight how PASSAGE's imaging and grism observations serve as a valuable precursor to Roman, offering insights into the potential of Roman's spectroscopic surveys that will transform our understanding of galaxy properties, distributions, and evolution.

An Early-type supernovae type-Ia host-galaxy-based local Cosmological Distance Ladder with Tip of the Red Giant Branch

Max Newman

Rutgers the State University of New Jersey

One of the most fundamental measurements in astronomy is distances. Distances are essential to measuring cosmologically significant parameters such as the local expansion rate of the Universe, the Hubble constant (H_0). The most precise measurements of H_0 use a three-rung local distance ladder to connect the local and high-redshift Universes. Type-Ia supernovae (SNe Ia), the third rung, extend the distance ladder into the Hubble flow owing to their high and standardizable luminosities, and whose properties are best calibrated through astronomical distance indicators in the second rung. Currently, local H_0 measurements select SNe Ia in star-forming, late-type host galaxies calibrated by Cepheid distances to prioritize consistency in SNe Ia properties. However, an alternate, parallel distance ladder using SNe Ia in non-star-forming, early-type host galaxies (ETGs) calibrated by the Tip of the Red Giant Branch (TRGB) distances can provide an independent check on the value of H_0 . At present, the number of host ETGs with the requisite data for precise TRGB distances is limited by their proximity to us. One of the 3 main science goals of the Nancy Grace Roman Space Telescope (Roman) is to measure cosmological parameters, including H_0 , using SNe Ia. Roman is uniquely capable of increasing the sample of ETG SNe Ia hosts both in the high-redshift Universe and in the local Universe. Locally, the majority of ETG hosts are situated beyond the feasible distance the TRGB with Hubble Space Telescope (HST). Roman will provide exquisite data for TRGB distances to previously inaccessible ETGs with its large field of view (FoV) and optical HST-like resolution at infrared (IR) wavelengths, coupled with the 1-2 mag increase in TRGB brightness in the IR relative to optical wavelengths. However, to use these data, the TRGB needs to be standardizable in the near-infrared (NIR) where its luminosity changes significantly as a function of metallicity. In this talk, I will present our work to test the feasibility of the parallel ETG TRGB distance calibrated distance ladder using new and archival HST data. I will also demonstrate that the NIR TRGB in Roman can be precisely calibrated using the techniques we developed and applied to IR HST and JWST NIRCам data.

Simulating galaxy proper motions and real time cosmology with the Roman Space Telescope

Jennie Paine

University of Maryland, Baltimore County / NASA GSFC

The proper motions of galaxies and their correlations across the sky probe a variety of cosmological and observer-induced phenomena. One potential observable is secular parallax caused by the velocity of the solar system barycenter with respect to the CMB rest frame, which will manifest as a distance-dependent proper motion dipole. A statistical measurement of the secular parallax signal as a function of redshift could therefore be used to place a novel geometric constraint on the Hubble constant. We investigate the feasibility of measuring galaxy proper motions with the Roman High Latitude Wide Area Survey (HLWAS) over the course of the nominal five year mission, and the sensitivity to correlated proper motion signals such as secular parallax. Proper motion precision is related to the number of epochs and maximum time baseline, so galaxy proper motions with the HLWAS will be dependent on the details of the observing schedule and the accuracy of tracking astrometry between filters. We use the OpenUniverse Roman image simulations to assess the single epoch astrometric precision for low redshift galaxies in several filters, and create simulated astrometric catalogs over the HLWAS footprint. By measuring the secular parallax signal in these simulated catalogs, we assess the resulting error on the Hubble constant and its dependence on survey parameters.

Constraints on cosmology and baryonic feedback DESxACT (lensing x tSZ) data

Shivam Pandey

The Johns Hopkins University

I will present a joint analysis of the weak gravitational lensing (shear) data obtained from the first three years of the observations from the Dark Energy Survey and the thermal Sunyaev-Zel'dovich (tSZ) effect measurements from a combination of the six years of Atacama Cosmology Telescope observations and Planck. A combined analysis of shear (which traces the projected mass) with the tSZ effect (which traces the projected gas pressure) can jointly probe both the distribution of matter and the thermodynamic state of the gas, accounting for the correlated effects of baryonic feedback. By modeling the small-scale auto-correlations of shear jointly with shear-tSZ cross-correlations, we improve upon the cosmological constraints compared to shear alone and find the cosmological constraints to be consistent with the Planck primary CMB data analysis. On the astrophysical front, we find evidence for reduced pressure in low-mass halos, consistent with predictions for the enhanced effects of feedback from active galactic nuclei on the gas thermodynamics. By comparing the inferred matter power suppression and integrated tSZ effect, we find that hydrosimulations with mild baryonic feedback are in 2-4 sigma tension with our constraints. These constraints are expected to improve dramatically with Roman data and its cross-correlations with Simons Observatory, greatly improving our understanding of baryonic feedback that is important for both cosmological and galaxy formation models.

Hunting the Faintest Galaxies: Detection Efficiency of Dwarfs in the Local Volume with Roman WFI

Deepthi Prabhu

University of Arizona

The Wide Field Instrument on the Roman Space Telescope will revolutionize our view of nearby galaxy halos: unveiling their dwarf galaxy populations down to very faint luminosities; resolving the stars in stellar streams and other substructures; and identifying their star clusters. Resolved stellar population studies of faint dwarf galaxies in the Local Volume can provide crucial insights into galaxy formation, star formation histories, and the role of environment in shaping low-mass systems. To assess the detection efficiency of such systems with Roman, we generated simulated WFI images using the Space Telescope Image Product Simulator (STIPS) and the WINGS (Wide-field Infrared Nearby Galaxies Survey) pipeline, incorporating synthetic dwarfs with realistic star formation histories, crowding effects, and foreground contamination. Here I will discuss the key results from these image simulations, along with an overview of nearby galaxy science that will be enabled by Roman WFI.

Mock galaxy catalogs for the Roman Galaxy Redshift Survey
Andrew Robertson

Carnegie Institution of Washington

The Roman Galaxy Redshift Survey will provide a transformative view of the Universe's large-scale structure, enabling precision tests of cosmology and galaxy evolution. To fully leverage this data, we require realistic mock galaxy catalogs that accurately reproduce the observed galaxy distribution. Semi-analytical models offer a computationally efficient, physically motivated approach to populating dark matter-only simulations with galaxies, bridging the gap between expensive hydrodynamical simulations and simpler empirical models. In this talk, I will present a mock galaxy catalog generated with the semi-analytical model Galacticus applied to the UNIT cosmological N-body simulations. This mock is being used both to simulate Roman Grism observations and to test large-scale structure analysis methods. I will highlight recent developments that enable a more systematic exploration of Galacticus's parameter space, leading to a model that reproduces key features of the observed galaxy population with unprecedented precision.

Current and Future Milky Way and Stellar Survey Programs of the Dark Energy Spectroscopic Instrument
Constance Rockosi

University of California - Santa Cruz

The Dark Energy Spectroscopic Instrument (DESI) collaboration recently released its DR1 catalog of spectroscopy and derived parameters for 4 million stars, most of them taken as part of the DESI survey of the Milky Way. I will highlight some recent DESI results on the outer disk and halo of our Galaxy. I will also present the new extension of that survey which will focus on stellar streams and dwarf galaxies in the Milky Way and the stellar halo of Andromeda. I will describe the DESI extension plans for observations of Milky Way stellar streams as luminous tracers of the mass and dynamics of our Galaxy's halo, and to constrain the low-mass dark matter subhalo population. The DESI extension will also observe Milky Way dwarf spheroidal galaxies to identify members out to large radial distances and understand the dynamical evolution of the dSph and interactions with the gravitational potential of the Milky Way. More DESI observations of the Andromeda galaxy and its stellar halo in the DESI extension will enable dynamical constraints on the mass profile and evolution of our nearest neighbor. I will also describe the status of planning for Milky Way and resolved stellar observations in the DESI-II project, and highlight complementarity with Roman and other projects.

Status of the Roman Galaxy Redshift Survey Project Infrastructure Team Grism Simulations

Ashley Ross

Ohio State University

I will describe the status of the Roman Galaxy Redshift Survey Project Infrastructure Team Grism Simulations. These simulations adapt the ‘grizli’ software package and are developed software within GRS PIT github. We simulate a 4 deg² area and are working to include realistic instrumental effects and noise (+variations), realistic galaxy distributions (including magnitudes, line fluxes, morphologies, etc.), and a realistic distribution of stars. The pipeline is designed be flexible enough to allow test of, e.g., roll angles, variations in redshift fitting, robustness to rare objects (e.g., lensed galaxies, high-z lya emitters, dusty star forming galaxies, rare stellar types), and the impact of various instrumental effects (by isolating and allowing them to be turned off/on). I will describe how the same code base can be used to define the small-scale footprint of the survey, e.g., by requiring a given wavelength range to be covered by some minimum number of exposures.

Cosmic Cartography for Cosmological Gain: Towards Multi-Probe Field-Level Inference

Eduardo Rozo

University of Arizona

Roman will produce the most accurate maps of the dark matter and galaxy density fields over its survey regions. We will demonstrate how combining the map-making and cosmological-inference process using field-based inference (a.k.a. field-based forward modeling) benefits both the resulting maps and cosmological posteriors inferred from the data, and discuss some of the challenges we anticipate towards making field-based inference analysis with Roman a reality. We will further consider the prospects for combining weak lensing and gravitational clustering data in a unified field-level inference pipeline to further improve the cosmological constraining power of Roman.

Enabling Clustering-based Redshift Calibration for Roman Cosmology

Yoquelbin Salcedo Hernandez

University of Pittsburgh

The characterization of redshift distributions of photometric redshift-selected samples must meet stringent requirements for Roman cosmology inference not to be degraded. Clustering redshifts provide a powerful alternative to color-based methods of redshift distribution calibration. Roman weak lensing analyses will use the clustering redshift implementation in the LSST DESC RAIL software package, but this code has yet to be validated. In this talk, I will describe how we are using SkySim5000 and Roman Rubin simulations to produce realistic DESI-like mock catalogs in order to validate the RAIL clustering redshift code with differently biased tracers of LSS.

Simulation-based forward-modeling of optical clusters

Andres Salcedo

University of Arizona

Galaxy clusters are embedded in the most massive bound structures in the Universe. These structures formed from gravitationally amplified peaks in the primordial matter distribution making their properties sensitive to cosmology. In the standard approach the abundances of clusters as a function of their mass are used to constrain cosmology. Because cluster masses cannot be measured directly this approach relies on observable proxies of cluster mass that are calibrated using weak gravitational lensing. Robustly marginalizing over these mass-observable relations is therefore critical to accurately measuring cosmology with clusters. We have developed a novel framework to forward model optical cluster selection in simulations using the halo occupation distribution (HOD) framework that predicts the abundance and lensing, down to small scales, of optical clusters. We present cosmological constraints from applying this methodology to redMaPPer clusters down to richness 10 identified in Dark Energy Survey Year 1 data. We also present analogous forecast constraints from future Roman survey data. Finally we present ongoing work to develop a framework for generating mock red-sequence galaxy photometry that will allow us to run the redMaPPer algorithm on simulated galaxy data in order to fully forward model cluster two-point functions as well as their cross-correlations with galaxies down to small scales.

Roman's Wide-field View of Stellar Streams

Robyn Sanderson

University of Pennsylvania

The Roman telescope promises to revolutionize the study of stellar streams in our Galaxy and beyond. Currently, we can study resolved stars in tidal streams only in our own Milky Way and, for a few of the brightest streams, in our nearest neighbor the Andromeda galaxy. These streams have provided the best constraints on many properties of our Galaxy's dark matter distribution, as well as key insights into the influence of the cosmic environment on galaxy formation. Streams have the potential to test a wide range of dark matter theories, both in their ability to map the large-scale dark matter distribution and their sensitivity to small-scale substructures, but this potential has yet to be fully realized. In our own Galaxy, our observational access to all six dimensions of phase space has been limited to the depth of the Gaia survey, which has restricted us to the least dark-matter-dominated regions of the Galaxy. Furthermore, cosmological simulations have shown that halo-to-halo variation will severely weaken statistical constraints derived from stream modeling unless we can observe streams in more than a single galaxy. I use synthetic Roman surveys of cosmological simulations to demonstrate how Roman's wide-field view and exquisite sensitivity will address both of these issues: by resolving stars in streams around the nearest 100 Milky-Way-like galaxies, and by extending Hubble's baseline for measuring precise proper motions in the outer Galaxy.

A Window into Gravity: Cosmic Voids x CMB lensing

Mar Perez Sar

Instituto de Astrofísica de Canarias

The discovery of the Universe's accelerated expansion prompted a collaborative effort to uncover the source of this acceleration, either through the identification of a new form of energy (the so-called dark energy) or by considering potential deviations from the general relativity theory at larger scales. To better comprehend the driving force behind this acceleration, researchers have extensively studied standard cosmological probes, such as the Cosmic Microwave Background, Type Ia Supernovae, and Baryon Acoustic Oscillations, pushing the boundaries of precision cosmology. However, discrepancies between measurements obtained from different methods suggest the presence of unaccounted systematic effects or yet-to-be-understood physics. In order to validate existing results and address systematic effects we need new cosmological probes and cosmic voids emerge as one of the most promising new laboratories since their dynamics are less affected by nonlinearities, and theories of modified gravity predict in them more pronounced deviations from our current models. In this work, we conduct forecasts for the upcoming mission of the Roman Space Telescope, involving the cross-correlation of voids with various observables, including CMB lensing and ARF (angular redshift fluctuations). This multifaceted approach aims to improve our understanding of the cosmological landscape and shed light on the nature of gravity in extremely under-dense cosmological regions.

Improving Sample Variance Modeling for Photometric Redshift Calibration in Stage IV Cosmology Survey

Nikolina Šarčević & Boyan Yin

Duke University

Cosmological constraints from late-time surveys are increasingly limited by systematics, with one of the dominant sources of uncertainty arising from photometric redshift errors. These redshift estimates are typically calibrated using deep and spectroscopic fields covering relatively small areas (~ 10 deg²), which are then applied to much larger wide-area surveys (~ 2000 deg² for Roman). This mismatch introduces sample variance, driven by large-scale structure fluctuations beyond the calibration fields, and has been shown to significantly affect redshift calibration and resulting cosmological constraints. In this joint talk, we will present our ongoing work to extend the theoretical framework developed by DES to better capture sample variance effects. We go beyond the standard assumptions of circular field geometry, wide separation, and uncorrelated redshift bins by accounting for realistic field shapes, spatial configurations, and redshift bin cross-correlations. Our goal is to develop practical guidance for designing future deep and redshift surveys that minimize the impact of sample variance on cosmological inference.

Combining Rubin and Roman photometry using LSST Science Pipeline

Tae-hyeon Shin

Carnegie Mellon University

The combination of the Rubin and the Roman data provides a unique opportunity for cosmological and astrophysical studies through the wide overlapping survey area, the broad bandpass coverage and the expected photometric performance of Roman observations, which could help resolving blended galaxies in Rubin images, calibrating Rubin photometry, and obtaining better photometric redshift. Meanwhile, the LSST Science Pipeline provides a flexible photometric calibration and measurement platform that could be readily applied to any observational images. In this presentation, I will present preliminary results of performing a photometric analysis on the simulated Rubin-Roman data based on the forced photometry on the Rubin images using detected objects from the Roman images, and the corresponding improvements in the overall photometric performance of the joint data.

Emulating Systematics in Covariance Matrices for Roman GRS Clustering Statistics

Jaide Swanson

Ohio University

The Roman Galaxy Redshift Survey aims at constructing comprehensive galaxy clustering catalogs which are essential for the precise measurement of Baryon Acoustic Oscillations (BAO), Redshift Space Distortions (RSD), and beyond. In this process, it is critical to characterize systematic uncertainties which can significantly impact clustering analyses and inferences about large scale structure. To aid in this procedure, we simulate galaxy clustering through the use of EZmocks which incorporate a range of systematics to mimic observational and theoretical uncertainties. These simulations allow us to construct covariance matrices that capture various forms of uncertainty and provide a quantitative measure of their impact on both two-point and three-point clustering statistics. These methods and results aim to provide insights into the techniques for uncertainty quantification in cosmology, which are directly applicable to the efforts of the Roman GRS.

Dual AGN and the status of photo-z: synergies across Euclid, Roman and a new HSC medium band survey

Federica Tarsitano

University of Geneva, Department of Astronomy

Supermassive black holes (SMBH) are polyglot citizens of the Universe: across multiple wavelengths, astronomers can observe them igniting as Active Galactic Nuclei (AGN) by matter accretion, and hear the ripples in spacetime, the gravitational waves (GW), they create in collisions. AGN activity is caused either by stochastic gas inflows or by galaxy mergers, the latter fostering the formation of dual AGN. These systems provide observational evidence of SMBH pairs and are the progenitors to BH binaries, which eventually merge and release GW. These phenomena trigger fundamental questions about how frequent they are, and whether the incidence of dual AGN can be used to predict coalescence rates. Instrumental challenges have limited the number of detections confirmed so far to a few hundreds. The Euclid survey, with its currently unmatched high-resolution imaging and wide field of view in the VIS filter, is expected to identify thousands of dual AGN. Another challenge in the identification of dual AGN is obtaining accurate photometric redshifts (photo-z). 1) As part of a systematic study of dual AGN in Euclid, which I am currently leading, I will present the first selection of red quasars in the Euclid Q1 dataset, based on color-color analysis and machine learning techniques (<https://arxiv.org/abs/2503.15319>). Red quasars are thought to represent a key phase in the co-evolution of SMBH and their host galaxies, possibly triggered by galaxy mergers, and provide important insights for a deeper understanding of AGN feedback and galaxy quenching. The sample of red quasars selected with my analysis has both high completeness and purity, and serves as a foundation for follow-up studies, such as morphological classification and environment, including the search for dual AGN candidates. The identified sample of red quasars already shows examples of candidate dual AGN and lensed quasars. Furthermore, I will discuss how the Roman survey, with superior high-resolution NIR imaging and spectroscopic capabilities, can significantly improve upon Euclid AGN and dual AGN selection. 2) Obtaining more accurate photometric redshifts is one of the main focuses of a new survey I am co-leading in collaboration with Japanese institutions. It is a Subaru HSC survey using a novel set of medium-band filters designed for a variety of science topics, covering both cosmology and legacy science. Furthermore, it will provide a significant contribution to the calibration of photo-z. I will discuss the characteristics and the current status of this new survey and how photo-z calibration through MB filters is crucial for ongoing and upcoming deep imaging surveys, including Euclid, Roman, Rubin, as well as the JWST. Information about the new HSC medium band surveys and the characteristics of the filters is available here: <https://sites.google.com/view/hsc-mb-workshop/home>.

**Insights from HSC-Y3 cosmic shear and prospects for HSC final year
analysis and stage IV surveys**

Ryo Terasawa

Institute for Physics and Mathematics of the Universe

Large-scale structure of the universe. Li et al. (2023) and Dalal et al. (2023) measured the tomographic cosmic shear correlation functions and power spectra, respectively, from the HSC-Y3 data, and then constrained the cosmological parameters from the model fitting. Although the small scale data has a high signal-to-noise ratio, accurately modeling matter distribution on these scales is still challenging due to possible contamination from baryonic physics. These baryonic effects have garnered attention as potential contributors to alleviating the S8 tension observed between weak-lensing cosmology and the cosmology inferred from Planck data. As an alternative to pursuing an accurate or flexible baryonic physics model, our approach involves assessing the performance of a dark matter (DM)-only model prediction. We measured the correlation functions at scales below the fiducial scale cuts, reaching the scales where large k-modes ($k \sim 10 \text{ h/Mpc}$) significantly contribute. Using this data, we evaluate the goodness-of-fit of DM-only model predictions. This model can fit the cosmic shear correlation functions measured from the HSC-Y3 data, even at scales below the fiducial scale cuts. The inferred cosmological parameters, especially S8, are not significantly biased compared to those from Li et al. (2023), which marginalize over a baryonic physics parameter and apply scale cuts to discard the scales where baryonic physics could largely affect the signal. From these findings, we conclude that we do not find a clear signature of baryonic effects in the HSC-Y3 cosmic shear data, considering its associated uncertainties. We further discuss the possibility of distinguishing an extreme baryonic effect for HSC final-year data and the Stage IV surveys such as Roman, LSST, and Euclid. Thanks to the statistical power of those future surveys, we will be able to reject an extreme feedback scenario at high significance using the cosmic shear data on small scales. Finally, we present the joint analysis of Planck CMB, CMB lensing from ACT DR6, and cosmic shear data from HSC-Y3 to investigate the possible solutions for the S8 tension, including late time growth suppression due to change in growth index.

Euclid mission: computing the Euclid survey

Ismael Tereno

IA - University of Lisbon

ESA's Euclid mission is designed to probe the dark universe via weak gravitational lensing and galaxy clustering. In addition, the combination of wide field-of-view and high-resolution optical imaging will enable a wide range of science as evidenced by the identification of 30 million objects in the 0.45% of the final survey area recently released (Q1 data release, March 2025). This talk, presented by the Euclid consortium survey scientist on behalf of the Euclid Survey Operations group, focus on the implementation of the Euclid survey, including its wide and deep components. I will describe the process of building a six-year observations schedule that takes into account system constraints and limitations, and science and calibration requirements. The Euclid survey has points in common with Roman's High Latitude Wide Area Survey (HLWAS). Having served in the HLWAS definition committee, I will also present a comparison of the two surveys and their synergies.

Cosmological constraints from joint analyses of clusters, galaxies, and weak lensing

Chun-Hao To

University of Chicago

The large-scale structure of the universe can be probed by different observables. Galaxy clustering, weak gravitational lensing, galaxy cluster abundances, and cluster clustering are each sensitive to different aspects of cosmic structure formation and are affected by different astrophysical and observational uncertainties. Consistency of different observables presents a strong test of our cosmological model. Further, combinations of all observable lead to the most precise and accurate constraint. In this talk, I will present the cosmological constraints from cluster abundances and auto/cross-correlations of clusters, galaxies, and lensing measured from the Dark Energy Survey. I will discuss the implications of the result and prospects for the Euclid, Rubin, and Roman era.

Illuminating the halo mass profiles of dwarf galaxies

Helena Treiber

Princeton University

Dwarf galaxies offer unparalleled insight into the small-scale challenges to Lambda-CDM. To distinguish between dark matter and baryonic contributions to these challenges, we must constrain the low-mass regime of the stellar-to-halo mass relation and investigate the mass profiles at tens of kpc scales for a large sample of dwarfs. Deep wide-field surveys enable precise weak galaxy-galaxy lensing measurements for the full mass profiles of dwarf galaxies, but are limited by the methodological challenge of identifying and characterizing a substantial sample. Focusing on the upcoming roles of Rubin and Roman in these efforts, we present a novel approach to use spectroscopic galaxies to calibrate a larger sample of photometrically-classified dwarf galaxies. With DESI and DES as a test bed, we isolate several stellar mass subsamples to constrain mass profiles down to halo masses of $10^{10.5} M_{\text{sun}}$. At fixed stellar mass, we probe the correlations between galaxy properties (e.g., surface brightness) and halo mass profiles. With the combination of our approach and DESI spectra, we are able to extract and characterize the most comprehensive sample of half a million galaxies with $M^* < 10^9 M_{\text{sun}}$. Roman and Rubin specifications will allow us to both extend to smaller scales and assemble larger, more complete samples. With continued efforts to improve our sample selection, this new window on dwarf galaxies will undoubtedly provide powerful constraints on both cosmological and galaxy evolution models.

Hunting for dark matter in the Milky Way with the Dark Energy Spectroscopic Instrument

Monica Valluri

University of Michigan

A Milky Way Survey is being carried out by the Dark Energy Spectroscopic Instrument (DESI) on the Mayall 4m Telescope at Kitt Peak. This highly efficient 5000-fiber spectrograph has already obtained spectra for over 10 million unique stars down to Gaia $G=19$ providing 6D phase space coordinates as well as other stellar parameters (effective temperature, logg, metallicity, abundance). DESI-MWS has also successfully obtained stellar spectra for stars in the Giant Stellar Stream and stellar halo of the Andromeda Galaxy and in the outer regions of many Milky Way dwarf galaxies. I will first describe some recent results on the kinematic structure of the GD-1 tidal stream and what this might say about dark matter substructure in the Milky Way. I will also describe the goals of an ongoing key project to measure the mass distribution of dark matter in the Galaxy. With the Roman Telescope's ability to obtain proper motions with $<50\text{km/s}$ precision out to the virial radius of the Milky Way, it will be possible to put much stronger constraints on the distribution of dark matter within the Milky Way (including time dependence in the distribution) and probe the nature of dark matter using the kinematic structure of tidal streams.

Kinematic Lensing with Roman Space Telescope

Jiachuan Xu

University of Arizona

Kinematic lensing (KL) is a new cosmological measurement technique that combines traditional weak lensing (WL) shape measurements of disc galaxies with their kinematic information. Using the Tully-Fisher relation, KL breaks the degeneracy between intrinsic and observed ellipticity and significantly reduces the impact of multiple systematics that are present in traditional WL. In this talk, I will report recent progress in pilot KL measurement using JWST JADES imaging and FRESCO grism data. I will then talk about the performance of KL given the instrument capabilities of the Roman Space Telescope, assuming overlap of the High Latitude Imaging Survey (HLIS) and the High Latitude Spectroscopy Survey (HLSS) over 2000 deg^2 . We quantify the cosmological constraining power on $\Omega_m\text{-S8}$ and $w\text{-}w_a$ by running simulated likelihood analyses that account for redshift and shear calibration uncertainties, intrinsic alignment, and baryonic feedback. Compared to a traditional WL survey, we find that KL significantly improves the constraining power on $\Omega_m\text{-S8}$ (1.7 times improvement) and $w\text{-}w_a$ (3.65 times improvement).

Dark Energy Survey Year-6 (DES Y6) Weak Lensing Pixel-to-Cosmology

Masaya Yamamoto

Princeton University

With the last decade of imaging surveys, such as the Dark Energy Survey (DES), a joint weak lensing and clustering analysis has been established as a powerful test of the cosmological model and probe of dark energy. In this talk, I will present weak lensing cosmology results measured with the Y6 shear catalog containing more than 150 million galaxies, constituting the most powerful weak lensing dataset to date. Extracting unbiased cosmological information requires a robust pixel-to-cosmology understanding, including in the measurements of galaxy shapes and fluxes from images and the modeling of astrophysical effects. While the quantity and quality of data promised by next-generation observatories, such as Roman and Rubin, will significantly improve, we must understand what systematic biases prevent us from unlocking their full cosmological information. I will highlight the technological advancements that DES Y6 has made across our analysis, and discuss the current limitations. Drawing on lessons learned, I will present a roadmap to maximize the scientific return from the Stage-IV weak lensing experiments, and with the combination of multi-probe observations such as CMB.

RAIL: open-source platform for photometric redshift estimation and research

Tianqing Zhang

University of Pittsburgh

For the Roman Space Telescope, virtually all extragalactic science cases rely on accurate galaxy redshift information. A large fraction of galaxies will rely on photometric redshifts (photo-z). We present the Redshift Assessment Infrastructure Layers (RAIL), an open-source Python library for scalable, probabilistic photo-z estimation. RAIL is a general-purpose toolkit applicable across multiple surveys, developed by the Rubin LSST Dark Energy Science Collaboration and the LINCC Frameworks. Its modular subpackages provide an end-to-end framework for stress-testing photo-z methods: a forward modeling suite for generating complex mock photometry, a unified API for computing per-galaxy and ensemble redshift PDFs using an extensible set of algorithms, and built-in metrics for evaluating both PDFs and point estimates. RAIL is well positioned to support photo-z estimation and research for Roman's High Latitude Wide Survey and other extragalactic programs. In this talk, we present RAIL's capabilities to the Roman science community, with the goal of fostering shared infrastructure for photometric redshift estimation in preparation for Roman data.

Data Augmentation, Efficient Marginalisation & Accelerated Computation for LSST Cosmology

Yunhao Zhang

University of Edinburgh, Institute for Astronomy

The exceptional statistical power and imaging depth of LSST will enable unprecedented constraints on the cosmological model, as well as on the nature of dark matter and dark energy. However, accurately estimating ensemble redshift distributions and efficiently marginalising over their uncertainties remain key challenges. In this talk, I will present a novel approach that leverages Self-Organising Maps (SOMs) to project the high-dimensional galaxy colour space into a two-dimensional representation. This enables the identification of regions in colour space poorly sampled by spectroscopy, which are then augmented using synthetic galaxy catalogues to build representative training datasets for photometric redshift estimation. Our method achieves sub-percent accuracy in the mean redshift distribution for both one-year and ten-year observations from the Rubin Observatory, and forward-models realistic variations from multiple sources of systematic error—including photometric noise, point-estimation bias, tomographic binning, and spectroscopic selection effects. Using these simulated redshift distributions, we show that conventional parametrisations—typically simple shifts along the redshift axis—severely underestimate statistical uncertainties, by up to an order of magnitude for galaxy clustering. To address this, I develop two distinct strategies grounded in data-driven and theoretical frameworks. First, I employ a machine learning algorithm, the Variational Autoencoder (VAE), for non-linear, lossless dimensionality reduction—offering greater efficiency than standard Principal Component Analysis (PCA). This approach compresses thousands of redshift distribution realisations into a Gaussianised latent space of significantly reduced dimensionality. These latent variables can be efficiently resampled using Gaussian priors, enabling the reconstruction of redshift distribution covariances and more accurate marginalisation over uncertainties. Cosmological forecasts using synthetic datasets demonstrate that weak lensing constraints remain robust under different marginalisation techniques. However, when combined with large-scale structure probe, our VAE-based approach yields a 20% reduction in the Figure-of-Merit—correcting overestimations from conventional methods and highlighting the necessity of this improved framework. This methodology will be integrated into the LSST-DESC inference pipeline for future collaboration-wide application in precision cosmology. The second approach reformulates summary statistics analytically in terms of systematic parameters, allowing direct analytic marginalisation over nuisance parameters without requiring extensive sampling in high-dimensional spaces. These formulae are optimised for parallel execution, offering significant computational speed-ups and enabling efficient exploitation of modern hardware such as GPUs. This principled, generalised mathematical framework can be applied across various areas of cosmology, including angular power spectra in curved spacetime, beyond the Limber approximation, higher-order statistics, and their covariances—paving the way for accelerated inference in the data-rich era of cosmological surveys. All three projects are supported by the LSST-DESC. The first project is currently undergoing DESC internal review, while the latter two are in active development and expected to be completed ahead of the conference. Preliminary results are included in the attached poster, which was presented at Euclid Consortium meeting this year.

Posters

Detection of Baryon Acoustic Oscillation Ring at Redshift (z) 0.067?

Majidin Abdullah

PhD Researcher, Faculty of Computing and Informatics, Multimedia University, Cyberjaya, Malaysia

For the Roman Space Telescope, virtually all extragalactic science cases rely on accurate galaxy redshift information. A large fraction of galaxies will rely on photometric redshifts (photo-z). We present the Redshift Assessment Infrastructure Layers (RAIL), an open-source Python library for scalable, probabilistic photo-z estimation. RAIL is a general-purpose toolkit applicable across multiple surveys, developed by the Rubin LSST Dark Energy Science Collaboration and the LINCC Frameworks. Its modular subpackages provide an end-to-end framework for stress-testing photo-z methods: a forward modeling suite for generating complex mock photometry, a unified API for computing per-galaxy and ensemble redshift PDFs using an extensible set of algorithms, and built-in metrics for evaluating both PDFs and point estimates. RAIL is well positioned to support photo-z estimation and research for Roman's High Latitude Wide Survey and other extragalactic programs. In this talk, we present RAIL's capabilities to the Roman science community, with the goal of fostering shared infrastructure for photometric redshift estimation in preparation for Roman data.

Galaxy Distances and Peculiar Velocities in the Era of Roman

Gagandeep Anand

Space Telescope Science Institute

We are entering a gold era of measuring precise and accurate galaxy distances with the recent launch of JWST and the soon-to-launch Roman Space Telescope. Tip of the red giant branch (TRGB) distances to nearby galaxies provided by JWST can anchor surface brightness fluctuation (SBF) measurements with Roman, which extend much further in range than the TRGB. With the potential to measure SBF distances to thousands of galaxies within hundreds of Mpc, Roman will enable the construction of well-sampled peculiar velocity fields for cosmological analyses. The vast number of SBF distances will also allow us to obtain a value of the Hubble constant which can match the precision of the Population I route which uses Cepheids and Type Ia supernovae.

Compressing the Galaxy Color-Redshift Relation for Roman using UMAP

Finian Ashmead

University of Pittsburgh

Spectroscopic redshift (spec-z) data sets will be critical for Roman photometric redshift (photo-z) estimation, both for training machine learning algorithms and optimizing template-based methods.

However, spec-z data sets are both limited in size and not fair representations of photometric samples. Spec-z training sets sparsely sample the high-dimensional Rubin+Roman color space, so dimensionality reduction methods are used to compress color space to improve photo-z training/calibration. The most popular such approach is self-organizing maps (SOMs), which partition color space into discrete cells. However, SOMs often feature sharp discontinuities between adjacent cells in key quantities including redshift and specific star formation rate (sSFR), preventing reliable interpolation across the SOM. We consider an alternative to SOMs, UMAP (Uniform Manifold Approximation and Projection), that has critical advantages over SOMs. We show that UMAP can compress an eight-dimensional Rubin+Roman-like color space to three dimensions, recovering a thin manifold with continuous, monotonic, and roughly orthogonal trends in redshift and sSFR, the primary drivers of overall galaxy SED shapes. By interpolating and resampling from our UMAP, we will be able to construct new spec-z training sets that match photometric samples, improving the training/calibration of Roman photo-z's.

Simulation-trained UNet to Identify Tidal Streams in Milky Way-type Galaxies

Rosie Bartlett
LJMU Liverpool

Tidal stellar streams are of particular interest to the study of dark matter as their number counts and morphological features are directly linked to the nature of dark matter subhalos around their host galaxies. However, the identification of stellar streams in images of galaxies is difficult as they are very faint compared to other stellar components. Additionally, the large influx of images expected from upcoming large-scale sky surveys will make it increasingly unrealistic to expect to be able to identify stellar streams by visual examination alone. Here we will present a machine learning classifier trained to identify streams in images of simulated galaxies, with the aim to be able to use it on images from surveys. We use the Auriga suite of high-resolution cosmological simulations of Milky Way-mass galaxies to create a dataset of over 1500 images of galaxies with tidal features which can be automatically labelled, pixel-by-pixel, according to the origin of stellar particles. This level of labelling would be difficult and time consuming to do by hand with observations. We also avoid the issues associated with combining existing observational datasets, which would be necessary to get a large enough training sample. For example, differences in observing equipment and data processing pipelines can introduce irrelevant patterns that the classifier picks up on, reducing its effectiveness. We use this set of images to train a UNet - a type of convolutional neural network architecture which identifies structures in images through pixel-by-pixel labelling, allowing us to localise streams within an image. We will also assess performance on observations and, if needed, fine-tune the classifier on smaller observational datasets (such as upcoming data from Euclid), labelled by experts. In the future we plan to further extend this to analyse possible perturbations in the streams produced by interactions with nearby dark matter subhalos and, more generally, to quantify phase-mixing undergone by streams.

Simulation-based modeling with neural networks for IA and bias

Jonathan Blazek
Northeastern University

Taking full advantage of high-precision cosmological data from Roman and other upcoming surveys will require both improved understanding of systematic effects and new statistical approaches. Two main systematics are intrinsic alignments (IA) and galaxy bias, which impact measurements of weak lensing and galaxy clustering. Current modeling often utilizes perturbation theory to extract information beyond the linear regime. However, future analyses will likely require fully nonlinear descriptions, especially for weak lensing measurements that rely on small-scale information. I will present recent and ongoing work to develop a simulation-based modeling framework for IA and bias, based on gravity-only simulations and semi-analytic models for galaxy occupation and IA. We are able to produce large, simulated volumes with realistic galaxy statistics, including flexible parameterizations for IA and the galaxy-halo connection. Using these simulations as training data, we have constructed neural network-based emulators to allow direct, simulation-based modeling of IA, lensing, and galaxy clustering. This approach will provide an accurate, nonlinear model for both standard lensing statistics (e.g. the two-point lensing and clustering correlation functions) as well as any beyond two-point statistic that can be measured from simulated data.

Neural Network Emulators for Roman 3x2pt Analyses: Forecasting the Dark Energy

Figure-of-Merit

Haley Bowden

University of Arizona

The joint weak lensing and galaxy clustering (3x2) analysis of the Roman High-Latitude Wide-Area Survey has the potential to provide competitive constraints on cosmological parameters, including evolving dark energy. Yet, in preparation for the survey, quantifying the impact of various systematic effects and different survey scenarios on this science return poses a major computational bottleneck. To overcome this bottleneck, we use neural network emulators to greatly accelerate the computation of data vectors while maintaining high accuracy, allowing us to efficiently run many likelihood analyses. We assess how different systematic effects (e.g., photometric-redshift and shape measurement uncertainties) contribute to the overall error budget. Additionally, we examine how survey area and depth impact the dark energy figure-of-merit, providing insight into optimal survey strategies.

Wavelength-Dependent PSF in Roman Grism Simulations

Keith Buckholz

Yale University

I will describe the methods and software being used to implement wavelength-dependent PSF into the Roman Galaxy Redshift Survey Project Infrastructure Team Grism Simulations. The Roman WFI slitless grism's 10000 Å wavelength range is wide enough that a given object's PSF will vary significantly from the reddest to the bluest wavelengths. To more realistically simulate contamination, especially from stars, we are developing code which allows an object's PSF to vary with wavelength across its simulated dispersed image. This code is being developed alongside the broader Roman GRS PIT grism simulations within the GRS PIT github.

Constraining Low-Mass Galaxy Evolution using Internal Stellar Age Gradients from Resolved Stars

Roger Cohen

Rutgers the State University of New Jersey

The shallow potential wells of low-mass galaxies render them ideal probes of the physics driving galaxy evolution. Within the Local Volume, Hubble and JWST have amassed a wealth of imaging of low-mass galaxies, resolving stars from their cores to several half-light radii across a huge swath of galaxy mass-metallicity-environment parameter space. We present radial stellar age gradients measured from star formation histories fit directly to color-magnitude diagrams for a statistically significant sample of Local Volume dwarfs. We demonstrate that internal stellar age gradients are an actionable parameter for both discriminating between different sets of cosmological simulations as well as placing novel purely empirical constraints on low-mass galaxy evolution. Case studies of the nearest dwarfs provide tantalizing hints of how Roman's high-fidelity, wide-field imaging will further our understanding of galaxy evolution across a range of environments.

Deciphering Baryonic Feedback with ACT Galaxy Clusters

Nihar Dalal

The Ohio State University

The goal of the next generation of cosmic shear surveys is to probe the matter distribution of the universe to incredible precision. In order to actually attain this level of precision on cosmological parameters, we need to use information at small scales of ~ 1 Mpc, which requires a robust model of baryonic feedback. We use the Dark Matter + Baryon (DMB) model, a flexible halo model with several parameters to describe baryonic feedback that is well fit to a variety of different hydrodynamical simulations. Using a sample of tSZ selected galaxy clusters from ACT with masses calibrated via DES, we show that the tSZ Y-M relation can provide constraints on several DMB model parameters, and thereby give us crucial information about the impact of baryonic feedback on cosmic shear. We compare to predictions from several hydrodynamic simulations, and discuss implications for future surveys such as Roman and Rubin.

Probing Dark Matter and Large-Scale Structure with Roman's High-Precision Weak Lensing Surveys

Debjyoti Dutta

The Nancy Grace Roman Space Telescope's unprecedented combination of wide-field imaging and high-resolution sensitivity will revolutionize weak gravitational lensing studies, offering an unparalleled view of the cosmic web and the distribution of dark matter. By mapping the distortion of galaxy shapes across vast cosmic volumes, Roman will provide a precise measurement of the matter power spectrum and its evolution over cosmic time. This work will focus on leveraging Roman's weak lensing data to constrain the clustering properties of dark matter and test modifications to General Relativity at large scales. We will explore synergies between Roman and other contemporary surveys, such as Euclid and the Rubin Observatory, to enhance constraints on cosmic shear and galaxy-halo connection models. Additionally, we will discuss machine-learning-based approaches for mitigating systematics in shear measurements and photometric redshifts. With its ability to probe small-scale nonlinear structures and large-scale cosmological anisotropies simultaneously, Roman will offer critical insights into the fundamental nature of dark matter and the physics driving cosmic acceleration.

Probing Dark Matter and Large-Scale Structure with Roman's High-Precision Weak Lensing Survey DeepDISC: Deep Learning-Driven Deblending Using Overlapping Roman and Rubin LSST Data

Yash Ejjagiri

University of Illinois at Urbana – Champaign

DeepDISC, our deep learning object detector/deblender/classifier, addresses a critical challenge in large-scale cosmic surveys: the systematic effects of source blending and classification. DeepDISC offers a versatile range of applications, but this study focuses on unrecognized blends, a major source of systematic error present in ground-based surveys such as the Legacy Survey of Space and Time (LSST). With the Nancy Grace Roman Space Telescope's unprecedented capability to survey the sky 1000 times faster than Hubble, while maintaining similar sensitivity and resolution, it presents a unique opportunity to enhance our understanding of galaxy structures and distributions. By leveraging Roman's higher resolution space-based imaging in combination with Rubin Observatory data, we aim to significantly improve the recognition of blended sources compared to traditional detection algorithms. Our model will be trained on simulated Rubin images and input catalogs as a baseline, with the addition of Roman imaging data during training and testing phases. This approach will allow us to quantify the impact of Roman's higher resolution on blend recognition, source classification accuracy, and overall catalog completeness and purity. By comparing DeepDISC's performance against truth catalogs and science pipeline results from both Roman and LSST, we will demonstrate how this synergy between space-based and ground-based observations can optimize scientific output and reduce systematic uncertainties that affect weak lensing measurements. Preliminary tests show a 10% improvement in detection completeness-achieved exclusively through joint Roman-LSST training-leading to a better mapping of the universe that will be crucial for downstream cosmological analyses.

Dark Matter and Galaxies in and Around Galaxy Clusters

Shenming Fu

SLAC National Accelerator Laboratory

We present observational evidence of the impact of triaxiality on radial profiles that extend to 40 Mpc from galaxy cluster centers. We measure cluster weak lensing and excess galaxy density profiles, extracted along the cluster’s major or minor axes projected on the plane-of-the-sky, and name these the “axis-aligned profiles”. By stacking thousands of nearly relaxed galaxy clusters from public data releases, we find a significant difference between the axis-aligned profiles: plus/minus 10–20% along the major/minor axis compared to the azimuthally averaged profile. This difference appears inside the clusters (~ 0.4 Mpc) and extends to the large-scale structure regime (~ 10 – 20 Mpc), suggesting an elliptical 2-halo term. The magnitude of the difference appears to be relatively insensitive to cluster richness and redshift, and extends further out in the weak lensing surface mass density than in the galaxy overdensity. Also, the normalized lensing profiles exhibit a clear necking feature at the cluster edge, indicating a morphological transition between the cluster halo and the filamentary structure. We find similar evidence in N-body cosmological simulations. In addition, we have identified analogous signatures of cluster triaxiality in the phase space using observational spectroscopic data – the line of sight speeds of galaxies along the cluster major and minor axes are systematically different as well, starting from the inside to the large-scale neighborhood of clusters. Looking forward, this measurement can be easily applied to other datasets and can inform cluster systematics modeling related to triaxiality far beyond the centers of clusters.

Stress Testing a Simulation Based Inference Approach to Weak Lensing Galaxy Cluster Mass Inference

Akum Gill

University of Michigan

We present an open source Python package to compare simulation-based inference (SBI) approaches to MCMC inference in the context of galaxy cluster mass estimates from gravitational weak lensing data. The package, CLSBIWeakLens, provides a modular framework to flexibly run numerical experiments on cluster mass estimation from radial profiles, a typical data vector in optical cluster cosmology from surveys such as the Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST). CLSBIWeakLens has modules to define the ‘simulations’ used to train the SBI, modules to build the inference procedures, and a straightforward interface for the user to create new experiments through user-defined configuration files. Our framework allows for testing the robustness of inference posteriors to noise in the data, approaches to stack data vectors to average out the noise, and modeling choices for population statistics and the mass distribution within each galaxy cluster. We illustrate example experiments that we lay out in tutorials, highlighting (1) tests on the effects of noisy data on posteriors with inference performed on stacked radial profiles and on individual radial profiles, and (2) tests on inference performed with a misspecified model. This framework provides foundations to the potential application of SBI to speed up inference in hierarchical models for galaxy cluster cosmology. The source code is publicly available on GitHub.

A 6D Jeans Analysis of the Sagittarius Dwarf Spheroidal core

Isabelle Goldstein

Texas A & M University

The stellar kinematics in dwarf galaxies can provide a wealth of information about its underlying dark matter distribution. Using Gaia DR3 data, we examine the kinematics of the central core of the Sagittarius (Sgr) dwarf spheroidal galaxy using data which includes proper motions and line-of-sight velocities for member stars in addition to their projected positions. We extract a sample of bright stars that are high-probability members of Sgr. We obtain a velocity anisotropy of $\beta_a = -2.24 \pm 1.99$, which implies a system with tangentially-biased orbits. Proper motions and complete position information could be used to break the existing velocity anisotropy and central density degeneracy; however without accurate distances to these stars, a 6D Jeans analysis cannot be performed. We use new observations obtained with the Magellan/MIKE spectrograph to measure distances and line-of-sight velocities for RR Lyrae and red clump stars with the Sgr core to perform a full 6D Jeans analysis.

Enhancing Spectral Resolution with Diffusion Models: Super-Resolving Low-Resolution Galaxy Spectra

Aryana Haghjoo

University of California – Riverside

High-resolution spectroscopy is essential for studying galaxy properties, but acquiring such data is observationally expensive. We present a novel application of diffusion-based deep learning models to enhance the spectral resolution of galaxy spectra, increasing the resolving power from $R \sim 100$ to $R \sim 1000$. Our approach utilizes JWST/NIRSpec observations from the JADES program, where we reconstruct high-resolution spectra from the low-resolution PRISM dataset ($R \sim 100$). To achieve this, we combine three medium-resolution datasets—F070LP/G140M, F170LP/G235M, and F290LP/G395M—each covering different wavelength ranges, into a unified high-resolution reference spectrum. The model is trained on 80% of the data, with the remaining 20% used for validation. Validation is performed by assessing the accuracy of recovered atomic line wavelengths and flux ratios (e.g., $H\alpha/H\beta$). By leveraging learned priors from high-resolution data, this method enables superior deblending of emission lines, such as [NII] and $H\alpha$, compared to traditional stellar mass scaling approaches, leading to more precise redshift measurements for galaxy clustering among other things. Our method has broad implications for future deep-field surveys, including those from the Roman Space Telescope, where low-resolution grism spectra could be computationally transformed into high-resolution datasets, unlocking new insights into galaxy formation and evolution.

Mapping the Whole Sky with Roman

Jesse Han

Harvard University

The Nancy Grace Roman Space Telescope offers an unprecedented opportunity to deliver a high-spatial-resolution ($\sim 0.1''$), multi-epoch, all-sky infrared map to the astronomical community. This capability will uniquely complement a broad array of current and upcoming ground- and space-based surveys—such as Rubin/LSST, Euclid, SPHEREx, DESI, SDSS-V, GALAH, 4MOST, WEAVE, and others. Roman's combination of uniform depth, fine resolution, and infrared sensitivity will not only enhance the science return of these efforts, but also enable transformative standalone discoveries. We propose NANCY: a fully public, legacy all-sky survey comprising two epochs of wide-band infrared imaging. Roman will measure proper motions for stars across the Milky Way, reaching $100\times$ fainter than Gaia and extending to the Galaxy's edge. This dataset would benefit virtually all areas of astrophysics—from stellar populations to near-field cosmology—by providing a precise, deep, high-resolution infrared foundation. As one example, NANCY proper motions can detect perturbations in the Sagittarius stream from dark matter substructure, offering direct insight into the small-scale structure of CDM halos. We outline a feasible pathway for obtaining the first all-sky epoch within Roman's nominal five-year mission.

Predictions of the early cosmic web structure and its impact on galaxy morphologies

Farhanul Hasan

Space Telescope Science Institute

The large-scale cosmic web supplies galaxies with mass and momentum that enables their continuous growth, but the physical mechanisms underlying this connection remain unclear. We developed a novel method that uses galaxies as tracers to map the cosmic web by emulating the growth of the "slime mold" organism. To study the impact of gas accretion on the morphological evolution of galaxies, we apply this method to the IllustrisTNG cosmological simulations. While most dark matter halos remain aligned with their nearest filament across $z=0-4$, the stellar components of galaxies lose this alignment at $z<3$, suggesting baryonic feedback processes at cosmic noon redistribute angular momentum of gas as it accretes from filaments to small scales closer to galaxies. We also find that, at fixed stellar mass at $z>1$, galaxies residing in lower density filaments tend to be more elongated, disky, and compact than those in higher density filaments. At lower redshift, this dependence is less pronounced. We will apply our slime mold method on the upcoming High Latitude Wide Area Survey with Roman to produce the first high-quality maps of the observed cosmic web at $z>1$. Roman's large field-of-view, depth, and measurement of spectroscopic redshifts will uniquely enable this breakthrough. Combined with high-resolution imaging of galaxies, this can revolutionize our understanding of how angular momentum is transferred from the cosmic web to galaxies. Finally, I will show how the identification of cosmic web structure at different redshifts depends on the stellar mass and magnitude-completeness limits of large galaxy surveys.

Cosmological Simulations and the Galaxy--Halo Connection in the Roman Era

Andrew Hearin

Argonne National Laboratory

The character of cosmological survey data in the Roman era will be qualitatively unlike the measurements of the past 20 years. The spatial extent of near-future datasets is such that multi-wavelength information from thousands of square degrees of overlapping sky will become available for the first time. Cosmological simulations coupled with forward models of the galaxy--halo connection provide critical tools to help ensure that our theoretical predictions will meet the quality of the data. In this talk, I will review recent advances in large cosmological simulations and the galaxy-halo connection, and discuss where the state of the field will be upon arrival of Roman data.

Mapping Ionized Bubble Structures Around Protoclusters During the Epoch of Reionization with Roman

Intae Jung

Space Telescope Science Institute

Recent JWST observations have enabled efficient identification of reionization-era galaxies, particularly through strong $H\beta+[O III]$ emission from $z \sim 7$ galaxies, captured via flux excess in the NIRCcam F410M filter. Leveraging this technique across public JWST fields, we have assembled a robust sample of $z \sim 7$ $H\beta+[O III]$ emitters, enabling unprecedented statistical studies of galaxies during the mid-phase of reionization. By analyzing their spatial clustering, we identify protocluster candidates and investigate their connection to the growth of ionized regions, probing how large-scale structure influenced the topology of reionization. The Roman Space Telescope's wide-field spectroscopic capabilities will revolutionize this effort. Roman's blind emission-line surveys over contiguous 0.281 deg^2 fields will allow for efficient, unbiased searches for Lyman- α emission at $z > 7$, revealing the morphology of ionized bubbles and their relationship to underlying density fields traced by galaxies and clusters. Roman will deliver a comprehensive, large-scale view of reionization, connecting galaxy formation, ionizing photon escape, and cosmic structure growth in synergy with JWST. This presentation will highlight our current progress and outline future plans to leverage Roman to probe the link between ionized bubbles and protoclusters at large scales.

Galaxy Structure Formation As Predicted by Stellar Streams Observed by Roman and Other Surveys

Seppo Laine

Mergers and tidal interactions between massive galaxies and their dwarf satellites are a fundamental prediction of the Lambda Cold Dark Matter cosmology and create a plethora of faint structures in the outskirts of galaxies. These patterns are often referred to as stellar streams and provide important observational diagnostics of nonlinear structure formation. However, constructing a statistically meaningful sample of stellar streams beyond the local Universe has proven a daunting observational challenge, and thus the full potential for deepening our understanding of galaxy assembly using stellar streams has yet to be realized. In this poster we report on a case study, SPRC047, a stellar stream around an edge-on galaxy at $z = 0.031$. We conclude that to obtain reliable estimates for the age and metallicity of the low surface brightness streams observed only in integrated light, observations covering ultraviolet to mid infrared wavelengths are needed, together with absolute flux calibration uncertainties at or below the 1% level. We also present the first results from the pioneering systematic survey of stellar tidal streams around a sample of > 3000 nearby galaxies based on DESI LS imaging data, with the ultimate aim of comparing their incidence and structural properties with those predicted by state-of-the-art cosmological simulations. We discuss how Roman's observations of stellar streams around nearby galaxies will improve our understanding of galaxy structure formation.

**Galaxy Structure Formation As Predicted by Stellar Streams Observed by Roman
and Other Surveys Removing correlated noise from the Roman sensor chip array through
destriping algorithms**

Katherine Laliotis

The Ohio State University

Measurements of weak gravitational lensing require extreme control of systematic errors. Even a small amount of error introduced by instrument systematics like the brighter-fatter effect, inter-pixel capacitance, or correlated noise can bias weak lensing measurements of galaxy shear γ by a significant factor. Previous works have shown the H4RG detectors of the Nancy Grace Roman Space Telescope (Roman) Wide Field Instrument (WFI) show correlations in their noise fields at a level significant for weak lensing measurements, even after application of reference pixel corrections. In this paper, we present imDestripe: a new Python module utilizing Roman's multiple dithered image observing strategy and linear algebra techniques to remove correlated noise stripes from observed images. We assess the success of this method at suppressing correlated read noise, and further estimate the improvement on weak lensing statistics gleaned from the algorithm's application.

Exploring hydrodynamics with the Frontier-E simulation

Patricia Larsen

Argonne National Laboratory

Frontier-E is a revolutionary new simulation run on the Frontier supercomputer, evolving over 4 trillion particles using a hydrodynamic version of the hardware-hybrid accelerated cosmology (HACC) code, with conservative reproducing kernel SPH particles and sub-grid physics models, out to scales of 3.15Gpc/h. Such extreme-scale hydrodynamic simulations, enabled by exascale machines, bring opportunities to explore baryonic effects and push cosmological analysis into smaller scales where such modeling is vital. I will present further details of the simulation run, alongside early results and images from the Frontier-E Universe.

Star Formation History of Nearby Galaxy from UV, Optical and Infrared Observations

Denis Leahy

University of Calgary

Local group galaxies can be studied with high spatial resolution, allowing mapping of stellar populations and dust and gas properties at sub-kpc scales. Methods for inferring the star formation history from combined UV, optical and infrared data are described. The resulting measurements of spatial variations of star formation history and are some of the best indicators of the conditions of mass accretion of the galaxy over cosmic time. Some of the new results for star formation in nearby galaxies and their implications are discussed.

Stellar Halo Outskirts as Proxies for Dark Matter Halo Mass

Katya Leidig

University of Maryland

Using deep imaging from Hyper Suprime-Cam (HSC) as a proof of concept, we have shown that the stellar mass in the outskirts of brightest cluster galaxies (BCGs)—specifically between 50 and 100 kpc—can serve as a promising proxy for dark matter halo mass. To explore the physical origin and robustness of this connection, we forward model stellar halo profiles from the IllustrisTNG simulations, generating mock 2D surface density profiles out to 500 kpc. These mock-observed profiles match well with HSC data and allow us to systematically test alternative definitions of outskirt mass that may better trace halo mass. With the upcoming Roman Space Telescope, we will be able to extend this analysis to larger samples and greater radii, thanks to its depth and wide-area coverage. Roman will enable precise measurements of stellar halos around BCGs well beyond 100 kpc and across a range of environments, allowing us to apply and refine these simulation-informed models to constrain dark matter halo masses in a new observational regime.

DeepDISC-WL: Deep Learning for Efficient and Robust Weak Lensing Shape measurement

Shurui Lin

Shape measurement is a key step in weak lensing shear estimation. DeepDISC-WL aims to develop a scalable approach that combines object detection, deblending, classification, photometric redshift estimation, shape measurement, and eventually shear inference.

We plan to achieve this based on our existing DeepDISC framework (Merz et al. 2023 and Merz et al. 2024; DESC-PUB-00177) and incorporate hybrid CNN-transformer architectures or generative models to enhance training and validation. Key products include precise probabilistic shape measurement end-to-end deep learning models, enabling high-precision shear measurements in complex observational settings.

VENUS in the Half-Shell: Wider Environments of Massive Lensing Galaxy Clusters with Roman and Rubin

Ray Lucas

Space Telescope Science Institute

VENUS is a JWST Cycles 4 & 5 NIRCам + NIRSpec Treasury Program to observe 60 of the best-studied lensing galaxy clusters in the redshift range 0.18 (Abell 1689) $< z < 0.89$ (El Gordo), with an emphasis on the lensing and detection and characterization of objects such as distant, lensed galaxies and stars, variable AGN, and transient objects such as supernovae whether in the clusters themselves or lensed supernovae at higher redshift behind the lensing cluster. As such, the focus of the program will necessarily be on the area of the clusters themselves and lensed objects behind them. However, each cluster, like VENUS on the half-shell, also exists within a surrounding environment to which it is connected, and which it may influence and in turn be influenced by in various possible ways. The advent of both the Rubin optical and Roman infrared observatories will allow for a synergy between the two as well as facilities such as Subaru's HyperSuprimeCam which may be propitious for a new and more detailed characterization of the environments of these clusters, and of such higher-resolution features as the environments and frequencies of various types of supernovae and variable AGN etc. not only in the clusters, but in the areas surrounding them along filaments and voids in the Large-Scale Structure, and for the study of such farther-field phenomena as weak lensing farther away from the clusters. Rubin's repeated wide-field optical observations open up time-domain studies to go along with Roman's wide-field infrared observations with greater morphological detail. Since Roman's shortest wavelength filters may still be too red for finding dropouts at lower redshift, the frequent repetitive (and additive, for cumulative depth) optical imaging in Rubin's ugrizy filters may potentially be combined with Roman's higher resolution wide-field infrared imaging to both allow for more accurate photometric redshifts for objects and comparative higher resolution studies around the outskirts of the clusters and along filaments and voids in the Large Scale Structure when the number of optical and infrared filters are combined. Depending on the redshift and angular sizes of each cluster on the sky, the number of Roman fields required to cover them and their environments sufficiently widely may vary from a single Roman field to perhaps one or two or a few, and the time required to reach reasonable depths over a wide enough area may therefore also vary. If too expensive for the whole VENUS sample, or even the subset that is available to both Rubin and Roman, an alternative may be to simply study the evolution of cluster cosmology and Large Scale Structure with a subset of

higher-redshift VENUS clusters and their environments accessible to both which will generally be smaller in angular size and represent clusters at an earlier time in the universe, and possibly requiring only a smaller Roman footprint along with some assistance from Rubin photometry where possible for identifying photometric redshifts for galaxies in the filaments around lower-redshift clusters. If spectroscopic redshifts for some of the galaxies in the wider areas around these clusters already exist in surveys such as the HSC, they may also help act as a check on the accuracy of the photometric redshifts from combining Roman and Rubin data in general. This combination of time variable studies, additive depth, and coverage across a generous range of optical and infrared wavelengths may have the potential to open up newer, more detailed, wider-field studies of galaxy clusters and cluster cosmology, and the galaxies, AGN, and various kinds of supernovae and other objects in the extended surrounding environments of at least some if not all of these well-studied clusters.

Constraining Extended Circumgalactic Dust Halos with TNG300

Bryanne McDonough

Northeastern University

It is now well established that large quantities of dust exist around galaxies, extending over tens of megaparsecs. The presence of this dust around foreground galaxies affects the light received from background sources through extinction and reddening. Constraining the amount of this dust around foreground galaxies has broad implications for interpreting observations that will be made with the Roman Space Telescope, especially regarding supernovae cosmology and high-redshift galaxy evolution. In this talk, I will discuss the post-processed dust models I have applied to the results of the TNG300 simulation and I will present radial profiles of dust column density as a function of galaxy characteristics such as redshift, luminosity, stellar mass, and star formation rate. Observational investigations into large-scale dust distributions typically require large data sets and the technique of 'stacking' many systems together to obtain statistically significant results. My work with the TNG300 simulation will inform these observational studies by constraining whether and how the distribution of dust around galaxies varies as a function of galaxy properties.

DeepDISC photo-z: Image-based Photometric Redshift Estimation for Large Scale Surveys

Grant Merz

University of Illinois at Urbana – Champaign

Source redshifts are a key component in cosmological analyses including weak lensing and galaxy clustering. However, complete spectroscopic redshift samples will be impossible to obtain for upcoming surveys such as the Legacy Survey of Space and Time and those utilizing the Nancy Grace Roman Space Telescope. This problem has led to the development of photometric redshift (photo-z) estimation, as photometry represents a low resolution spectral energy distribution (SED) and therefore can be used to constrain a source's redshift. Traditional photo-z methods utilize catalog-level aperture photometry to either fit to a set of template SEDs, or use as a training set for a machine learning algorithm. However, a growing focus has been placed on image-based photo-z estimation with deep learning. Advances in deep learning and artificial intelligence have produced robust and reliable photo-z estimators that utilize all pixel-level information of a source. We present our photo-z estimator, DeepDISC photo-z, which has been vetted on simulated LSST data and integrated with LSST Dark Energy Science Collaboration software. Our method is based on open-source AI models designed to detect, deblend, and measure source properties. Our method uses a state-of-the-art vision transformer model and a Mixture Density Network to produce photo-z posteriors for every detected object.

We present our results of a comparison study involving our method and traditional photo-z estimators on simulated LSST data. We find that our model produces lower bias, scatter, and outlier fractions when compared to traditional methods, and is less sensitive to systematic effects such as blending. Additionally, we demonstrate our model's effectiveness in preliminary results on real data from JWST. An important use-case of our method will be on overlapping Roman+Rubin observations, as the near-infrared Roman filters are expected to improve photometric redshift observations for higher redshift sources. We also present preliminary results of our photo-z estimator on simulated Rubin+Roman data.

Rest-Frame Near-Infrared Size Evolution of Low-Mass Quiescent Galaxies Out to Redshift $z = 4$

Gourab Nandi

University of Missouri – Columbia

We study the size and morphology of dwarf galaxies (stellar mass of 10^8 to $10^{9.5}$ solar mass) at high-redshift ($0 \leq z \leq 4$) by using the NIRCcam broad-band images from the JWST Advanced Deep Extragalactic Survey (JADES) and the Cosmic Evolution Early Release Science Survey (CEERS). Dwarf galaxies are fundamental to our understanding of galaxy formation and evolution as they are sensitive probes of the physics of dark matter halos and the mechanisms that regulate galaxies' star formation and shape. In this work, we analyze the stellar morphology (half-light radius, Sérsic index, axial ratio, etc.) of $\approx 40,000$ dwarf galaxies complete to 28 ABmag in F444W to as early as 1.5 Gyrs after the Big Bang. It hence places strong constraints on models of galaxy structure formation. By exploring the size-mass relation and the redshift evolution of its slope and scatter, we find that star-forming galaxies are well represented by a single power law on the size-mass plane over the entire redshift range.

Conversely, the stellar mass-size relation is steep for quiescent galaxies with stellar masses $\gtrsim 10^{10} M_{\odot}$ and flattens at lower masses. As a result, two separate power laws are preferred for the stellar mass-size relation of quiescent galaxies. We find no strong redshift dependence in the slope of the relation of star-forming galaxies as well as of high-mass quiescent galaxies. We also show that star-forming galaxies with stellar masses $\geq 10^8 M_{\odot}$ and quiescent galaxies with stellar masses $\gtrsim 10^{10} M_{\odot}$ have undergone significant size growth since $z \sim 4$, as expected; however, low-mass quiescent galaxies have not. In future work, we will extend this analysis to $z \sim 1$ environments using upcoming Roman data, connecting galaxy structure and evolution to large-scale cosmic web features. Roman will also help study the evolution of UV and optical sizes of early galaxies out to $z \sim 3$. We present our results of a comparison study involving our method and traditional photo- z estimators on simulated LSST data. We find that our model produces lower bias, scatter, and outlier fractions when compared to traditional methods, and is less sensitive to systematic effects such as blending. Additionally, we demonstrate our model's effectiveness in preliminary results on real data from JWST. An important use-case of our method will be on overlapping Roman+Rubin observations, as the near-infrared Roman filters are expected to improve photometric redshift observations for higher redshift sources. We also present preliminary results of our photo- z estimator on simulated Rubin+Roman data.

Spectroscopy for Training and Calibrating Roman's Photometric Redshifts

Jeffrey Newman

University of Pittsburgh

Most extragalactic studies with Roman will rely upon redshift estimates from imaging data - i.e., photometric redshifts (or photo-z's) - whether as the only proxy for z or to resolve ambiguous line identifications in grism spectra. However, without deep spectroscopy from other facilities, Roman's potential to enable precise and well-characterized photo-z's will be limited. Secure redshift measurements for 20,000-30,000 galaxies down to the depths of Roman lensing measurements would provide a nearly ideal training set for both template-based and machine learning photometric redshift algorithms, improving their performance at predicting redshifts for individual objects. The same sample could enable the high-precision characterization of redshift distributions (at the $\Delta z \sim 0.002(1+z)$ level) that is needed for cosmological measurements from the High Latitude Wide Area Survey not to be limited by photo-z systematics. In this talk, I will discuss these needs as well as a potential program, the Subaru-PFS/Roman (SuPR) Deep Survey, that could meet them.

Displacement Field Analysis of Large-Scale Structures via Optimal Transport in Spectroscopic Surveys

Farnik Nikakhtar

Yale University

The universe we observe today is dotted with galaxy clusters separated by vast voids, in sharp contrast to its initial state, which was nearly uniform with only minor density fluctuations. The evolution from this early uniformity to today's complex structure of galaxies is a profound transformation, with many intermediate processes still unexplained. In this talk, I will explore this transformation, focusing on the reconstruction of the initial density and displacement fields of galaxies observed through spectroscopic surveys. I will present the latest cosmological measurements from the DESI data, utilizing the baryon acoustic oscillation (BAO) technique. Additionally, I will discuss advancements in reconstruction algorithms that have enabled significant improvements across several areas, including BAO analysis, proto-halo morphology, and the kinematic Sunyaev-Zel'dovich (kSZ) effect. I will conclude by highlighting how these developments will be further enhanced by upcoming data from the Nancy Grace Roman Space Telescope.

Cosmic Cartography with Roman: Probing the Galaxy-halo Connection

Grecco Oyarzun

Space Telescope Science Institute

Although the connection between halo growth and galaxy formation is at the core of current cosmological models, our understanding of this relationship from an observational perspective is very limited. The key to unraveling the galaxy-halo connection is in the synergy between photometric and spectroscopic surveys, both of which will be revolutionized by Roman. I will begin the talk by outlining traditional and novel methods for estimating the properties of dark matter halos (e.g. halo mass and halo age) from photometric observations. Then, I will discuss examples of how these measurements, in combination with spectroscopic characterization of galaxies, can be used to constrain the relationship between halo growth and galaxy assembly. I will focus on recent detections of galaxy assembly bias (the correlation between galaxy properties and halo properties other than halo mass) in SDSS and DESI. I will then conclude by highlighting how Roman will kick start a new era in observations of the galaxy-halo connection by taking these types of studies to the next level with the unprecedented statistical power enabled by its field-of-view and sensitivity.

Constraining Intergalactic Dust with Supernova Color Evolution

Erik Peterson

Duke University

The recent DESI analyses have made it clear that, depending on the analysis and treatment of systematics, similar Type Ia supernova samples (i.e., Pantheon+ and Union3) can result in different constraints on cosmological parameter measurements. One large difference between Pantheon+ and Union3 is that Union3 considers intergalactic dust while Pantheon+ does not. In this talk, I will focus on how well we can constrain intergalactic dust, which increases as a function of redshift (but also decreases in potency as a function of redshift) and was determined to be the second largest systematic for Union3, by analyzing how supernova color evolves with redshift. First, I will discuss how much we can already constrain intergalactic dust from real data from the Dark Energy Survey. Then I will forecast how well Roman will be able to constrain intergalactic dust and how much it will impact cosmological parameters such as Ω_M and w (as well as w_a and w_0).

Exploiting the full scale-extent of future large-scale structure measurements

Calvin Preston

University of Cambridge

The Nancy Grace Roman Telescope will deliver an unprecedented dataset of galaxies, providing a powerful ability to test the cosmological model on relatively small cosmological scales using weak lensing. In this talk, I will motivate going beyond cosmological parameter constraints, like the S8 parameter, to exploit the full scale-extent of future weak lensing measurements. I will show forecasts for the ability of future weak lensing surveys to reconstruct the shape of the matter power spectrum, well into non-linear regime. I will argue that future cosmic shear surveys are uniquely suited to be able to detect potential non-standard dark matter signatures, and distinguish them from the imprint of baryonic feedback effects. I will conclude by arguing that in combination with cross-correlations with future CMB experiments such as observations from the Simons Observatory, we can reconstructing the matter power spectrum across all cosmological scales, bridging the gap between non-linear scales observed by weak lensing to linear scales observed by the CMB.

Low-Redshift Dwarf Galaxies and their Star Clusters using Euclid, DESI, Rubin, and Roman

Aaron Romanowsky

San Jose State University

I will present initial work using Euclid and DESI to study thousands of low-redshift dwarf galaxies and their star cluster systems, providing a preview of similar science that can be done with Roman, as well as synergies with Rubin. The focus is on how dwarfs' stellar populations and star formation histories depend on mass, surface brightness, and environment. The analyses use different levels of detail, from resolved to unresolved, as the galaxy distances span ~ 1 Mpc to hundreds of Mpc. Initial work has been carried out on "3D photo-z's": analyzing color images of candidate dwarf galaxies with convolutional neural networks to estimate their distances.

Exploring Cosmic Acceleration: the 3 years of the DESI data

Hee-Jong Seo

Ohio University

The Dark Energy Spectroscopic Instrument (DESI) is soon entering its fifth and final year of a five-year redshift survey, targeting 40 million extragalactic sources across 14,000 square degrees of the northern sky, reaching redshifts up to 4, using the Mayall 4-meter telescope at Kitt Peak National Observatory. One of its primary goals is to measure the cosmic expansion history precisely and accurately through baryon acoustic oscillation (BAO) measurements. In this talk, I will summarize the results from the DESI First and Third Year BAO analyses, assess the relevant systematics, and discuss their intriguing cosmological implications, including evidence for time-evolving dark energy.

Precision Cosmology with Optical Clusters - projects and prospects with ongoing and future surveys

Tomomi Sunayama

Academia Sinica Institute of Astronomy and Astrophysics

Over the next decade, large-scale galaxy surveys will map billions of galaxies, enabling high-precision measurements of cosmic structure. Galaxy clusters have the potential to be among the most powerful cosmological probes, yet their full potential remains unrealized due to significant systematic uncertainties. Optical cluster detection, while capable of identifying lower-mass clusters than other methods, is particularly susceptible to systematics. However, its advantage lies in the improved precision of cluster mass measurements through weak lensing. In this talk, I will explore the opportunities and challenges posed by upcoming galaxy surveys and discuss strategies to make optical clusters reliable cosmological probes. I will also highlight insights from Subaru HSC and the prospects for the Roman Space Telescope.

Optical Testing of the Wide Field Instrument: Connecting Performance to Survey Science

Eric Switzer

NASA Goddard Space Flight Center

The Wide Field Instrument (WFI) on NASA's Roman Space Telescope is designed for wide-area surveys requiring high-precision imaging and spectroscopy. We conducted thermal vacuum (TVAC) optical testing to characterize instrument performance, and this presentation will emphasize considerations unique to WFI's wide field of view, which enables large-scale surveys. A star projector provided test data for calibrating dispersion and field distortion in the spectroscopic modes. The projector also enabled wavefront verification and the development of an observatory-level PSF model. A flat-field diffuser characterized the field-dependent chromatic response of imaging filters. A blackbody source allowed the evaluation of thermal backgrounds and instrument light-tightness—both critical for achieving high sensitivity. This presentation will discuss reference files derived from the TVAC measurements and tie instrument performance and knowledge requirements to the mission's survey science goals.

Line Intensity Mapping Cross-correlations with Roman
Rakshitha Thaman
New York University

Roman is anticipated to bring transformative insights to the study of large scale structure (LSS) and cosmology with its superb capabilities and unprecedented field of view. One approach to maximize Roman's scientific return is to harness the synergy with line intensity mapping (LIM), which accounts for emission from all galaxies along the line of sight across hundreds of square degrees. Cross-correlation of Roman galaxy maps and LIM can be used to extract robust constraints for both galaxy evolution and cosmology across cosmic time. We explore creating forecasts for these cross correlations using simulated past lightcones constructed with the physically backed, versatile Santa Cruz semi analytic models (SAM), which requires only a small fraction of computational resources and is more viable compared to hydrodynamic simulations. We will present forecasts for the cross-power spectrum between mock Roman galaxy survey and CII LIMs anticipated by EXCLAIM, a NASA balloon borne mission. We will also compare these forecasts with analytical models and discuss how these can be used to constrain parameters like SFR, CII intensity and bias, and $H(z)$.

Synthetic Galactic Plane Surveys with py-ananke for the Roman Space Telescope
Adrien Thob
University of Pennsylvania

Building on the vision outlined in the Galactic Roman Infrared Plane Survey (GRIPS) white paper, the Nancy Grace Roman Space Telescope will conduct the Galactic Plane Survey (GPS) as its first General Astrophysics program. This survey will push our exploration of the crowded and highly obscured Galactic disc to unprecedented depths, reaching 25.5 mag in the near-infrared with 0.1 arcsec resolution. In preparation, we use the py-ananke pipeline to create a suite of synthetic surveys emulating the GPS, incorporating models of dust extinction. These surveys are generated from the Milky Way-like simulated galaxies in the Latte suite of high-resolution FIRE cosmological simulations. By placing the solar viewpoint at varied positions within each simulated galaxy, we construct distinct surveys that mirror the proposed footprint outlined in the original GRIPS white paper, covering the inner Galactic plane ($|b| < 3^\circ$ and $|l| < 60^\circ$) with additional coverage in the bulge ($|b| < 10^\circ$, $|l| < 10^\circ$). We provide photometry in the planned F106, F158, and F213 filters of the Roman Wide Field Instrument, as well as proper motions based on a proposed survey cadence. The resulting mock catalogs are subdivided using a HEALPix tessellation of the Galactic plane and are publicly released via Globus. We anticipate that these synthetic surveys will serve as a robust testbed for refining analysis techniques and data reduction pipelines for the GPS. Finally, we discuss key features of these surveys, including their similarities and differences from known Milky Way properties, and outline the available tools for accessing them.

From Star-Forming Regions to AGN: Modeling Emission Lines in Galacticus
Sachithra Weerasooriya
Carnegie Observatories

Accurately determining the density of emission-line galaxies is crucial for optimizing galaxy surveys, particularly the Roman Space Telescope. This study introduces an improved emission-line model for star-forming and narrow-line region galaxies within the Galacticus semi-analytic framework (Benson 2012). Emission-line luminosities are computed using a pre-computed grid generated with Cloudy (Ferland et al. 1998, Catzikos et al. 2023). For HII regions, line luminosities are obtained by integrating each contribution to each emission line over the star formation history, accounting for the age and metallicity of stars formed. For narrow-line regions, we interpolate in the galaxy's metallicity, and the AGN's ionization parameter, and spectral index to extract emission-line luminosities from the Cloudy grid. Preliminary results show that our model reproduces $H\alpha$, [NII], and [OII] luminosity functions without further calibration, aligning closely with the observations of Favole et al. (2024) at $z = 0.05$ for star-forming galaxies. Additionally, our models provide reasonable matches to emission-line ratios and the total $H\alpha$ luminosity function across different redshifts, comparing well with HiZELS survey data.

Lyman-alpha at Cosmic Dawn with a Simulated Roman Grism Deep Field
Isak Wold
Catholic University of America

Lyman-alpha (Lya) surveys are an important tool to constrain the timing and topology of reionization. However, at $z > 8$, ground-based Lya surveys become ineffective due to the increasing night sky background, and even at $z \sim 7$, expensive spectroscopic follow-up is required to confirm Lya candidates and eliminate contaminants. The Roman Space Telescope's ability to obtain deep near-infrared spectra over a wide field of view offers the opportunity to revolutionize this field. To investigate this further, we have simulated a deep multi-position-angle Roman WFI grism survey and tested our ability to recover $z > 7$ Lya emitters. We show how a novel data cube search technique -- CUBGRISM -- originally developed for GALEX grism data can be applied to Roman grism data to produce a Lya flux-limited sample without requiring a continuum detection. Given our adopted reduction technique, we investigate the impact of altering the number of independent position angles and total exposure time. Our results indicate that a proposed deep Roman grism survey can achieve Lya line depths comparable to the deepest $z = 7$ narrow-band surveys, allowing us to study the evolution of Lya populations and infer the ionization state of the intergalactic medium at cosmic dawn.

The gap and spur of the Jet stream examined with deep photometry

Zijing Xue

University of Southern California

Thin, dynamically cold stellar streams are powerful probes of the presence of small-scale dark matter subhalos in the Milky Way gravitational potential. Multi-band, wide-field deep photometric studies have played a crucial role in detecting streams and their substructures, though most have concentrated on density substructures of streams closer to the Milky Way disk, which causes noise in the dark matter signal. The Jet stream is reported to potentially harbor a $\sim 4^\circ$ under-density and a spur off its main track analogous to that of GD-1; it also lies clear from the Milky Way disk, suggesting a higher likelihood of detecting past encounters of dark matter subhalos. We obtain deep (~ 25.5 mag) photometry in the u, g, and r bands with the Magellan Megacam, and run an analysis of the images with legacypipe based on the Tractor framework. Combining with the delicate astrometry from Gaia Data Release 3, we derive a catalog of highly likely members of the Jet stream. We then analyze our high-resolution density map with dust extinction maps to confirm that the density variations do not correlate with known dust structures, and build a model for the stream morphology. Future wide-field photometric and spectroscopic data collected by the Roman Space Telescope will empower more discoveries of density substructures in similar cold stellar streams, as well as further improve our understanding of these phase space structures and their connection to dark matter perturbations.

Goku: A 10-Parameter Simulation Suite for Cosmological Emulation

Yanhui Yang

University of California – Riverside

We present Goku, a suite of cosmological N-body simulations, and the corresponding 10-dimensional Gaussian process (GP) emulator, GokuEmu, for the nonlinear matter power spectrum. The simulations span the base parameters of Λ CDM cosmology and its extensions, including dynamical dark energy (w_0, w_a), the sum of the neutrino masses ($\sum m_\nu$), the effective number of neutrinos (N_{eff}), and the running of the scalar spectral index (α_s), enabling tests of new physics with data from upcoming surveys such as the Nancy Grace Roman Space Telescope, Euclid, and LSST. Designed within the MF-Box framework, which integrates multi-scale and multi-fidelity simulations, the suite includes high-fidelity simulations evolving 3000^3 particles in 1 (Gpc/h)^3 volumes and low-fidelity simulations with 750^3 particles across varying box sizes. This approach achieves percent-level accuracy in high-likelihood regions and 5% accuracy across broader parameter ranges, while reducing computational costs by 94% compared to single-fidelity methods.

Key innovations include an adaptive sampling strategy and the use of beam search to optimize generalization accuracy. The emulator is valid for redshifts $z \leq 3$ and scales $0.01 \lesssim k \text{ (h/Mpc)} \lesssim 10$. Beyond the matter power spectrum, the simulations also support analyses of other statistical measures, such as the halo mass function. Furthermore, we are developing a neural network-based emulator to improve redshift interpolation by incorporating finer redshift bins in training, while also enabling faster inference to overcome the GP's poor scaling with sample size.