Cosmology 2025 @ Elba Island

Sunday 7 September 2025 - Saturday 13 September 2025

Hermitage Hotel, Isola D'Elba

Book of Abstracts

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Quintessence fields as Early Dark Energy resolutions to the Hubble tension

Author: Sergio Sevillano[1]

[1] *Durham University*

The Hubble tension is one of the most important open challenges in cosmology, presenting a significant difference in the inferred values of the Hubble constant from observations at both high and low redshifts. One possible solution involves so-called Early Dark Energy (EDE), which introduces an extra burst of energy around matter-radiation equality that fades away faster than radiation. In this talk, I'll show how certain scalar field models that present scaling regimes can help create the Early Dark Energy spike we are looking for. Then, I'll expand this result to include more general models involving both Quintessence and K-essence, evaluating their potential in addressing the Hubble tension.

References:

https://iopscience.iop.org/article/10.1088/1475-7516/2024/05/078

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Dark Hydrogen Atoms as Baryonic Dark Matter

Author: Eugene Oks[1]

[1] *Auburn University, USA*

From Plank Collaboration: baryonic dark matter (bDM) exists. Bowman et al (2018) observed absorption in 21 cm line 2-3 times stronger than predicted by standard cosmology, so that primordial hydrogen gas was much cooler than predicted. Barcana (2018) and McGaugh (2018) suggested a bDM as cooling agent. Oks (2020): quantitative explanation of that 21 cm signal –based on the DM in the form of the 2nd flavor of hydrogen atoms (SFHA), corresponding to the 2nd solution of the Dirac equation for hydrogen atoms. Its existence is evidenced by 3 types of atomic experiments. The SFHA have only S-states: they do not couple to electromagnetic radiation. Application: solving the neutron lifetime puzzle via SFHA-based enhancement of the 2-body decay of neutrons (Oks, 2024). By the 2-body decay of neutrons neutron stars slowly produce bDM in the form of SFHA, there is astrophysical evidence. Most of bDM is SFHA (Oks, 2025). The SFHA is based on the standard Dirac equation and is within the Standard Model, no change of laws

References:

1) Int. J. Mod. Phys. D 2025/34/2550008. 2)[REVIEW] New Astron. Reviews 2023/96/101673. 3)[REVIEW] New Astron. Reviews 2021/93/101632. 4) New Astron. 2024/107/102134. 5) New Astron. 2024/113/102275. 6) Res. Astron. Astrophys. 2023/23/035011

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Bulk viscosity analysis with new holographic dark energy in f(R, T) theory

Author: Simran Kaur[1]

[1] *Maitreyi College*

This paper represents the viscous circumstances to imitate new holographic dark energy behavior in modified f(R, T) gravity theory with a flat Friedmann–Robertson–Walker model with bulk viscosity. Here, we assume bulk viscosity to be directly proportional to Hubble's parameter (ζ∝H),i.e.,ζ = ζ 0H, where ζ is assumed to be bulk viscosity coefficient, ζ0 is a positive constant, and H is Hubble's parameter. In this particular model, we consider f(R, T) = R + λT, where R represents the Ricci scalar, λ as a constant, and T as trace of the energy–momentum tensor. The focus of this article majorly revolves around the concept that the negative pressure induced by bulk viscosity could potentially act as the driving force behind dark energy, contributing to the expansion of the universe. We precisely determine the scale factor's primary solution and examine all possible conditions: deceleration as well as acceleration, which contributes to the universe's evolution.

References:

https://cdnsciencepub.com/doi/abs/10.1139/cjp-2024-0109?journalCode=cjp

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JWST's Little Red Dots: Masters of Disguise in the High-Redshift Universe

Author: Fabio Pacucci[1]

[1] *Center for Astrophysics | Harvard & Smithsonian*

The "Little Red Dots" (LRDs) are a puzzling population of compact red sources at redshift z > 4, identified by JWST. These objects challenge our current astrophysical models in several ways. First, I will discuss the detection of overmassive black holes relative to the stellar mass of their host galaxies. Second, I will address the X-ray weakness problem, where these sources remain undetected in deep X-ray surveys. I will use GRRMHD simulations to show how mildly super-Eddington accretion can resolve this issue. Third, I will explore the extremely high stellar densities at the cores of these objects and their potential for triggering runaway stellar collisions; I will also describe how low-spin halos can generate such a peculiar population, and explain the abundance, compactness, and redshift distribution of the LRDs. Throughout the talk, I will also discuss how the LRDs represent a perfect bridge to study other populations of black holes, including black hole seeds at z > 20.

References:

1) https://ui.adsabs.harvard.edu/abs/2023ApJ...957L...3P/abstract ; 2) https://ui.adsabs.harvard.edu/abs/2024ApJ...976...96P

167

An effective theory for violent relaxation in cold dark matter halos: origin of the universal halo profiles

Author: Uddipan Banik[1]

Co-author: Amitava Bhattacharjee [2]

[1] *Institute for Advanced Study Princeton*

[2] *Princeton University*

Cold dark matter halos are known to harbor universal density profiles such as the NFW, Einasto and prompt cusp profiles in cosmological N-body simulations. Despite decades of research, the origin of these profiles has remained elusive. I will present a first principles kinetic theory calculation based on the Vlasov-Poisson equations that, for the first time, provides a microscopic description of the emergence of universal profiles from the violent relaxation of dark matter halos. First, I will present a quasilinear theory that yields the NFW profile as a quasi-steady state attractor of collisionless relaxation of accreted matter. Next, I will present an effective theory for violent relaxation that yields both NFW and prompt cusps as quasi-steady attractors. The halo gets stuck in these quasi-steady states for a long time before Maxwellianizing into an isothermal sphere.

References:

https://arxiv.org/abs/2411.18827

Morning Session 3 / **168**

How our Nuclear Star Cluster formed and grew due to first generation globular clusters disruption

Author: Maryna Ishchenko[1]

[1] *Main Astronomical Observatory of National Academy of Sciences of Ukraine*

The Nuclear Star Cluster (NSC) is at the centre of the Galaxy, an extremely dense star system. Several mechanisms are exists to explain how NSCs form, including gas migrating or GCs merging to the NSC.

Based on the second idea, we will present the processes involved in the complete decay of GCs during their interaction with the NSC of our Galaxy.

We have generated 'theoretical' GCs in a time-varying potential as these likely formed 10 Gyr ago. Initial positions for the GCs were randomly generated in the total angular momentum energy phase space, taking into account various orbital parameters. For the GCs N-body simulations, we employed a high-order, dynamical N-body code with updated stellar prescription and time-variable external potential.

In total, we integrated 150 GC models from -10 to -5 Gyr interval. Consequently, we will present the total mass and stellar accretion rates to the NSC from our GC models. We will also analyse the parameters of cluster orbits where star accretion is more prevalent.

References:

https://www.aanda.org/articles/aa/full_html/2024/09/aa50399-24/aa50399-24.html#S6

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The "Missing baryons"in the cosmic web—what is it? Where is it? How much?

Author: Yin-Zhe Ma[1]

[1] *Stellenbosch University, South Africa*

Previous studies of galaxy formation have shown that only 10 per cent of the cosmic baryons are in stars and galaxies, while 90 per cent of them are missing. In this talk, I will present three observational studies that coherently find significant evidences of the missing baryons. The first is the cross-correlation between the kinetic Sunyaev-Zeldovich maps from Planck with the linear reconstructed velocity field. The second measurement is the cross-correlation between the thermal Sunyaev-Zeldovich effect with gravitational lensing map and we detect the cross-correlation for 13 sigma with RCSLenS and Planck data. The third study is to stack the cosmic voids to have a direct detection of warm hot gas inside the voids. These detections coherently brings a picture of how baryons distribute in the cosmic web. I will briefly describe how these studies can be improved with future CMB-S4 and LSST observation data.

References:

arXiv: 1404.4808, 1412.6051, 1504.03339, 1608.07581 1709.05024 1903.06654, 2206.05689, 2310.18478

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Radio Search of Dark Matter

Author: Yin-Zhe Ma[1]

[1] *Stellenbosch University, South Africa*

Dark matter is the dominant matter in the Universe. In this talk, I will introduce two major scenarios of dark matter: Axion dark matter and WIMP (Weakly Interactive Massive Particle) and show how radio telescopes can search and put constraints on these candidates. The first one is Axion, which was originally postulated to solve the strong CP problem in particle physics. Axions can be converted into monochromatic radiation in the neutron star's magnetosphere, constituting a unique window to probe its existence with a radio telescope. We used MeerKAT telescope for 10 hours to observe the isolated neutron star RX J0806.4-4123 in the UHF band. I will show that the upper limit of the axion decay constant is in the mass range of 2.5—5 mu-eV, which corresponds to MeerKAT 544-1,088 MHz. We also used FAST telescope to observe the synchrotron emission of WIMP dark matter decay in COMA Berenices dwarf galaxy and obtained strong constraints on WMIP decay channels. Additionally, I will also present some future prospects.

References:

2022, Physical Review D, 106 , 083006; and 2023, Physical Review D, 107, 103011

172

An alternative gravity theory based on the Schouten and Codazzi tensors

Author: Roberto Sussman[1]

[1] *ICN-UNAM*

I present a second order gravity theory to be denoted as ''Schouten-Codazzi Gravity" (SCG), as it is based on Schouten and Codazzi tensors. The field equations are constructed considering as source the energy momentum tensor of General Relativity, with the field equations given by the sum of the Schouten tensor and a generic second order symmetric tensor constructed with generic diffeomorphisms of the eigenvalues of the Ricci tensor and satisfying the Codazzi differential condition. This construction is concomitant with the invariant characterization of general spacetimes in terms of the algebraic structure of curvature tensors. Exact SCG solutions for static spherical symmetry

(vacuum and perfect fluid), FLRW models and spherical dust fluids generalize known general relativistic exact solutions. SCG is "work in progress" in an incipient stage that still requires significant theoretical development, but the theory provides valuable guidelines in the search for alternatives to General Relativity

References:

Sussman, R.A. and Nájera, S., "Schouten-Codazzi gravity". Classical and Quantum Gravity, 41, 245019 (2024). LANL e–Print 2411.06257

174

Big-Bang Nucleosynthesis as a Probe of Primordial Black Hole Abundance

Author: Luca Visinelli[1]

[1] *Università di Salerno & INFN*

We investigate a scenario in which primordial black holes (PBHs) with masses $M_{\rm PBH} < 10^9\,{\rm g}$ undergo Hawking evaporation around the epoch of Big-Bang nucleosynthesis (BBN). The evaporation process injects energy into the thermal plasma, altering both the expansion rate of the Universe and the baryon-to-photon ratio during nucleosynthesis. These modifications affect the primordial abundances of light nuclei, providing a sensitive probe of early-universe physics. We present numerical solutions of the cosmological evolution equations, exploring a range of PBH masses and initial abundances. The resulting non-standard Hubble rate and baryon-to-photon ratio are incorporated into the BBN code *PArthENoPE* to compute the modified light-element yields. Comparing our results with observed abundances, we derive stringent upper bounds on the PBH abundance at formation in the mass range $10^8\,{\rm g} < M_{\rm PBH} < 10^9\,{\rm g}$, providing the most robust limits to date in this regime. Based on 2405.18493

References:

https://arxiv.org/abs/2405.18493

Afternoon session / 175

Superheavy Dark Matter, GUT Axions and High Frequency GWs from Structure Formation and X Miracle

Author: Zhijie (Jay) Xu[1]

[1] *Pacific Northwest National Lab*

We propose a new framework based on structure formation at the free-streaming scale and a modified "X miracle" beyond the standard WIMP paradigm. Both point to nonthermal, superheavy fermionic dark matter of 10^{12}GeV. Unlike WIMPs that are light, semi-relativistic, and unaffected by gravity at freeze-out, the X miracle incorporates gravity, introducing a new fundamental scale $r_X = 10^{-13}\text{m} \gg m_X^{-1}$ that breaks the unitarity bound and allows for a large cross section $10^{-21}\text{m}^3/\text{s}$. At this mass, free streaming mass matches the particle mass, enabling the earliest gravitationally bound structures to form at 10^{-6}s and release binding energy as 100kHz gravitational waves or as GUT-scale axions. Superheavy sterile neutrinos are natural candidates, addressing dark matter, neutrino mass, and baryogenesis. Boltzmann equation suggests a relic abundance from early annihilation,

with one in a billion particles surviving. This offers explanations for ultra-high-energy cosmic rays and Hubble tension.

References:

arXiv:2202.07240

176

Do we live in a superposed universe?

Author: Yaghoub Heydarzade[1]

[1] *Department of Mathematics, Bilkent University*

I will present a novel exact solution to the Einstein field equations with a perfect fluid source that exhibits a nonlinear superposition of two distinct homogeneous FLRW metrics. Interestingly, while the resulting configuration is generally inhomogeneous, it asymptotically evolves toward two different homogeneous FLRW spacetimes in the early- and late-time limits of cosmic evolution. The solution displays a scale factor inversion symmetry and gives rise to two distinct types of topological transitions: one occurring dynamically during the universe's evolution, and another emerging in the spatial asymptotic regions. These features offer intriguing insights into the possible superposed nature of the universe and raise fundamental questions about its global structure and dynamics.

References:

Journal of Cosmology and Astroparticle Physics (JCAP), 6, 060 (2020); Phys. Rev. D 100, 064048 (2019)

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Detection of cosmological dipoles aligned with transverse velocities

Author: Yan-Chuan Cai[1]

Co-authors: Anna de Graaff [2]; John Peacock [1]; Shadab Alam [3]

[1] *University of Edinburgh*

[2] *Max Planck Institute for Astronomy*

[3] *Tata Institute of Fundamental Research*

On large scales, peculiar velocities encode rich cosmological information. While the line-of-sight components are routinely detected, measuring transverse velocities for extragalactic objects has been nearly impossible. I will present the first detection of transverse velocities through their gravitational imprints on the Cosmic Microwave Background.

References:

https://arxiv.org/pdf/2504.02525

Afternoon session / 178

Addressing the Hubble tension and a proposal to increase the accuracy of cosmological observables

Author: Horst Foidl[1]

[1] *Department of Astrophysics at the University of Vienna*

The Hubble tension denotes the discrepant values of H_0 obtained from direct measurements in the local Universe compared to those derived from the CMB. Observational programs often compare their data also with extensions to ΛCDM applying dynamical models of dark energy (DDE) with a time-dependent equation of state parameter w. They use the MCMC method to fit the ΛCDM extensions to their data, where they use the CPL model $w(a) = w_0 + w_a(1-a)$ as the parametrization of the DDE model. We discovered a degeneracy in the MCMC method and propose a complementary computational procedure as an extension to the MCMC method that breaks the degeneracy, where our results reveal that the CPL model $w(a) = -0.9 + 0.1(1-a)$ could provide a resolution to the Hubble tension problem. Moreover, we find that this approach can serve as a kind of consistency check for cosmological models and will increase the accuracy of inferred cosmological parameters significantly, in particular for ΛCDM extensions with DDE.

References:

10.1051/0004-6361/202348955 - Astronomy & Astrophysics, Volume 686, id.A210, 20 pp. by Horst Foidl and Tanja Rindler-Daller

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Non-minimal coupling of scalar fields in the dark sector and generalization of the top-hat collapse

Author: Priyanka Saha[1]

[1] *Phd scholar, IIT Kanpur*

In this article we propose a new way to handle interactions between two scalar fields, in the cosmological backdrop, where one scalar field oscillates rapidly in the cosmological time scale while the other one evolves without showing any periodic behavior. We have interpreted the rapidly oscillating scalar field as the dark matter candidate while the other scalar field is the canonical quintessence field or the non-canonical phantom field. A model of a generalized top-hat-like collapse is developed where the dark sector is composed of the aforementioned scalar fields. We show how the non-minimal coupling in the dark sector affects the gravitational collapse of a slightly overdense spherical patch of the universe. The results show that one can have both unclustered and clustered dark energy in such collapses, the result depends upon the magnitude of the non-minimal coupling strength.

References:

https://link.springer.com/article/10.1140/epjc/s10052-025-14080-6

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The fast, the slow and the merging: probes of evaporating memory burdened PBHs

Author: Michael Zantedeschi[None]

The so-called memory-burden effect implies that evaporating Primordial Black Holes (PBHs) inevitably stabilize before complete decay. This stabilization opens a new mass window for PBH Dark Matter below 10^{15} g. I will discuss how this novel window is well within reach of detection both locally, via high-energy γ-rays and neutrinos measurements as well as across cosmological distances with the CMB. I will further describe how our findings restrict the values of the critical exponent characterizing the memory burden phenomenon.

References:

2506.13861 + 2503.21740 + 2410.07037 +2405.13117

Morning session 4 / **181**

Evolution of Mass and Structure in Dark Matter Halos: Scaling Laws from Dwarfs to Galaxy Clusters

Author: Masao Mori[1]

Co-authors: Michi Shinozaki [1]; Yuka Kaneda [1]; Kohei Hayashi [2]; Go Ogiya [3]; Andreas Burkert [4]

[1] *University of Tsukuba*

[2] *National Institute of Technology, Sendai College*

[3] *Zhejiang University*

[4] *University Observatory Munich*

We investigate the mass evolution of dark matter subhalos in Milky Way–like galaxies using ultra-high-resolution N-body simulations (Kazuno et al. 2024). Subhalos undergo early accretion followed by tidal stripping, losing over 80% of their mass by z = 1. Their orbits closely resemble those of Milky Way satellites, as revealed by Gaia EDR3, reinforcing the CDM paradigm. In contrast, Kaneda et al. (2024) examine internal structure. The radius of maximum circular velocity emerges as a critical scale where observed surface densities align with CDM predictions from the concentration–mass (c–M) relation. This agreement reflects the universality of dark matter halo scaling relations, including the near-constant central surface density seen from dwarf galaxies to galaxy clusters. Remarkably, despite baryonic feedback, observational evidence from UFDs and SPARC rotation curves confirms that these relations persist down to halo masses below 10^8 M$\odot$, highlighting their robustness across a broad mass range.

References:

Kazuno, Mori, Kaneda & Otaki, PASJ, 76, L39 (2024); Kaneda, Mori, Otaki (2024), PASJ, 5, pp. 1026–1040; Ogiya, Mori, Ishiyama, & Burkert, ApJ, 440, L7 (2014)

Afternoon session / **182**

The Characteristic Mass for Cusp–Core Transformation in Dark Matter Halos

Author: Michi Shinozaki[1]

Co-authors: Masao Mori [1]; Yuka Kaneda [1]; Kohei Hayashi [2]

[1] *University of Tsukuba*

[2] *National Institute of Technology, Sendai College*

Shinozaki et al. in prep. present an analytical model that embeds the cusp–core transition into the c–M relation of dark matter halos. The model accounts for deviations from scaling relations in galaxies, where central surface densities fall below c–M predictions. In contrast, UFDs retain high central densities consistent with CDM. Assuming supernova(SN) feedback drives the transition, the model predicts it operates within a characteristic halo mass range of 10^8–10^{11} M⊙, defining a critical stellar mass and a "forbidden region"where core formation is ineffective. The framework is validated by analysis using SPARC and UFD data (Hayashi, Kaneda, Mori & Shinozaki in prep.). These data confirm that most galaxies lie outside this region and can undergo the transition, while groups, clusters, and UFDs remain trapped within it. The observed diversity in low-mass density profiles likely arises from variations in star formation efficiency and the coupling efficiency between SN feedback and the dark matter potential.

References:

Kaneda, Mori, Otaki (2024), PASJ, 5, 1026

Afternoon session / **183**

Disentangling Modified Gravity and Massive Neutrinos with Intrinsic Shape Alignments of Massive Halos

Author: Jounghun Lee[None]

Co-author: Marco Baldi [1]

[1] *Bologna University*

We present a new diagnostics based on the intrinsic shape alignments of group/cluster size dark matter halos to disentangle the effect of f(R) gravity from that of massive neutrinos. Using the snapshot data from a series of the DUSTGRAIN-pathfinder N-body simulations for the Planck ΛCDM cosmology and three f(R) gravity models with massive neutrinos, we first determine the probability density functions of the alignment angles between the shape orientations of massive halos and the minor principal axes of the local tidal fields. The numerically obtained results turn out to agree very well with the analytic formula derived under the assumption that the anisotropic merging along the cosmic web induces the halo shape alignments. The four cosmologies, which several standard diagnostics failed to discriminate, are found to yield significantly different best-fit values of the single parameter that characterizes the analytic formula.

References:

Astrophys. J. 945 (2023) 15

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IMBH Mergers and Growth: The Role of Nuclear Star Clusters and Host Environment

Author: Fazeel Mahmood Khan[1]

[1] *New York University Abudhabi*

Intermediate-mass black holes (IMBHs; 10^4–10^6 M⊙) reside at the center of dwarf galaxies, but their assembly and dynamical evolution remain poorly understood. We present high-resolution N-body simulations exploring IMBH binary dynamics in dwarf galaxies using realistic structural parameters.

In nucleated dwarfs, compact nuclear star clusters efficiently drive IMBHs to the center via dynamical friction and support rapid binary hardening. A small population of stellar-mass black holes further accelerates coalescence by maintaining a dense cusp that replenishes the loss cone, enabling IMBH growth through repeated mergers on cosmological timescales. These dense environments also promote the formation of Intermediate-Mass Ratio Inspirals (IMRIs) on radial orbits. In contrast, IMBH binaries in non-nucleated dwarfs stall due to low stellar densities. Based on our study, we provide a recipe to estimate IMBH binary merger times from host galaxy properties, applicable to both cosmological simulations and observations.

References:

1. https://doi.org/10.1093/mnras/stab2646 2. https://iopscience.iop.org/article/10.3847/1538-4357/ad8082/meta

Afternoon session / **185**

Void spin distribution as a powerful probe of $_8$

Authors: GEONWOO KANG[1]; Jounghun Lee[1]

[1] *Seoul National University*

We present a numerical proof of the concept that the void spin distributions can provide a tight constraint on σ_8 without without being severely deteriorated by the degeneracies of σ_8 with $\Omega_{\rm cdm}h^2$, M_ν and w. Applying the Void-Finder algorithm to AbacusSummit N-body simulations of 15 different cosmological models, we identify the voids and measure the magnitudes of rescaled specific angular momenta of void halos as their spins. We determine the probability density distribution of void spins for each model and for the first time find it to be well approximated by the generalized Gamma distribution. It turns out that the best-fit values exhibit very sensitive dependence only on σ_8. This exclusive σ_8-dependence of the void spin distributions is confirmed to be robust against the variation of the mass and number cuts of void halos. We also test an observational feasibility of estimating the void spins from real data on the galaxy redshifts.

References:

Kang, G. and Lee, J., "Void spin distribution as a powerful probe of σ_8", Journal of Cosmology and Astroparticle Physics, vol. 2025, no. 6, Art. no. 011, IOP, 2025. doi:10.1088/1475-7516/2025/06/011.

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Study of Dark Matter using MaNGA Survey

Author: Nur Adryna Farhana Norizam[1]

Co-authors: Zamri Zainal Abidin [1]; Chorng-Yuan Hwang [2]; Norsiah Hashim [1]

[1] *Universiti Malaya, Kuala Lumpur, Malaysia*

[2] *National Central University, Taiwan*

The cold dark matter (CDM) cosmological model, which has proved very successful in explaining cosmic structure, states that dark matter is made up of weakly interacting particles (WIMPs). Despite this, CDM has continued to have challenges with observations, particularly those involving dwarf galaxies and the innermost portions of dark matter halos, one of which is the cusp-core problem. According to the ΛCDM model, these galaxies should have an obvious peak or "cusp" in the centre where dark matter is concentrated; yet, certain studies show that certain dwarf galaxies have

a flatter distribution (core-like). Using data from MaNGA survey, this research aims to investigate (i) dark matter by analysing density profiles of dwarf galaxies and (ii) resolving the cusp-core problem.

Keywords: Dark Matter; Dwarf Galaxies; MaNGA Survey; Cusp-core Problem

References:

Abidin, Z. Z., Asmi, N., Mat Sabri, M. R., Rohaizi, M. A., Hashim, N., & Ibrahim, U. F. S. U. (2024). The excess of diffuse radio emission in galaxy clusters A4038 and A1664. Physics of the Dark Universe, 44(101449), 101449. doi:10.1016/j.dark.2024.101449;

Afternoon session / **187**

Cosmography through the ages of low-redshit early-type galaxies

Author: Carlos Alonso Álvarez[1]

Co-authors: Alessandro Bressan [1]; Andrea Lapi [1]; Marcos M. Cueli

[1] *SISSA*

Using Early Type Galaxies (ETGs) ages as cosmic chronometers has been recently revisited as a model independent way to determine the Hubble parameter, through the inspection of their Lick indices. We present a cosmographic analysis of the ages of SDSS Legacy ETGs, aiming at a novel continuous fit of the Hubble parameter along the redshift range of the data.
We introduce a robust stacking procedure to enhance the signal-to-noise ratio of the spectra, rendering the estimated ages much more reliable. Stellar ages are subsequently derived using two independent SPS models, which are then fit with a second order Taylor expansion in y-redshift $y = z/(1+z)$ of the Hubble parameter $H(z; H_0, q_0, j_0)$. We obtain estimations for the Hubble constant H_0, deceleration q_0 and jerk j_0 parameters. Notably we find $H_0 = 69.5^{+4.3}_{-7.4}$, and the overall sampling of $H(z)$ is competitive wrt to punctual estimations from the literature.

Following these results, higher-z work with (e)BOSS data is ongoing.

References:

Cosmography via stellar archaeology of low-redshift early-type galaxies from SDSS (submitted for revision at Astronomy & Astrophysics)

Afternoon session / **188**

Stream Splitting as a New Signature of Dark Matter Subhaloes and Intermediate-Mass Black Holes in the Milky Way

Author: Yuka Kaneda[1]

Co-authors: Andreas Burkert [2]; Masao Mori [1]; Takanobu Kirihara [3]; Yohei Miki [4]

[1] *University of Tsukuba*

[2] *Max-Planck-Institut f¨ur extraterrestrische Physik*

[3] *Kitami Institute of Technology*

[4] *Information Technology Center, The University of Tokyo*

The population of dark matter subhaloes in the Milky Way provides constraints on the dark matter particle mass. Previous studies suggest that stellar streams serve as probes of dark substructure through the dynamical signatures, such as gaps, imprinted by perturbations. With the advent of the Gaia satellite, several streams running nearly parallel to each other have been discovered. In this study, we report that a single stellar stream can split into two parallel streams following an encounter with a dark matter subhalo or an intermediate-mass black hole. This stream splitting occurs when the perturber approaches along the stream's tidal axis. Our scenario is supported by analytical modelling and N-body simulations. Moreover, the morphology and kinematics of the resulting parallel streams have possibility to offer an estimation of the mass of the perturber. Our results highlight that not only gaps but also splits should be considered to estimate the true abundance of subhaloes.

References:

Kaneda, Mori, Otaki (2024), PASJ, 5, pp. 1026–1040; Kazuno, Mori, Kaneda & Otaki, PASJ, 76, L39 (2024)

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The promise of precision cosmology with gravitational wave spectral sirens: mitigating biases from astrophysical uncertainties.

Author: Anarya Ray[1]

[1] *Northwestern University*

Gravitational waves from compact binary mergers are powerful cosmological probes that do not rely on the distance ladder. The spectral siren method constrains cosmological parameters from the spectrum of measured compact object masses and distances, without requiring electromagnetic counterparts or incomplete galaxy catalogs. However, astrophysical uncertainties in compact binary formation propagate to models for their mass and redshift distributions, potentially biasing cosmological measurements. I will demonstrate a novel astrophysics-agnostic spectral-siren probe of cosmic expansion using non-parametric population models, present the latest constraints from binary black hole catalogs, and discuss the potential for sub-percent level measurements in the near future. I will then show how binary neutron star mergers are less susceptible to residual astrophysical uncertainties affecting current binary black hole models, promising reliable cosmography with third-generation detectors at sub-percent precision.

References:

https://arxiv.org/abs/2404.02522, https://iopscience.iop.org/article/10.3847/2041-8213/add34a

Morning session 4 / 192

Implications for Cosmic Birefringence from Recent Cosmological Observations

Author: Toshiya Namikawa[None]

In this talk, I present implications for the cosmic birefringence from recent cosmological observables. We begin by showing constraints on cosmic birefringence induced by ALPs using the Planck EB power spectrum. We find that cosmic birefringence signal is consistent with a constant rotation model and some specific ALP masses are excluded. Next, we show that cosmic birefringence can explain a higher optical depth $\tau \simeq 0.09$ as a result of the DESI BAO measurements and CMB observations within the standard cosmological model. Specifically, we use the fact that the recent cosmic birefringence measurement, $\beta_0 = 0.34\,\mathrm{deg}$, has the phase ambiguity, $\beta = \beta_0 + 180n\,\mathrm{deg}$

with $n \in \mathbb{Z}$). An ALP-induced birefringence model with a nonzero n can suppress the reionization bump in the EE spectrum while allowing for a large optical depth. We show a viable parameter region that simultaneously explain the large-scale CMB polarization, Planck EB power spectrum, and an eleveted value of τ.

References:

https://arxiv.org/abs/2506.20824, https://arxiv.org/abs/2506.22999

Afternoon session / **193**

Dark Matter in extra-dimensional scenarios

Author: Andrea Donini[None]

Co-authors: Alejandro Muñoz Ovalle [1]; Juan Herrero Garcia [2]; Miguel García Folgado [1]; Nuria Rius [3]

[1] *IFIC*

[2] *IFIC, UV/CSIC*

[3] *Valencia University*

The Nature of Dark Matter is, still, a widely open question that allows for very different anwers. One option is represented by particles that do interact gravitationally (as hinted by experiments), albeit with a coupling with gravity enhanced by an underlying extra-dimensional space-time. Several options have been proposed, either within a WIMPy or FIMPy approach, with different possibility for the geometry of the 5D space-time. I will shortly review these options and their experimental constraints, focusing eventually in a recent proposal of a Randall-Sundrum 5D setup with three branes that avoid most of the collider bounds while still producing the required amount of DM relic abundance.

References:

M. G. Folgado, A. Donini and N. Rius, "Gravity-mediated Scalar Dark Matter in Warped Extra-Dimensions", JHEP 01 (2020) 161 (preprint), JHEP 02 (2022) 129 (erratum) • e-Print: 1907.04340 [hep-ph]

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Emergence of inflaton potential from asymptotically safe gravity

Author: Agustín S[1]

[1] *Radboud University*

Asymptotic safety is a powerful mechanism for obtaining a consistent and predictive quantum field theory beyond the realm of perturbation theory. It hinges on an interacting fixed point of the Wilsonian renormalization group flow, which controls the microscopic dynamics. Connecting the fixed point to observations requires constructing the set of effective actions compatible with this microscopic dynamics. In this talk, I will describe a way to perform this connection at the level of a four-dimensional scalar-tensor theory. As a result, I will show how a single-field inflationary model, compatible with observations, naturally emerges from a gravitational UV fixed point.

References:

The talk is based on arXiv: 2406.10170 (Phys. Lett. B 2024.139154).

195

Universal black hole solutions for all F(R) gravitational theories

Author: Agustín S[1]

Co-author: Cristobal Laporte [1]

[1] *Radboud University*

In this talk, I'll examine the solution space of vacuum, static, and spherically symmetric spacetimes within F(R) theories, introducing novel methods that reduce the vacuum equations to a single second-order equation. I'll derive analytic expressions for the metric functions in terms of the arbitrary functional F(R), providing detailed insight into how the gravitational action impacts the structure of spacetime. I'll analyze conditions under which solutions are asymptotically flat, regular at the core, and contain an event horizon, obtaining explicit expressions for entropy, temperature, and specific heat in terms of F(R). By using a single metric degree of freedom, I'll identify the most general solution and examine its (un)physical properties. For the more general case two metric functions, I'll use approximation schemes to explore corrections to Schwarzschild-(anti)de Sitter spacetimes, finding that F(R) extensions to GR induce instabilities. If time suffices, I'll show the current status of the research.

References:

The talk will based on the publication https://doi.org/10.1103/PhysRevD.111.044020

Afternoon session / **196**

Nonextensive Entropies as Holographic Dark Energy in Cosmology

Author: Mariusz Dabrowski[1]

[1] *University of Szczecin*

A plethora of various entropic forms have been presented in the literature recently starting with famous Tsallis q-entropic statistics [1]. Like the Bekenstein-Hawking (horizon) entropy, which is nonextensive due to its scaling with the area and not with the volume, they go beyond the standard extensive and additive Boltzmann-Gibbs formulation of thermodynamics. However, they fit perfectly to gravity due to taking into account long-range interactions between subsystems.

During my talk, I will briefly present the properties of the selected nonextensive entropies (Tsallis, Tsallis-Cirto, Barrow, Renyi, Tsallis-Jensen, Sharma-Mittal, Kaniadakis) and show their application for the explanation of the dark energy phenomenon in the universe (known as Holographic Dark Energy (HDE) models) making statistical comparison against LCDM using the Bayesian evidence criterion [2]. Interestingly, Barrow and Tsallis-Cirto entropies have the property of 'near-extensivity' 'which agrees with our previous result [3].

References:

1. M.P. Dąbrowski, Entropy, 26, 814 (2024). 2. I. Cimdiker, M.P. Dabrowski, V. Salzano, arXiv: 2503.18320, European Physics Journal C (to appear). 3. T. Denkiewicz, V. Salzano, M. P. Dąbrowski, Phys. Rev. D108, 103533 (2023).

197

Gravitational Wave Signals from Spectator Scalar Fields

Author: Sarunas Verner[1]

[1] *University of Chicago*

In this talk, I will present a novel mechanism for gravitational wave (GW) generation from spectator scalar fields in the early universe. Spectator scalar fields with masses below the inflationary scale can produce significant isocurvature power spectra in the ultraviolet region, generating substantial curvature perturbations at small scales. These perturbations result in a stochastic gravitational wave background with typical amplitudes of Ω_GW hˆ2 = 10ˆ{-18} –10ˆ{-6} across frequencies ranging from 10ˆ{-18} to 1 Hz. Notably, these signals fall within detection ranges of planned gravitational wave observatories. I will demonstrate that these gravitational waves impose new, more stringent constraints on spectator field masses than those derived from isocurvature perturbations alone. Finally, I will explore enhancement mechanisms for the isocurvature power spectrum through direct coupling between the inflaton and spectator fields, highlighting how such interactions modify the resulting GW signatures.

References:

https://arxiv.org/abs/2506.12126

Afternoon session / **198**

Probing GeV-Scale Dark Matter Annihilation with the JUNO Experiment

Author: Utane Sawangwit[1]

Co-authors: JUNO Collaboration ; Jaruchit Siripak [2]

[1] *National Astronomical Research Institute of Thailand (NARIT)*

[2] *Suranaree University of Technology, Thailand*

The Jiangmen Underground Neutrino Observatory (JUNO) is poised to make significant contributions to neutrino physics, including the indirect search for dark matter from the annihilation of WIMPs with masses in the GeV range, which can become gravitationally trapped within the solar core. While Pulse Shape Discrimination (PSD) is a standard technique for classifying events in JUNO , this work demonstrates that a substantial improvement in sensitivity can be achieved by applying dedicated machine learning (ML) and deep learning (DL) algorithms. This enhanced signal-to-background discrimination JUNO can become a leading instrument in the search for solar WIMPs, with a projected sensitivity that is comparable to current limits from major facilities like the IceCube Neutrino Observatory, particularly in the challenging low-mass WIMP range (3-20 GeV). This work highlights JUNO's strong potential to probe the existence of dark matter and its important role in the global multi-messenger effort.

References:

https://doi.org/10.1016/j.ppnp.2021.103927 , Angel Abusleme et al JCAP09 (2023) 001, J Siripak et al 2023 J. Phys.: Conf. Ser. 2431 012094

199

The Dark Energy Survey Year 6 3x2pt: Multi-Probe Modeling Strategy and Validation

Authors: Agnès Ferté[1]; David Sanchez Cis[2]; Jonathan Blazek[3]

Co-author: The Dark Energy Survey Collaboration DES

[1] *SLAC*

[2] *University of Zurich*

[3] *Northeastern University*

The Dark Energy Survey (DES) is preparing to release its Legacy cosmological analysis based on six years of observations, comprising shape and position measurements for over 130 million galaxies across 5,000 square degrees. This unprecedented dataset enables a powerful joint study of weak gravitational lensing and galaxy clustering—commonly referred to as the 3×2pt analysis—to robustly constrain the ΛCDM model and its extensions. In this talk, I will present the development of our modeling pipeline, designed to fully exploit the statistical power of the DES Y6 data. I will highlight key components of the theoretical framework, including the modeling of baryonic feedback effects on cosmic shear, the treatment of galaxy bias in galaxy clustering and galaxy-galaxy lensing, and the mitigation of other dominant systematics. Finally, I will show validation results and discuss forecasted cosmological constraints, underscoring the expected impact of the DES Y6 analysis on our understanding of the Universe.

References:

https://arxiv.org/pdf/2105.13549

Morning session 4 / **200**

DArk Matter Particle Explorer: 9 years in Space

Author: Andrii Tykhonov[1]

[1] *Universite de Geneve (CH)*

The Dark Matter Particle Explorer (DAMPE) is a pioneering calorimetric space experiment that has been successfully operating since December 2015. Its primary scientific objectives include measuring the spectra of both primary and secondary cosmic-ray species, searching for potential indirect signatures of dark matter in cosmic rays, and gamma-ray physics. For electrons and gamma rays, DAMPE covers an energy range from a few GeV up to around 10 TeV, achieving an exceptional energy resolution of nearly 1%. For hadronic cosmic rays, its measurements reach several hundred TeV in kinetic energy.

In this talk, we will begin with an overview of the DAMPE mission and its current operational status in orbit. We will then highlight key scientific achievements, including recent measurements of the BCNO group, iron nuclei, the extended light element spectra beyond 100 TeV, and other significant results.

References:

https://doi.org/10.1103/PhysRevLett.134.191001; https://doi.org/10.1103/PhysRevD.109.L121101; https://doi.org/10.1103/PhysRevD
https://doi.org/10.1038/nature24475

Afternoon session / **201**

Cosmoglobe: Planck-HFI and advanced dust modelling

Author: Raelyn Sullivan[1]

Co-authors: Hans Kristian Kamfjord Eriksen ; Ingunn Kathrine Wehus

[1] *ITA, University of Oslo*

The Cosmoglobe collaboration has conducted a groundbreaking joint analysis of the Planck-LFI, WMAP, and DIRBE data. Its unified, end-to-end, Bayesian approach provides improved control over systematic errors, leading to enhanced cosmological constraints and more accurate component maps and sky models. In this talk, I will provide an overview of the Cosmoglobe approach and highlight key results from the collaboration's joint analysis to date. I will also present our currently ongoing reanalysis of the Planck-HFI data, which is already demonstrating areas of improvements. Additionally, I will introduce a new multi-component dust model based on the Planck-HFI NPIPE maps. This now includes a nearby dust template, a CII-correlated dust component, and an H-alpha–correlated dust component. By expanding the complexity of the dust model, we achieve a more realistic and physically motivated description of Galactic foregrounds—ultimately enabling a clearer view of the cosmic microwave background.

References:

https://arxiv.org/pdf/2303.08095, https://arxiv.org/pdf/2408.10952

202

Holographic Inflation in f(R,T) Gravity and Observational Constraint

Author: Sara Taghavi[1]

Co-authors: Khaled Saeidi [2]; Tayeb Golanbari [3]; Zohdiye Ossoulian [4]

[1] *Department of Physics, University of Kurdistan, Sanandaj, Iran*

[2] *Khaled Saaidi, Co-author Department of Physics, Faculty of Basic Sciences, University of Kurdistan, Sanandaj, Kurdistan, Iran*

[3] *Tayeb Gol-Anbari, Co-author Assistant Professor, Department of Physics, Faculty of Basic Sciences, University of Kurdistan, Sanandaj, Kurdistan, Iran*

[4] *PhD Student in Particle Physics, Department of Physics, Faculty of Basic Sciences, University of Kurdistan, Sanandaj, Kurdistan, Iran*

We explore the realization of inflation within the framework of **f(R,T) gravity**, incorporating a holographic dark energy (HDE) component based on the Granda–Oliveros (GO) infrared cutoff and Tsallis entropy.

Assuming that the scalar field potential is driven by the HDE density, we analyze the inflationary dynamics under the slow-roll approximation and derive the key cosmological observables.

Our results show that, for an appropriate range of model parameters, both the scalar spectral index and the tensor-to-scalar ratio are in excellent agreement with current observational constraints.

Furthermore, we reconstruct the potential in terms of the scalar field and examine the implications of the swampland conjectures.

We find that the model satisfies the refined swampland criteria for values of the coupling parameter λ of order $\mathcal{O}(10^2–10^3)$.

These results suggest that holographic inflation in **f(R,T) gravity** offers a theoretically consistent and observationally viable scenario.

References:

Full version of the manuscript is available on arXiv:2301.02631

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Hamilton-Jacobi formalism for f(R, T) inflation: observational constraints, swampland criteria, and TCC

Author: Sara Taghavi[1]

Co-authors: Khaled Saeidi [2]; Tayeb Golanbari [3]; Zohdiye Osoliyan [4]

[1] *Department of Physics, University of Kurdistan, Sanandaj, Iran*

[2] *, Co-author Department of Physics, Faculty of Basic Sciences, University of Kurdistan, Sanandaj, Kurdistan, Iran*

[3] *Assistant Professor, Department of Physics, Faculty of Basic Sciences, University of Kurdistan, Sanandaj, Kurdistan, Iran*

[4] *PhD Student in Particle Physics, Department of Physics, Faculty of Basic Sciences, University of Kurdistan, Sanandaj, Kurdistan, Iran*

We explore inflation in **f(R, T)** modified gravity using the **Hamilton-Jacobi formalism**, where the Hubble parameter depends on a noncanonical scalar field. This formalism enables an exact description of inflation without slow-roll approximations. Power-law and exponential forms of the Hubble parameter are considered. Using observational data, model parameters are constrained, yielding results for the scalar spectral index (n_s) and tensor-to-scalar ratio (r) consistent with Planck observations.

We further examine the model's theoretical consistency via the **Swampland Criteria** and the **Trans-Planckian Censorship Conjecture (TCC)**. While the Swampland conditions are satisfied for wide parameter ranges, the model generally does not meet the TCC bounds due to the high energy scale of inflation. Our results show that combining **f(R, T)** gravity with noncanonical fields within the Hamilton-Jacobi approach provides a viable and observationally consistent inflationary model beyond standard frameworks

References:

Z. Ossoulian, Kh. Saaidi, S. Taghavi, T. Golanbari, "Inflation in f(R,T) gravity with observational constraints", arXiv:2301.08319 [gr-qc], 2023.

Afternoon session / 204

Superfluid dark matter: from theory to observations

Author: Valerio De Luca[1]

[1] *University of Pennsylvania*

In this talk we will review the model of superfluid dark matter, based on the existence of sub-eV particles with repulsive self-interactions. These particles are able to generate a superfluid core in galaxies upon Bose-Einstein condensation and thermalisation. We will delve into the various phenomenological implications of the model, including the formation of vortices, the behaviour around black holes and dynamical friction, and discuss prospects of detectability through gravitational wave experiments.

References:

arXiv: 2505.23900

Morning Session 2 / **205**

Formation of Nuclear Star Clusters and Supermassive Black Holes via First-Generation Globular Cluster Disruption.

Author: Peter Berczik[1]

Co-author: Maryna Ishchenko [2]

[1] *Main Astronomical Observatory, National Academy of Sciences of Ukraine*

[2] *Main Astronomical Observatory of National Academy of Sciences of Ukraine*

The Nuclear Star Cluster (NSC) resides at the center of the Milky Way galaxy and represents an extremely dense stellar system. Most such systems are also known to harbor Supermassive Black Holes (SMBHs).

Several mechanisms have been proposed to explain the formation of NSC+SMBH structures, with two prevailing scenarios:

(i) the inward migration of gas toward the galactic center, followed by star formation from the accreted material, and

(ii) the inward migration and subsequent disruption or merger of Globular Clusters (GCs), resulting in the buildup of a common NSC.

In our study, we focus on the second scenario —the complete decay of GCs during their interaction with the central NSC+SMBH. We model the orbital dynamics and mass loss evolution of present-day GCs, assuming they formed approximately 10 billion years ago. To accomplish this, we employ time-varying Milky Way-like potentials, extracted from the Illustris TNG-100 cosmological simulation.

References:

1) A&A, 2023, 674, id.A70, 24 pp. 2) A&A, 2024, 689, id.A178, 17 pp.

Morning session 5 / **206**

Explaining the H0 Tension via the Local Hole and CMB Lensing

Author: Tom Shanks[1]

[1] *Durham University, UK*

Observational evidence for a large local galaxy underdensity goes back to the 1990's and, like the "Hubble tension", remains unexplained by standard ΛCDM. Wong et al (2022) show that this "Local Hole"covers >90% of the sky out to ~200Mpc with an ~20-30% underdensity, consistent with previous observations (e.g. Keenan, Barger and Cowie, 2014). We have speculated that this underdensity could explain the H0 tension but an even larger/more underdense "Hole"would be required, uncomfortable given that the current Local Hole is already a 4σ deviation from ΛCDM. However, recall that we are only measuring galaxy density and biasing has to be taken into account. Crucially, Kaur et al (2025) find that galaxy-CMB lensing results from Planck+ACT give significantly higher amplitudes at 2-halo scales than predicted. These results argue for an anti-bias that increases the local mass underdensity to ~50% over 200Mpc, enough to explain the Hubble tension (eg Huterer 2023), although remaining in disagreement with ΛCDM.

References:

"The local hole: a galaxy underdensity covering 90 per cent of sky to ≈200 Mpc", Wong J.H.W., Shanks T., Metcalfe N. and Whitbourn J.R., 2022, MNRAS, 511, 5742.

207

Stacked X-ray and Optical Reverberation Mapping of eROSITA eFEDS QSOs

Authors: Alice Eltvedt[1]; Tom Shanks[1]

[1] *Durham University, UK*

The high luminosities of QSOs originate from a black hole accretion disk surrounded by an X-ray corona. The broad line region (BLR) that lies at ~10x larger radii is also known to be ionized by UV radiation from the accretion disk to produce the broad emission lines. Here, we find new evidence for reprocessing and reflection of coronal X-rays in the BLR that may allow re-radiation of the accretion disk+corona. Using the stacked reverberation mapping technique we find that the radius of the quasar BLR is ~35 light days for CIV. Using the same technique, we find a similar ~35-day lag for UV continuum-X-ray cross-correlations, with the X-rays lagging the continuum. We also find a still longer ~50-day lag where the UV continuum now lags the X-ray. Both lags are longer than expected from an accretion disk+X-ray corona of ~3 light days extent. We conclude that the QSO BLR makes a significant contribution to QSO X-ray emission while also reflecting X-rays reprocessed into the UV back to the accretion disk.

References:

"Stacked reverberation Mapping", Fine S., Shanks T., Green P., Kelly B.C., Croom S.M., Webster R.L., Berger E., et al., 2013, MNRAS, 434, L16.

208

Exploring new physics in the Dark Sector at CMS

Author: CMS Collaboration[None]

Among the intriguing scenarios of new physics that provide explanation to several shortcomings of the Standard Model (SM), hidden valley scenarios include a Dark Sector that extends the SM with a non-Abelian gauge group, similar to quantum chromodynamics with new matter and gauge fields analogous to the SM quark and gluon fields. This may result in a rich phenomenology which we can access through portal interactions. In this talk we present the most recent results from CMS that explore such Dark Sectors by exploiting dedicated data streams and innovative usage of the

CMS detector. We focus on the recent results obtained using the full Run-II data-set collected at the LHC.

References:

arXiv:2405.13778 [hep-ex], arXiv:2310.12229 [hep-ex], ...

209

Searches in CMS for long-lived particles and other non-conventional signatures

Author: CMS Collaboration[None]

Many models beyond the standard model predict new particles with long lifetimes. These long-lived particles (LLPs) decay significantly displaced from their initial production vertex thus giving rise to non-conventional signatures in the detector. Dedicated triggers and innovative usage of the CMS detector boost are exploited in this context to significantly boost the sensitivity of such searches at CMS. We present recent results of searches for long-lived particles and other non-conventional signatures obtained using data recorded by the CMS experiment during the completed Run-II and the ongoing Run-III of the LHC.

References:

2409.10806 , 2405.17605 , ...

Morning session 5 / **210**

Data-driven galaxy-AGN co-evolution studies with eROSITA, Euclid and LSST

Author: Johannes Buchner[1]

[1] *Max Planck for extraterrestrial Physics*

Galaxy evolution follows the tapestry set by cosmology, but is modulated by central supermassive black holes. Human lifetimes limit the study of the stochastic gas motion from halos to the event horizon. Nevertheless, the last few decades have revealed a probabilistic multidimensional link between AGN outflows, black hole mass, accretion, galaxy mass, star-formation, morphology, and obscuration. Degeneracies linger in the demographic evolution of black holes and their radiative processes, which are important to resolve if we want to precisely understand the cosmic mass outflow budget affecting galaxies and the intergalactic medium. The millions of AGN found by new surveys (eROSITA, Euclid, LSST, SphereX, SDSS-V, DESI, 4MOST) will be able to break these degeneracies if selection effects are addressed with scalable inference methods. First results with *eROSITA* include abundant over-massive black holes at odds with their interpretation as seed remnants and tight correlations in current simulations.

References:

https://ui.adsabs.harvard.edu/abs/2024A%26A...692A.161B/abstract https://ui.adsabs.harvard.edu/abs/2024A%26A...689L...2B/abstr
https://ui.adsabs.harvard.edu/abs/2019ApJ...874..117B/abstract https://ui.adsabs.harvard.edu/abs/2015ApJ...802...89B/abstract

Afternoon session / **211**

Trace Anomaly, Condensates and Cosmological Constant

Author: Kehfei Liu[None]

We explore the origin of the cosmological constant. One salient and intriguing property of the cosmological constant is that the associated pressure is the negative of its energy density. By analyzing the energy-momentum tensor form factors of hadrons, we find that the QCD trace anomaly balances the pressure from quarks and gluons, thereby playing a key role in hadron confinement. This anomaly originates from the gluon and quark condensates in the vacuum and exhibits the same pressure-energy density relation as the cosmological constant. A similar phenomenon is observed in type II superconductors, where the same pressure-energy density relation arises from the unpairing of Cooper pairs in the vortex core. In view of these analogies, it is suggested that the cosmological constant could arise from the trace anomaly of a vacuum condensate resulting from the spontaneous breaking conformal symmetry in quantity gravity. The presence of a condensate could resolve the issue of energy conservation.

References:

K.F. Liu, Phys. Lett. B 849, 138418 (2024), doi:10.1016/j.physletb.2023.138418 [arXiv:2302.11600]

Morning session 5 / **212**

Processing of gas in galaxies within the cosmic web.

Author: Gianluca Castignani[1]

[1] *INAF OAS Bologna*

Galaxies are distributed in a complex filamentary network of matter called the cosmic web. It remains debated which is the overall impact of the cosmic web in processing cold gas of galaxies, as they move through large-scale filaments around the clusters down to the densest regions of the cluster cores. I will present the results of a large observational campaign, mainly exploiting IRAM millimeter facilities, with the goal of quantifying the processing of galaxies' gas in the cosmic web and with cosmic time. I will discuss the degree of such processing in a variety of dense megaparsec-scale environments. Finally, I will discuss the potential of such studies for next generation multi-wavelength facilities. Thousands of distant clusters and BCGs will be detected with Euclid, enabling an unprecedented leverage to constrain galaxy evolution in cluster.

References:

Castignani et al. 2022, A&A https://ui.adsabs.harvard.edu/abs/2022A%26A...657A...9C/abstract

Morning session 4 / **213**

Mapping Gravity with Extragalactic Streams and Citizen Science

Author: Nathaniel Starkman[1]

Co-authors: Jake Nibauer [2]; Jo Bovy [3]; Lina Necib [4]; Michael Walmsley [3]; Sarah Pearson [5]; Sirui Wu [5]

[1] *MIT Kavli Institute for Astrophysics and Space Research*

[2] *Princeton*

[3] *University of Toronto*

[4] *MIT*

[5] *University of Copenhagen*

Wide-field surveys like Euclid mark a new era of extragalactic stellar stream studies, with exciting applications in measuring baryon and dark matter distributions, and connecting galaxies to their cosmological context.
I present results from a pilot study combining Euclid imaging with Zooniverse classifications to detect and analyze streams. We use projected stream morphologies to constrain the shape and barycenter of each host galaxy's potential, jointly probing baryonic and dark matter distributions. These inferences complement lensing, with sensitivity to halo geometry on tens of kpc scales. The method enables both stacked, population-level constraints on halo triaxiality and barycenters, and individual-halo inference on the same. Already, we find promising agreement with ΛCDM predictions. Our program will identify thousands of streams, enabling precise constraints on halo shapes and barycenters across large samples and redshifts, offering a new dynamical test of dark structures.

References:

Nibauer et al 2023 – 10.3847/1538-4357/ace9bc

Morning session 5 / **214**

The Host Masses of Active Galactic Nuclei before Cosmic Noon with TNG-Cluster and other cosmological Simulations of Galaxies

Author: Akanksha Kapahtia[1]

Co-authors: Annalisa Pillepich [1]; et. al.

[1] *Max Planck Institute for Astronomy Heidelberg*

We investigate the host dark matter halo masses of AGNs across various cosmological simulations of galaxies (Illustris, IllustrisTNG, TNG-Cluster, Simba and EAGLEs). In particular we examine the co-evolution of the luminosity of AGNs in relation to the mass of their host dark matter halo from z=7 to z=3. Despite differences in AGN feedback implementations and SMBH seeding prescriptions across simulations, we find that AGNs of a given luminosity can occupy a wide range of halo masses, exhibiting a significant scatter. We also find that in the TNG model, the median halo mass of "quasars" remains roughly constant with redshift which is consistent with quasar clustering measurements, implying that luminous quasars do not exclusively occupy the most massive halos, which increasingly host supermassive black holes depleted of their gas reserves near cosmic noon.

References:

Not yet published

Morning session 5 / **215**

Stellar Tracers of the Local Dark Matter Velocity Distribution Over a Range of Galaxy Simulations

Author: Xiuyuan Zhang[None]

Dark matter (DM) remains one of the central unresolved questions in modern physics. The majority of terrestrial direct detection experiments for DM rely on the assumption that the local DM velocity distribution conforms to the Standard Halo Model (SHM). However, perturbations arising from merger events can induce deviations from the SHM. Previous studies have suggested that the local stellar velocity distribution may serve as a tracer for DM populations originating from the same progenitor systems. In this talk, I discuss how we systematically investigate the impact of the merger history on the correlation between local stellar and DM velocity distributions across multiple halos from the FIRE latte suite. Additionally, we assess the influence of simulation resolution on these results. We find that DM accreted from lower-mass mergers at earlier times exhibits a stronger correlation with its stellar counterpart, highlighting the importance of merger history in interpreting local DM phase-space structure.

References:

https://arxiv.org/abs/1810.12301

Morning Session 2 / **216**

Dark matter searches in dwarf irregular galaxies with gamma-ray observatories.

Author: Viviana Gammaldi[1]

[1] *San Pablo CEU, Madrid, Spain.*

I will review the state-of-the-art of dark matter (DM) searches in dwarf irregular galaxies (dIrrs). DIrrs have been proposed as new astrophysical targets of interest for DM searches in gamma rays, complementary to dwarf spheroidal galaxies, galaxy clusters and the Galactic center. DIrrs show high DM content (with respect to the luminous matter), relatively close distance and low gamma-ray background: all these characteristics make dIrrs interesting targets for DM searches. After the first proof-of-concept paper, dIrr galaxies have been studied by both satellite and ground-based observatories, such as Fermi-LAT, HAWC and HESS. I will review the main results obtained so far, as well as preliminary observational prospects for the upcoming Cherenkov Telescope Array Observatory.

References:

Ready to submission CTAO paper, arXiv number coming soon

Afternoon session / **217**

Theoretical Predictions for the Inner Dark Matter Distribution in the Milky Way Informed by Simulations

Author: Abd El Aziz Hussein[1]

Co-authors: Andrew Wetzel [2]; Justin Read [3]; Lina Necib [4]; Manoj Kaplinghat ; Martin Rey [5]; Oscar Agertz [6]; Stacy Kim [7]

[1] *Massachusetts Institute of Technology*

[2] *Department of Physics & Astronomy, University of California, Davis*

[3] *University of Surrey*

[4] *MIT*

[5] *University of Bath*

[6] *Lund Observatory*

[7] *Ohio State University*

Understanding the distribution of dark matter (DM) within a few kpc of the Milky Way's center is critical for interpreting and projecting indirect detection signals. Some studies use the inner DM profile directly from hydrodynamic cosmological simulations; however, differences in baryonic physics prescriptions can significantly affect the resulting DM profiles. In this talk, I will quantify the impact of the various baryonic physics implementations by modeling the DM profile in FIRE-2, Auriga, Vintergatan, and Illustris TNG50 using the adiabatic contraction algorithm from Gnedin et al.2004. We find that FIRE-2's stellar feedback dominates over baryonic contraction, while the other simulations are well described by adiabatic contraction. Using models calibrated to simulations and the observed stellar profile in the Milky Way, we provide a theoretical bound on the inner DM distribution in our Galaxy, setting a new standard for DM direct detection analyses and a departure from the overuse of unphysical profiles.

References:

https://arxiv.org/abs/2501.14868

Morning Session 3 / **218**

Cosmology with prompt cusps

Author: Sten Delos[1]

[1] *Carnegie Observatories*

Every dark matter halo forms with a ρ ∝ r^{−1.5} density cusp at its center. This *prompt cusp* has a mass comparable to the cutoff scale in the spectrum of initial density perturbations. For warm and interacting dark matter models, prompt cusps significantly influence the structures of low-mass halos, so they are an important consideration for efforts to use satellite galaxies, strong lensing, and stellar streams to constrain the dark matter mass and interaction properties. For annihilating dark matter, prompt cusps amplify the annihilation rate an order of magnitude above previous predictions. I will present the basis for prompt cusps in simulations and theory, including new results showing how each halo's central cusp depends on the dark matter model. I will also discuss two observational tests of dark matter that prompt cusps enable: the measured kinematics of dwarf galaxies can strongly constrain warm dark matter, while gamma rays from galaxy clusters strongly constrain annihilating dark matter.

References:

MNRAS 518, 3509 (2023); MNRAS 522, L78 (2023); JCAP 10, 008 (2023); Phys. Rev. D 109, 083512 (2024); arXiv:2501.14865; arXiv:2506.03240

Afternoon session / **219**

Production, thermalisation and constraints on hidden sector dark matter from asymmetric reheating

Author: Jean Kimus[1]

Co-authors: Michel Tytgat ; Simon CLERY [2]

[1] *Université Libre de Bruxelles*

[2] *IJCLab - Théorie*

The evolution of the early Universe may have been driven by a hot hidden sector, made of dark matter and possibly other companion particles. Such conditions can be achieved, for instance, by asymmetric reheating from inflaton decay, and open new regions in the parameter space. In this talk, using dark QED as a benchmark model for the dark sector, I will introduce asymmetric reheating and the conditions of thermalisation in the produced hidden sector. Next I will present the main classes of reheating scenarios in this framework and show the corresponding cosmological constraints in the parameter space, with a focus on the unitarity limit on the dark matter mass.

References:

2405.10792, 2105.01263, 1806.01865

Afternoon session / 220

Exploring keV-scale physics with CUORE: a new window for dark matter searches

Authors: Anastasiia Shaikina[1]; The CUORE Collaboration[None]

[1] *Gran Sasso Science Institute, Istituto Nazionale di Fisica Nucleare*

Initially designed to search for neutrinoless double beta decay, the CUORE (Cryogenic Underground Observatory for Rare Events) experiment also offers a unique opportunity to explore potential dark matter signals at the keV-scale. Leveraging over 2 tonne·yr of TeO_2 exposure, we optimized data processing and event-selection techniques, achieving stable detector performance and effective event reconstruction down to thresholds as low as 3 keV. CUORE's large exposure, segmented detector structure, ultra-low-background environment, and excellent energy resolution enable sensitive searches for cosmic axions originating from the galactic halo, solar axions, and WIMP-induced annual modulation signals. We present our advanced low-energy analysis methods, current status, and future prospects of these ongoing dark matter searches.

References:

arXiv:2505.23955

Opening and Morning Session 1 / 221

Needlets and foreground removal for SKAO HI intensity maps

Author: Bianca De Caro[1]

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Intensity Mapping (IM) of the 21-cm line of the neutral hydrogen (HI) has become a compelling new technique to map the large-scale structure of the Universe. One of the main challenges is the presence of strong foreground emissions of several orders of magnitude larger than the HI signal. Here we implement a version of the Principal Component Analysis, a blind component-separation technique, based on a kind of spherical wavelets called needlets. These functions exploit double localization both in real and in harmonic space. We test the Need-PCA performances on a set of maps that simulate the SKA AA4 telescope. We compare our results with other component separation methods such as Generalised Morphological Component Analysis (GMCA) and Generalized Needlet Internal Linear Combination (GNILC). All the methods have comparable results. We also test our pipeline in the presence of systematics such as polarization leakage e we find similar results.

References:

to be submitted within end of August

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Probing dark matter properties through the morphology of the intergalactic medium in emission

Author: Titouan Lazeyras[1]

[1] *University of Milano-Bicocca*

The nature of dark matter (DM) is a pivotal question of cosmology. A crucial property is its mass. Current constraints are degenerate with assumptions about the thermal history of the universe and galaxy formation. I will present a new promising probe to constrain DM properties: fluorescent emission from the intergalactic medium (IGM) around bright quasars. This emission is produced by the cold diffuse gas, which has been minimally impacted by galactic processes, making it an optimal tracer of the underlying DM field. Before being able to exploit observations, it is necessary to study similar structures in simulations with different DM implementations. I will present our new suite of zoom-in hydrodynamical simulations which we use to create mock observations of the surface brightness at the Lyman-alpha wavelength in cold and warm DM scenarios. Using topological tools, I will show that the morphology of the emission from the IGM is impacted by the nature of DM, making it more clumpy in the cold DM case.

References:

https://academic.oup.com/mnras/article/526/2/1850/7261732

Morning Session 2 / 223

Cosmology with Ultralight Dark Matter

Author: Kimberly Boddy[1]

[1] *University of Texas at Austin*

The presence of ultralight dark matter in the early Universe suppresses small-scale structure formation. Moreover, if it couples to the Standard Model, it can induce a variation of fundamental constants. In this talk, I will discuss the cosmological impact of an ultralight dark matter field with an effective quadratic coupling to the Standard Model, such that the fine structure constant and the mass of the electron have time-dependent, oscillatory variations. I will present CMB constraints on this scenario for a wide range of dark matter masses, associated with the oscillations occurring around BBN and the formation of the CMB.

References:

associated paper will appear on arXiv in the coming weeks

Opening and Morning Session 1 / **224**

DESI Peculiar Velocity Survey and the DR1 Fundamental Plane sample

Author: Caitlin Ross[1]

[1] *The University of Queensland*

The Dark Energy Spectroscopic Instrument (DESI) Peculiar Velocity Survey aims to provide measurements of the growth rate of structure and the Hubble constant in our local universe. To do so the survey, over the course of its 5 years of operations, aims to measure peculiar velocities for over 186,000 galaxies using both the Fundamental Plane and Tully Fisher relations. Additionally, these peculiar velocity catalogues will be used to build density reconstruction maps which can be used to study the galaxy velocity field and underlying dark matter distribution. In this talk I will present the work being conducted by the DESI Peculiar Velocity Survey with a particular focus on the Fundamental Plane sample and its uses in cosmology. With Data Release 1 the sample contains peculiar velocities for 98,000 early-type galaxies making it the largest existing sample of peculiar velocities and potentially resulting in the tightest constraints on the growth rate of structure at z<0.1, to date.

References:

https://doi.org/10.1093/mnras/staf700

Afternoon session / **225**

Microlensing of Microlensing: Resolving Time-Delay Bias with Multi-Plane Quasar Lensing

Author: nada salama[1]

Co-authors: Daniel Ballard ; Geraint Lewis ; Huimin Qu [1]

[1] *The University of Sydney*

When a luminous source is gravitationally lensed, its images arrive at different times. These time delays can be measured in lensed quasars to constrain H_0, offering a possible resolution to the Hubble tension. A quasar's point-like nature, however, makes it sensitive to microlensing: deflections caused by compact objects within lensing galaxies that introduce small additional delays. If unaccounted for, microlensing-induced delays can bias time-delay measurements, and estimates of H_0. We use the Python library JAX to build an inverse ray-tracing pipeline, simulating light propagation through multiple lens planes. Applying this to the newly observed lensed quasar J1721+8842, with an intermediate lensing plane, we construct realistic microlensing maps and light curves. These reveal a distinctive signature due to a novel microlensing of microlensing effect. Our forthcoming analysis aims to quantify the resulting bias on H_0, providing new insight into systematics affecting cosmology with strong lensing.

References:

Dux, F., et al. "J1721+ 8842: The first Einstein zigzag lens." Astronomy & Astrophysics 694 (2025): A300.

Morning session 4 / **226**

Learning about the early Universe with the cosmic 21-cm signal

Author: Andrei Mesinger[None]

The 21-cm hyperfine line of HI is set to revolutionize studies of the first billion years, spanning the cosmic dawn of the first stars and eventual reionization of our Universe. I will discuss the potential of this probe in learning about the unknown astrophysics of the first galaxies as well as physical cosmology. Preliminary claims of a detection of the mean (sky-averaged) 21cm signal showcased its potential in constraining exotic dark matter-baryon interactions in the early Universe, although recent robust interpretation points against new physics. The true potential of the cosmic 21cm signal is in mapping out the first half of our observable Universe through HI fluctuations. Current upper limits on the 21-cm power spectrum already provide new insights into the heating of the intergalactic medium, likely caused by a new population of high mass X-ray binaries. Future detections will allow us to set the strongest available constraints on exotic heating mechanisms through dark matter decay and annihilation.

References:

https://ui.adsabs.harvard.edu/abs/2023ApJ...945..124H/abstract, https://ui.adsabs.harvard.edu/abs/2025A%26A...698A.152C/abstrac
https://ui.adsabs.harvard.edu/abs/2024JCAP...01..005F/abstract.

Afternoon session / **227**

Characterization of Galaxy Cluster Gamma-Rays.

Author: Thyra Eysselinck[1]

Co-authors: David Zurek [2]; Joshua Tan [3]; Owen Henry [4]; Timothy Paglione [5]

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[5] *CUNY York, AMNH, Simons Foundation*

Barring a few potential exceptions, galaxy clusters (GC) are not confirmed gamma-ray sources despite theoretical expectations. We use 16 years of Fermi-LAT data to characterize the gamma-ray emission of a population of GC selected from the Planck Sunyaev-Zeldovich catalog. We employ a likelihood stacking technique to uncover the cumulative gamma-ray signal from this population. The stack of 207 target clusters significantly exceeds the cumulative likelihood of a large control field sample. Refitting our targets as extended sources consistently increases the likelihoods, indicative of large-scale GC emission rather than point source contamination. We also create a stacked spectral energy distribution (SED) and perform likelihood-based correlation analyses between the gamma-ray luminosities and X-ray data. We compare the SED to physical models to gauge the balance between hadronic and leptonic processes, gain insight into the role of cosmic rays in GC evolution, and the nature of cosmic ray acceleration in GC.

References:

A stacking survey of gamma-ray pulsars, Song Y., Paglione T. A. D., Tan J., Lee-Georgescu C., Herrera D., 2023,

Opening and Morning Session 1 / **228**

RockStar Baryogenesis: Baryogenesis from primordial CP violation

Authors: Edward Kolb[1]; Venus Keus[2]

[1] *University of Chicago*

[2] *Dublin Institute for Advanced Studies (DIAS)*

I will present a novel Baryogenesis mechanism in which an asymmetry of scalars in a three-Higgs doublet model produced exiting a CP-violating inflationary set-up is translated into an asymmetry of baryons through electroweak instantons.

References:

JHEP 07 (2025) 156

Afternoon session / **230**

Unveiling small-scale dark matter structure with starless halos: Are mass and concentration estimates reliable?

Author: Francesco Turini[1]

[1] *Università degli studi Milano-Bicocca*

RELHICs (REionization-Limited HI Clouds) are a population of gas-rich, starless dark matter halos predicted by the ΛCDM model. Being in hydrostatic equilibrium with the dark matter and the UV background, their gas distribution provides a unique opportunity to directly probe the structure of dark matter halos on small scales. These systems have recently become accessible to observations thanks to deep radio surveys as FAST. I will present results from high-resolution cosmological simulations from the EAGLE project, focusing on the performance of mass and concentration estimators applied to simulated RELHICs. Using a physically motivated model for the HI and gas profiles, we can infer halo properties directly from observable quantities. We find that mass estimates are unbiased on average, though systematic deviations appear in the most HI-rich systems due to environment pressure effects. This analysis provides guidance for current and future observational efforts with upcoming facilities such as SKA.

References:

Alejandro Benitez-Llambay and Julio F. Navarro 2023 ApJ 956 1- Alejandro Benitez-Llambay , Carlos Frenk, Volume 498, Issue 4, November 2020, Pages 4887–4900, https://doi.org/10.1093/mnras/staa2698

Morning Session 2 / **231**

Scaling Relations between the Luminous and Dark Matter Density Parameters of Milky Way Dwarf Spheroidal Galaxies

Author: Casey Watson[1]

[1] *Millikin University*

We use surface brightness and velocity dispersion data to constrain the parameters of the luminous and dark matter densities for a sample of 10 Milky Way, dwarf spheroidal galaxies (MW dSphs). We model the luminous matter density with a generalized Plummer profile, of inner slope γ_*, and the dark matter (DM) density with a Zhao-type model, of inner slope γ. The specific DM density model we use has the advantage of an analytic mass integral, facilitating particularly simple DM density and mass profile fits for any $0 \leq \gamma \leq 1$. We find that the best-fit values of γ_* and γ are correlated with each other, as well as with other parameters, such as the effective radii, $R_{\rm eff}$, and the stellar-to-total mass ratios of the dSphs in our sample. Additionally, we find that the best-fit DM scale radii and scale density parameters are also correlated with $R_{\rm eff}$.

References:

For instance, Walker, et al. (2009): arXiv:0906.0341; 2009ApJ.704.1274W and Donato, et al. (2009): arXiv:0904.4054; MNRAS.397.1169D, which each have hundreds of more recent citations, introduce similar relations to which I will compare my results.

Morning Session 3 / **232**

Is there a need to go beyond LCDM?

Author: Andrea Valerio Maccio[1]

[1] *New York University Abu Dhabi*

The LCDM model has ben challenged many times in the past decade, mainly by galaxy observations on small scales: from the abundance of satellites, to the distribution of dark matter within galaxies. In my talk I will first revise all these claims with the help of cosmological numerical simulations of galaxy formation from the NIHAO project. I will then discuss whether there is indeed an observational motivated need to abandon Cold Dark Matter and move beyond such a simple model.

References:

Afternoon session / **233**

The CMS PPS spectrometer searching for photon-DM interaction

Author: Nicola Turini[1]

[1] *INFN Sezione di Pisa, Universita' di Siena*

The CMS Precise Proton Spectrometer (PPS) has opened a new window in the gamma-gamma interactions at TeV energies. A discussion on recent results and future searches will be presented focusing on the impact of photon-DM interaction at cosmological level

References:

Morning Session 3 / **234**

Tests of LCDM on small scales

Authors: CARLOS,SILVESTRE FRENK[None]; Carlos Frenk[1]

[1] *Durham ICC*

The LCDM model has the virtue of having strong predictive power in so far as the properties of the dark matter are concerned. For example, the mass function of dark matter halos is known to high precision, from the mass scale of the Earth to that of rich clusters. The predictive power is weakened when baryons are considered because of the complex astrophysical processes to which they can give rise. This shortcoming can be mitigated with detailed modelling which has become increasing sophisticated over the years. Neglecting such processes is dangerous and this has led to the often voiced view that LCDM suffers from a "small-scale crisis", that is that it disagrees with data on the scales of galaxies and below. I will discuss this perceived crisis and focus on claims that the abundance and properties of the galaxies recently discovered at very high redshift by the JWST are inconsistent with LCDM.

Morning Session 3 / **235**

Astrophysical Signatures of Gravothermal Collapse in Dark Matter Halos

Authors: Hai-Bo Yu[1]; Haibo Yu[None]

[1] *University of California Riverside*

I will present recent high-resolution N-body simulations of self-interacting dark matter (SIDM) and discuss their implications across a broad range of astrophysical observations. In particular, I will highlight novel signatures arising from gravothermal collapse in dark matter halos. I will then explore the prospects for detecting these signatures in strong gravitational lensing systems, stellar streams, dwarf galaxies, and the formation of supermassive black holes. Together, these studies open promising new avenues for probing the fundamental nature of dark matter.

References:

Afternoon session / **237**

Probing Charm Baryon Dipole Moments at the LHC: the ALADDIN experiment

Author: Nicola Neri[1]

[1] *Università degli Studi e INFN Milano (IT)*

The magnetic and electric dipole moments (MDM and EDM) of charm baryons remain unmeasured and offer a unique window into physics beyond the Standard Model. In particular, a nonzero EDM would signal new sources of CP violation, potentially linked to the baryon asymmetry of the universe.

The proposed ALADDIN experiment at the LHC aims to perform the first direct measurement of these moments. By accessing the charm sector, ALADDIN explores a largely untested regime where non-perturbative QCD effects and new CP-violating mechanisms may emerge.

This talk will outline the physics motivations behind the measurement, its relevance to cosmology, and recent experimental progress toward realizing this program.

Opening and Morning Session 1 / **238**

Mapping out the Dark Matter in the Milky Way with Stars

Author: Lina Necib[1]

[1] *MIT*

In this talk, I will explore the interfacing of simulations, observations, and machine learning techniques to construct a detailed map of Dark Matter in the Milky Way, focusing on the Galactic Center/Halo and dwarf galaxies. For the Galactic Halo, I will present a recent work that reveals a decline in the stellar circular velocity, inducing tensions with established estimates of the Milky Way's mass and Dark Matter content. I will discuss how the underestimated systematic errors in such a common methodology necessitates a revised approach that combines theory, observations, and machine learning. In dwarf galaxies, I will present a novel Graph Neural Network methodology that facilitates the accurate extraction of Dark Matter density profiles, validated against realistic simulations. I will conclude with a discussion on the future trajectory of astroparticle physics, emphasizing the need for the integration of astrophysical probes, particularly those of stellar dynamics, with our understanding of Dark Matter in the Galaxy and its connection with Dark Matter detection experiments.

Opening and Morning Session 1 / **239**

Primordial Black Holes – Positivist Perspective, Quantum Quiddity and Galaxy Genesis

Author: Florian Kühnel[None]

Primordial black holes are black holes that may have formed in the early Universe. Their masses potentially span a range from as low as the Planck mass up to many orders of magnitude above the solar mass. This, in particular, includes those black holes recently discovered through gravitational waves, and (part of) these may conceivably be of primordial origin. After a general introduction on primordial black holes, I review the observational hints for their existence – from a variety of lensing, dynamical, accretion and gravitational-wave effects. As I will show, all of these (over 20) may be explained by a single and simple unified model, naturally shaped by the thermal history of the Universe. If time permits, I discuss how recent advances in our understanding of quantum effects in black holes impact PBHs. On the one hand, this concerns deviations from Hawking radiation in the form of the memory-burden effect. On the other hand, I will discuss vorticity, which we recently conjectured to be a new characteristic of (near-extremally rotating) black holes. In the second part of my talk, I will present novel results on large-scale simulations of spatially-correlated random fields, being able to resolve events as rare as one in 10ˆ13, and discuss their application to PBHs. Finally, I will elucidate on the role primordial black holes have on early galaxy and star formation.

Morning Session 3 / **240**

Modelling high redshift structure formation and reionization in the JWST era

The study of primitive stars and galaxies is an exciting new frontier in astrophysics and cosmology. They form within the first gigayear after the Big Bang and significantly impact their surroundings by emitting a lot of high-energy radiation that transforms the surrounding cold neutral gas into a hot and ionized medium. They also form an important evolutionary link between the smooth matter distribution at early times and the highly complex structures seen today. Fortunately, a whole slew of instruments that have been specifically designed to study the high-redshift Universe (JWST, ALMA, Roman Space Telescope, HERA, SKA, CCAT-p, SPHEREx), have started providing valuable insights into high redshift structure formation and reionization. Therefore, theoretical/numerical models must achieve sufficient accuracy and physical fidelity to meaningfully interpret this new data. In this talk, I will introduce the THESAN simulation framework that is designed to efficiently leverage current and upcoming high redshift observations to constrain the physics of early galaxy formation and reionization. The multi-scale nature of these processes is tackled by coupling large volume (˜100s Mpc) simulations designed to study the large-scale statistical properties of the galaxies, with high-resolution (˜ 10 pc) simulations that zoom-in on single galaxies which are ideal for predicting their resolved properties. I will discuss applications from the first set of papers, including predictions for high redshift galaxy properties, the galaxy-IGM connection and the back reaction of reionization on galaxy formation. I will finish by highlighting recent improvements to the model and proposed future work.

Morning Session 2 / **241**

Searches for dark matter using LHC Run-2 and Run-3 data recorded by the ATLAS experiment

Author: Alvaro Lopez Solis[1]

[1] *The Barcelona Institute of Science and Technology (BIST) (ES)*

Dark matter constitutes about 85% of the matter content of the Universe, yet its microscopic nature remains unknown. While astrophysical and cosmological observations provide compelling evidence for its existence, they do not reveal how it interacts with Standard Model particles beyond gravity. Collider experiments such as the LHC provide a complementary avenue of investigation by directly searching for dark matter production at the highest available energies. This approach enables the exploration of a wide variety of final states, ranging from traditional WIMP searches to more complex and intriguing scenarios involving dark sectors and new mediator particles. Such searches are crucial for mapping out the possible connections between cosmological evidence and particle physics signatures.
The sensitivity achieved by ATLAS underscores the continued impact of collider-based searches in probing the particle nature of dark matter and in constraining theoretical models. In this contribution, we will present an overview of dark matter searches performed with ATLAS during Run 2, based on the full dataset corresponding to an integrated luminosity of 140 fb^{-1}, as well as highlight recent results from the ongoing Run 3 data-taking campaign. Together, these results provide an essential complement to direct and indirect detection experiments.