XI Meeting on Fundamental Cosmology

Santander - 18-20th November 2025

Abstract book

Talks

Line Intesity Mapping / CMB

- **Present and Future of Line-Intensity Mapping**

Author: José Luis Bernal - IFCA

Abstract: Line-Intensity mapping (LIM) uses the integrated flux along the line of sight as tracer of the LSS. Using relatively low-aperture telescopes, it recovers radial information targeting known spectral lines discarding the continuum emission, which makes the experiments cheaper compared with galaxy surveys. Mapping the intensity fluctuations of an array of lines from HI 21cm to optical-UV lines offers a unique opportunity to probe redshifts well beyond the reach of other cosmological observations, access regimes that cannot be explored otherwise, and exploit the enormous potential of cross-correlations with other measurements. This promises to deepen our understanding of various questions related to galaxy formation and evolution, cosmology, and fundamental physics. In this talk I will cover the current status of LIM, the main detections and the promised potential for the future, with special focus on the next steps that must be taken to bring this technique to full speed for precision cosmology.

- **Field-level constraints on cosmic birefringence using hybrid E-B mode ILC maps**

Author: Mathieu Remazeilles - Instituto de Fisica de Cantabria (CSIC-UC)

Abstract: Cosmic birefringence—arising from potential parity-violating interactions between CMB photons and pseudo-scalar fields like axion-like particles—rotates the polarization plane of the CMB, inducing correlations between CMB E- and B-mode polarization. In this presentation, I will describe a new real-space, field-level methodology to infer cosmic birefringence directly from CMB fields. We implement a hybrid internal linear combination (ILC) approach that jointly processes E- and B-mode frequency maps, allowing us to disentangle the correlated and uncorrelated components of the CMB polarization fields. We then derive an analytic linear relation between the birefringence-induced correlated component of the CMB E-mode and the full CMB B-mode field, enabling direct linear regression across sky patches to extract the birefringence angle. Our approach, blind to prior foreground models, robustly distinguishes true

cosmic birefringence from instrumental polarization angle miscalibration and foregrounds, as the ILC weights differently project achromatic versus chromatic effects. In LiteBIRD mission simulations, it achieves constraints competitive with traditional power-spectrum approaches. Applied to Planck PR4 data, we detect a birefringence angle of beta = 0.32 +/- 0.12 degrees (2.7 sigma), consistent across varying sky fractions. This talk aims to highlight how this field-level method opens new opportunities to probe fundamental physics with the CMB.

- **Investigating parity violation with the polarization of the CMB**

  Author: Simone Paradiso - INAF-OAS

  Abstract: This talk introduces the polarization of Cosmic Microwave Background (CMB) as a powerful tool to investigate the occurrence of a parity violating process in the Universe, whose effect is the in-vacuum rotation of the linear polarization plane of photons during propagation, usually referred to as Cosmic Birefringence (CB). The CMB represents the earliest source of polarized radiation available in Nature, hence it offers a unique opportunity to prove new parity-violating physics occurring in the Universe. Recent analyses of Planck data yield hints of the detection of an isotropic CB signal at$\sim 3\sigma$ confidence level; such constraints are limited by the uncertainty on the instrumental polarization angle, and by the polarized foreground emission. Exploiting the enhanced sensitivity and resolution of future CMB experiments (Simmons Observatory, CMB-S4, LiteBird) we will be able to impose more stringent constraints on CB, and investigate the possibility of an anisotropic CB signal. In this talk we then introduce an alternative estimator to constrain both the isotropic and the anisotropic CB signal from maps of CMB polarization.

- **Constraints from CMB EB power spectrum with simulation-based inference**

  Author: Florie Carralot - SISSA

  Abstract: In the next decade, current and future CMB polarization experiments will collect data that are highly sensitive to the early stages of the Universe's evolution. Extracting cosmological parameters from these observations typically relies on methods that assume a Gaussian likelihood function. However, this assumption breaks down in presence of cross-correlated fields at large angular scales. In this talk, we use simulation-based inference (also known as likelihood-free inference), a neural network based technique, to learn statistical information directly from the parity-violating CMB EB power spectrum, without the need for an approximate likelihood function. This approach provides a more accurate way to probe the underlying axion dynamics responsible for cosmic birefringence.

Cosmic Microwave Background

- **The CMB power spectrum and cosmological constraints from ACT DR6**

  Author: Hidde Jense - Cardiff University

  Abstract: We present power spectra of the cosmic microwave background (CMB) anisotropy in temperature and polarization, and the most recent constraints on cosmology from these, as measured from the Data Release 6 (DR6) of the Atacama Cosmology Telescope (ACT) data. ACT DR6 measures the CMB power spectra over a quarter of the sky in multiple bands in both temperature and polarization with arcminute resolution. We find that the ACT angular power spectra are well fit by the sum of CMB and foregrounds, where the CMB spectra are described by the ΛCDM model. Combining ACT with larger-scale Planck data, the joint P-ACT dataset provides tight limits on the ingredients, expansion rate, and initial conditions of the universe. We find similar constraining power, and consistent results, from either the Planck power spectra or from ACT combined with WMAP data, as well as from either temperature or polarization in the joint P-ACT dataset. We use these new cosmic microwave background measurements to test foundational assumptions of the standard cosmological model, ΛCDM, and set constraints on extensions to it. We derive constraints from the ACT DR6 power spectra alone, as well as in combination with legacy data from the Planck mission, measurements of the CMB lensing from ACT and Planck, baryon acoustic oscillation measurements, and supernovae data. Together, these measurements provide the newest, tightest constraints on the ΛCDM model and a broad range of extensions.

- **Tenerife Microwave Spectrometer (TMS): absolute spectral measurements in the 10–20GHz range**

  Author: Jose Alberto Rubino-Martin - Instituto Astrofisica Canarias (IAC)

  Abstract: The Tenerife Microwave Spectrometer (TMS) is a new absolute spectrometer operating in the 10–20 GHz range that will be installed at the Teide Observatory (Tenerife, Spain), alongside the QUIJOTE (Q-U-I JOint TEnerife) experiment. Its main scientific goal is to measure absolute spectral distortions of the sky spectrum in this frequency range, with particular emphasis on characterizing the absolute monopole from our Galaxy and probing possible deviations of the CMB spectrum from a pure blackbody. TMS will also provide an absolute calibration for the QUIJOTE experiment.

  In this talk, I will review the TMS science case, with special emphasis on the characterization of the radio synchrotron background and its potential connections with fundamental physics. I will also present specific developments for TMS, including the instrument's thermal model and a detailed characterization of the radiometric chain, aimed at predicting the systematic effects that may impact the final measurements.

- **Commissioning of the QUIJOTE-TFGI and sensitivity forecasts for cosmological surveys**

Author: Mateo Fernández-Torreiro - CNRS-LPSC

Abstract: One of the main goals of current Cosmic Microwave Background (CMB) experiments is the detection of primordial B-modes, generated by gravitational waves during inflation. Achieving such a detection requires observations with exquisite polarization sensitivity, well beyond the capabilities of Planck. One promising approach is the use of a "true polarimeter" design, which produces polarization measurements for each individual detector and mitigates systematic effects, particularly bandpass leakage. This is the strategy adopted by the Thirty- and Forty-Gigahertz Instrument (TFGI), which observes the sky at 31 and 41 GHz from the second QUIJOTE telescope at the Teide Observatory.

In this talk, I will present results from the commissioning phase of TFGI, conducted between November 2021 and October 2022. Using Tau A, our primary calibrator, we characterized key instrumental properties including beam, gain, polarization performance, and instantaneous sensitivity. Observations of bright Galactic regions were also used to assess intensity-to-polarization leakage and the recovery of diffuse emission. Overall, the TFGI properties are consistent with expectations, though some issues were identified, particularly in the 41 GHz pixels. I will describe these problems, the proposed solutions, and the status of their implementation, with routine observations expected to resume in fall 2025.

We also used Galactic observations to construct noise half-maps and estimate the TFGI sensitivity. From these maps, we infer a polarization sensitivity of $8.4\,\mu\mathrm{K}\,\mathrm{deg}^{-1}$ after $0.57\,\mathrm{h}\,\mathrm{deg}^{-2}$ of integration, using only two pixels. This is already comparable to the sensitivity reached by WMAP over its full mission. Projections show that, once all 29 TFGI pixels are operational, the instrument will achieve a sensitivity of $\sim 1\,\mu\mathrm{K},\mathrm{deg}^{-1}$ over three cosmological fields covering 3600 deg^2 after 2.3 years of continuous observations. This sensitivity is sufficient to constrain the tensor-to-scalar ratio to $r \leq 0.05$, thereby meeting the TFGI design requirements.

- **Spatial Variations Of Polarized Synchrotron Emission In The QUIJOTE MFI Data**

Author: Jose Manuel Casas - University of Oviedo/ICTEA

Abstract: Polarized synchrotron emission from ultra-relativistic electrons spiraling the Galactic magnetic field has become one of the most relevant emissions in the Interstellar medium these last years due to the improvement in the quality of low-frequency observations. One of the recent experiments designed to explore this emission is the QUIJOTE experiment.

In this work, we aim to study the spatial variations of the synchrotron emission in the QUIJOTE MFI data, by dividing the sky into physically separated regions. For such task, we firstly use a novel component separation method based on artificial neural networks to clean the synchrotron maps. After train the network with simulations, we fit both EE and BB spectra by assuming a power-law model. Then, we give estimations for the index α_S, the amplitude, and the ratio between B and E amplitudes.

When analyzing the real data, we found a clear spatial variation of the synchrotron properties along the sky at 11 GHz, consistent with previous analyses, obtaining a steeper index in the Galactic plane of $\alpha_S^{EE} = -3.1 \pm 0.3$ and $\alpha_S^{BB} = -3.1 \pm 0.4$ and a flatter one at high Galactic

latitudes of $\alpha_S^{EE} = -3.05 \pm 0.2$ and $\alpha_S^{B} = -2.98 \pm 0.27$. We found average values at all sky of $\alpha_S^{EE} = -3.04 \pm 0.21$ and $\alpha_S^{BB} = -3.00 \pm 0.34$. Furthermore, after obtaining an average value of $A_S^{EE} = 3.31 \pm 0.08 \ \mu K^2$ and $A_S^{BB} = 0.93 \pm 0.02 \ \mu K^2$, we estimate a ratio between B and E amplitudes of $A_S^{BB}/A_S^{EE} = 0.28 \pm 0.08$.

Based on the results we conclude that, although neural networks seem to be valuable methods to apply on real ISM observations and in future QUIJOTE MFI2 data, combined analyses with *Planck*, WMAP and/or CBASS data are mandatory to reduce the noise contamination from QUIJOTE estimated maps and then improve the accuracy of the estimations.

- **Forecasting Synchrotron Spectral Parameters with the QUIJOTE-MFI2 Instrument**

Author: Ana Almeida - Instituto de Astrofísica de Canarias (IAC)

Abstract: Primordial B-modes are much fainter than polarized Galactic foregrounds across all frequency bands. At low frequencies, synchrotron emission is the dominant source of contamination. Accurate subtraction of this component requires highly sensitive low-frequency observations. The upcoming QUIJOTE-MFI2 instrument (10–20 GHz) will provide a factor of 2–3 improvement in sensitivity over the original MFI. We present detailed forecasts demonstrating that QUIJOTE-MFI2 data will be essential for constraining synchrotron spectral parameters. In particular, when combined with existing datasets, QUIJOTE-MFI2 improves the constraints on the synchrotron spectral index β_s by up to a factor of 22 relative to WMAP and Planck alone. For curved synchrotron models, it yields statistically unbiased results. In low-SNR regions, where synchrotron spectral parameters remain unconstrained by WMAP and Planck, QUIJOTE-MFI2 can measure β_s with an uncertainty of ± 0.45.

- **Diffuse polarised synchrotron reconstruction with GNILC**

Author: Md Ishaque Khan - Instituto de Física de Cantabria (IFCA-CSIC-UC)

Abstract: Primordial gravitational waves from inflation imprint a faint B-mode polarisation in the Cosmic Microwave Background (CMB), but this signal is strongly obscured by Galactic foregrounds. Detecting CMB B-modes therefore requires accurate characterisation of foreground polarisation, dominated by synchrotron emission at low frequencies. To address this, we apply the Generalised Needlet Internal Linear Combination (GNILC) method to Planck PR4 data (30–353 GHz), producing clean, low-noise synchrotron polarisation maps across frequencies without relying on prior models. GNILC employs needlets for localised processing in both pixel and harmonic space, a principal component analysis to retain modes above noise, and a multi-frequency weighting scheme orthogonal to the CMB spectrum to deproject the CMB. Radio source inpainting prior to GNILC processing further reduces contamination in the resulting maps. The method is validated on Planck NPIPE simulations, and PR4-derived GNILC weights are applied to NPIPE noise realizations to provide robust noise characterisation of the GNILC PR4 maps. The final GNILC PR4 maps at 30 and 44 GHz provide reliable

diffuse polarized synchrotron templates, as demonstrated by map inspection, noise estimates, power spectra, and low correlation with the Planck SMICA CMB map.

Constraints on cosmology with miscellaneous probes

- **Neutrinos in Cosmology: present challenges and future prospects with Euclid**

  Author: Maria Archidiacono - University of Milan

  Abstract: The increasing precision of cosmological observations has opened a new window for studying neutrinos. This talk will review the current cosmological constraints on neutrino properties, with particular attention to the emerging tensions and challenges in recent analyses. I will then discuss the potential of forthcoming large-scale structure data from the ESA Euclid mission, highlighting its capacity to detect the neutrino mass sum and provide insights into the existence of light particles beyond the Standard Model. This combination of current constraints and future prospects underscores the significant role cosmology plays in advancing neutrino physics.

- **First data from the Vera Rubin Observatory and prospects for Dark Energy research**

  Author: Ignacio Sevilla Noarbe - CIEMAT

  Abstract: The Vera Rubin Observatory recorded its first data on October 2024, and it is close to starting its 10-year Legacy Survey of Space and Time (LSST), which will have a deep impact on many subfields of astrophysics, in particular cosmology. In this presentation, we will briefly showcase the performance of the observatory with its commissioning camera and highlight what are the plans and forecasts for cosmology using this facility.

- **Cosmography via stellar archaeology of low redshift Early Type Galaxies**

  Author: Carlos Alonso Álvarez - SISSA

  Abstract: 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: T11 and K23, which are then fit with a second order Taylor expansion in y-redshift $y = z/(1 + z)$ of the Hubble parameter $H(z; H_0, q_0, j_0)$, which holds well up to $z \sim 0.6$. We obtain estimations for H_0, the deceleration q_0 and jerk j_0 parameters. Notably we find $H_0 = 70.0^{+4.1}_{-7.6}$, and the overall sampling of $H(z)$ is competitive wrt to point estimations from the literature. Regarding systematic uncertainties, we conclude that our methodology performs similarly to others.

We observed an oscillatory pattern in the age-redshift distribution, and found it was related to oscillations in relations index strength-redshift for some critical indices (Balmer, Fe, Mg). We confirmed that this pathology does not originate in our data treatment, as it was present in previous measurements in literature but remained unnoticed.

Currently we aim at unveiling the referred oscillation in index strength-redshift relations by inspecting other catalogs that target similar sources (i.e. GAMA) and expanding our cosmographic methodology to higher redshift (i.e. using BOSS, eBOSS and desi data).

- **Investigating Dark Matter Spikes in Low-Mass Black Hole X-Ray Binaries**

  Author: Francesca Scarcella - Instituto de Física de Cantabria

  Abstract: Dark Matter (DM) over-densities surrounding black holes (BHs) can form extremely steep density profiles, commonly referred to as spikes. Objects orbiting within such environments lose energy interacting with DM particles, leading to a decay in their orbital periods. Recently, unusually high period decay rates observed in two Galactic BH X-ray binaries have been interpreted as possible evidence for DM spikes (even though the standard theoretical conditions for spike formation are not satisfied in these systems). We critically test this interpretation using N-body simulations with the dedicated code NbodyIMRI, which self-consistently captures feedback effects that partially deplete the DM spike—effects absent from conventional analytical treatments. Extending the analysis to a third X-ray binary with anomalous period decay, we find that all three systems are consistent with the presence of DM spikes. The inferred density slopes display remarkably similar characteristics across systems.

- **Constraining the cosmological model and the mass and redshift distributions of the binary black hole population with the Einstein Telescope**

  Author: Ivan De Martino - Universidad de Salamanca

  Abstract: We investigate the capability of constraining the mass and redshift distributions of binary black hole systems jointly with the underlying cosmological model using one year of observations of the Einstein Telescope. To this aim, we fixed the underlying cosmological model to a flat Λ Cold Dark Matter model, then we considered the mass distribution given by a smoothed power law, and the redshift distributions given by the Madau-Dickinson model. We built mock catalogs with different signal-to-noise ratio (SNR) thresholds, and finally inferred astrophysical and cosmological parameters jointly adopting a hierarchical Bayesian framework. We found that as the SNR threshold decreases, the precision on the matter density parame-

ter $\Omega_{m,0}$ and the Hubble constant H0, improves significantly due to the increased number of detectable events at high redshift. However, degeneracies between cosmological and astrophysical parameters exist and evolve with the SNR threshold. Finally, we showed that one year of observations will serve to reconstruct the mass distribution with its features. Conversely, the redshift distribution will be poorly constrained and will need more observations to improve.

Large Scale Structure

- **Latest results from DESI and their implication**

  Author: Etienne Burtin - CEA - Paris-Saclay

  Abstract: The Dark Energy Spectroscopy Instrument (DESI) has undertaken the largest spectroscopic survey to date. I will describe the instrument and present the recently released DR2 results and focus on their cosmological implications.

- **The revival of QSO-galaxy correlations for cosmology**

  Author: Marcos M. Cueli - SISSA

  Abstract: Back in the 1960s, high-redshift QSOs were first hinted to be statistically associated to low-redshift galaxies in the sky. While such a correlation was confirmed 20 years ago as a weak lensing magnification effect, its potential for cosmology has not been exploited due to the popularity of shear-based observables. In this talk, we assess for the first time the potential of QSO-galaxy correlations as a cosmological probe, using state-of-the-art QSO catalogs like Quaia, WISE-PS1 and eBOSS-LSS, together with well-characterized lens samples. We discuss the outlook, advantages and shortcomings of this approach, with particular emphasis on the role of correct QSO redshift estimation and their number density. In particular, for the Quaia catalog we obtain very promising results, with comparable (or even better) signal-to-noise ratios to cosmic magnification on high-redshift submillimeter galaxies, especially when an optimal measurement strategy is applied to pool QSOs of different magnitudes, opening up a neglected pathway for cosmology.

- **Cosmology from the clustering of Evolutionary Map of the Universe radio continuum galaxies**

  Author: Jacobo Asorey Barreiro - CAPA - Universidad de Zaragoza

  Abstract: The distribution of radio continuum galaxies on the sky is a useful, fast, and accessible probe of the distribution of matter in the Universe, covering more than 12 billion years of cosmic history. It can be used to learn about the initial conditions, the physics of

dark matter, and the nature of the dark energy. However, since radio continuum galaxies are observed through synchrotron emission, they cannot easily be localised in the radial direction, and cross-identification sources from optical catalogues are still low. There are a number of unknown functions relating to the radio galaxy populations that all need to be modelled accurately in order to make reliable inferences about fundamental physics such as the number density of radio continuum galaxies (dN/dz) and radio galaxy bias. In the talk, I will show the latest cosmological results from the clustering of the Evolutionary Map of the Universe (EMU) galaxies and the prospects for future continuum surveys with SKAO.

- **GalSBI: Forward modelling galaxy surveys with simulation-based inference**

  Author: Silvan Fischbacher - ETH Zurich

  Abstract: Accurate modeling of galaxy populations can play a critical role in unlocking the full potential of large-scale structure surveys. In this talk, I will present GalSBI and SHAM-OT, two complementary frameworks that together enable the construction of highly realistic galaxy distributions in cosmological simulations.

  GalSBI is a phenomenological galaxy population model based on parametric descriptions of luminosity functions, morphologies, and spectral energy distributions. It is constrained through simulation-based inference, comparing Hyper Suprime-Cam imaging data to forward-modeled image simulations that incorporate all relevant observational, instrumental, and source extraction effects. GalSBI reproduces observed galaxy magnitudes, colors, sizes, and redshift distributions with high fidelity, and is available as an open-source Python package.

  To complement GalSBI's photometric realism with accurate spatial distributions, we developed the SHAM-OT framework, which reformulates subhalo abundance matching as an optimal transport problem. This enables the efficient assignment of galaxies to dark matter halos, achieving orders-of-magnitude improvement in computational efficiency over traditional methods.

  Together, GalSBI and SHAM-OT are a powerful framework for creating synthetic catalogs that accurately capture both the photometric and spatial properties of observed galaxy populations, offering a crucial tool for current and next-generation cosmological surveys.

  References: arXiv:2412.08701, arXiv:2502.17553, Fischbacher+ (in prep.)

Strong lensing / Large Scale Structure

- **Searching for gravitational waves in new frequency bands**

  Author: Diego Blas - ICREA/IFAE (Barcelona)

  Abstract: I will present current ideas to detect gravitational waves at the muHz and ¿ kHz bands. I will also describe why those bands are very relevant for fundamental cosmology.

- **The Next Step in Galaxy Cluster Strong Lensing: Modelling the Surface Brightness of Multiply Imaged Sources**

Author: Ana Acebron - Instituto de Física de Cantabria (CSIC-UC)

Abstract: Until now, strong-lensing models of galaxy clusters have primarily considered the positions of pointlike multiple images as their key observables.

SDSS J1029+2623 is one of the few currently known lens galaxy clusters with multiple images of a background quasar, whose host galaxy is lensed into a remarkable 22" long tangential arc. Focusing on this ideal testbed, I will showcase the inception of a new era of highly precise and accurate cluster strong lensing models by leveraging high-resolution imaging and extensive spectroscopic data. I will detail our methodology, which directly includes as observables large sets of secure multiple images over a wide redshift range, and, for the first time, the extended surface-brightness a strongly-lensed source, over 78,000 HST pixels. This analysis is no easy feat, requiring overcoming both modelling and computational challenges. I will highlight how, thanks to the increased number of observables, promising prospects for time-delay cosmography, quasar host galaxy properties, and mass substructure studies with lens galaxy clusters are now within reach.

The first light of cutting-edge facilities such as the JWST, Euclid, and Rubin-LSST is ushering the dawn of a golden era for strong gravitational lensing with galaxy clusters. This work lays the foundation for a novel generation of cluster strong-lensing models, where complementary lensing observables are incorporated as model constraints, fully exploiting the potentialities of these exquisite datasets.

- **Signatures of fuzzy dark matter inside radial critical curves**

Author: José María Palencia - Instituto de Física de Cantabria

Abstract: We investigated the strong gravitational lensing properties of fuzzy dark matter (FDM) haloes, focussing on the magnification properties near radial critical curves (CCs). Using simulated lenses, we computed magnification maps for a range of axion masses and halo configurations. We show that FDM produces enhanced central magnification and secondary CCs that are not easily reproduced by standard cold dark matter (CDM), even when subhaloes are included. The strength and scale of these effects depend primarily on the de Broglie wavelength, which is governed by the axion and halo masses. We find that axion masses in the range $m_\psi \sim$ 10e-22–10e-21 eV in galaxy-mass haloes lead to distinctive magnification distributions. Our results suggest that observations of highly magnified, compact sources near radial arcs, such as quasars or supernovae, could serve as a powerful test for the presence of FDM.

- **Primordial Power Spectrum reconstructions from LSS Surveys**

Author: Guillermo Martínez-Somonte - Instituto de Física de Cantabria (IFCA, UC-CSIC)

Abstract: We assess the potential of the J-PAS survey to constrain the primordial power spectrum using a non-parametric Bayesian reconstruction method. Simulated spectra are generated with a localized oscillatory feature, motivated by non-standard inflation, and analyzed in the range k in [0.02, 0.2] h/Mpc, where J-PAS is most sensitive and non-linearities remain subdominant. The primordial spectrum is reconstructed via linear interpolation across N knots in the logk, $P_R(k)$ plane, jointly sampled with cosmological parameters H0, Ωb h^2, Ωc h^2 using PolyChord. Feature detection is quantified through both the Bayes factor and a hypothesis test. We examine the recovery of the injected feature under different J-PAS configurations— redshift binning, tracer type, survey area, and filter strategy—and find that amplitudes as small as 2% can be detected when combining tracers and redshift bins.

As ongoing work, we are applying this reconstruction framework to existing large-scale structure data from BOSS and eBOSS, providing the first real-data validation of the method and setting competitive constraints on possible primordial features.

- **Exploring massive neutrino cosmologies with evolution mapping**

  Author: Andrea Pezzotta - INAF - OAB

  Abstract: Stage-IV redshift surveys, such as DESI and Euclid, will play a crucial role in advancing our understanding of the neutrino sector, complementing the insights obtained so far primarily from particle physics experiments. As theoretical models grow increasingly complex, it becomes essential to minimise the number of degrees of freedom in order to ensure a faster and more controlled exploration of the parameter space. A recently developed technique, known as evolution mapping, makes it possible to capture the combined effect of the evolution parameters (h, A_s, w_0, w_a, Ω_k, ...) solely in terms of the amplitude of the linear power spectrum at the redshift of interest. This framework has recently been extended to include both the total neutrino mass and the effective number of relativistic species. Within this formulation, different massive-neutrino cosmologies can be remapped onto each other by considering their evolution at appropriately shifted redshifts, in close analogy with the original formulation of evolution mapping. When combined with the analytical marginalisation of linear parameters, this approach has the potential to substantially reduce the convergence time of likelihood analyses for Stage-IV surveys.

Lyman-alpha / Baryon Acoustic Oscillations

- **Cosmology from the DESI Lyman-alpha forest**

  Author: Martine Lokken - IFAE

  Abstract: The Lyman-α forest observed by DESI provides a unique window into large-scale structure at redshifts 2-4. With unprecedented numbers of quasar spectra probing the fluctuations in neutral hydrogen along the line of sight, we can extract precision cosmological

information from a range of statistical measurements. I will review the DESI DR2 measurement of baryon acoustic oscillations in the Lyman-α forest, which provide an important high-redshift data point in the history of the universe's accelerated expansion. I will also discuss measurements of the one-dimensional power spectrum (P1D) and cross-spectrum (Px), as well as ongoing efforts to infer cosmological information such as the matter density and neutrino masses from these probes.

- **On the impact of strong absorbers metals in BAO measurements with new cosmological Lyman-alpha forest mocks.**

  Author: Manuel F. Ruiz-Herrera Bernal - CIEMAT

  Abstract: The Lyman-alpha forest has become a crucial probe for measuring Baryon Acoustic Oscillations (BAO) at high redshift, offering unique insight into the expansion history of the Universe during the matter-dominated era. However, precise cosmological constraints from Lyman-alpha BAO are challenged by contamination from metal absorption lines, which introduce spurious correlations and bias the inferred signal. Current models account for this effect by introducing observational corrections to the Lyman-alpha autocorrelation. In this work, we develop a more physically motivated framework by modeling metal absorption associated with strong systems in the circumgalactic medium (CGM), as well as a diffuse intergalactic medium (IGM) metal component. We implement this in new cosmological Lyman-alpha mocks, calibrated using observational constraints on Damped Lyman-alpha (DLA) systems and Strong Blended Lyman-alpha absorbers (SBLA). The resulting mocks reproduce both the incidence and clustering of strong absorbers, and the metal contamination in the one- and two-halo terms of the Lyman-alpha forest, i.e., reproducing the composite spectrum of the strong absorbers and the biased signal in the Lyman-alpha autocorrelation. We use these mocks to disentangle the contributions of CGM and IGM metals to BAO systematics, showing that while the considered CGM absorbers strongly impact the correlation, the full contamination is given by a combination of IGM and/or more CGM metal absorbers. Finally, we investigate the Lyman-alpha × SBLA cross-correlation as a BAO probe and show that the observed modeling issues in eBOSS data are not driven by metals as expected, but likely by other systematics such as quasar proximity effects. These improved mocks provide a robust platform for testing and validating analysis pipelines for current and future surveys like DESI and WEAVE-QSO, and even for training machine learning algorithms aimed at identifying galaxies in absorption in the Lyman-alpha forest.

- **Missing Components in ΛCDM from DESI Y1 BAO Measurements: Insights from Redshift Remapping**

  Author: Elena Fernández García - IAA-CSIC

  Abstract: We explore transformations of the Friedman-Lemaître-Robertson-Walker (FLRW) metric and cosmological parameters that align with observational data, aiming to gain insights into potential extensions of standard cosmological models.

We modify the FLRW metric by introducing a scaling factor, e2Θ(a) (the cosmological scaling function, CSF), which alters the standard relationship between cosmological redshift and the cosmic scale factor without affecting angular measurements or Cosmic Microwave Background (CMB) anisotropies. Using data from DESI Year 1, Pantheon+ supernovae, and the Planck CMB temperature power spectrum, we constrain both the CSF and cosmological parameters through a Markov Chain Monte Carlo approach.

Our results indicate that the CSF model fits observational data with a lower Hubble constant (although it is compatible with the value given by Planck 2018 within 1σ) and is predominantly dark-matter-dominated. Additionally, the CSF model produces temperature and lensing power spectra similar to those predicted by the standard model, though with lower values in the CSF model at large scales. We have also checked that when fitting a CSF model without dark energy to the data, we obtain a more negative conformal function. This suggests that the CSF model may offer hints about missing elements and opens up a new avenue for exploring physical interpretations of cosmic acceleration.

arXiv reference of the paper: 2503.22469

- **Validation of the DESI DR2 BAO Measurements from Galaxy and Quasars**

Author: Nicola Deiosso - CIEMAT

Abstract: The Dark Energy Spectroscopic Instrument (DESI) Data Release 2 (DR2) provides significantly improved Baryon Acoustic Oscillation (BAO) measurements over DR1 by incorporating a larger and more complete sample of galaxies and quasars, including BGS, LRGs, ELGs, and QSOs. We validate the DR2 BAO analysis through extensive robustness tests on blinded data and consistency checks after unblinding, using mock catalogs that accurately reproduce the selection and clustering properties of the observed sample. A central focus is the comparison between two key statistical approaches—the configuration-space two-point correlation function and the Fourier-space power spectrum. We find that BAO constraints are stable and consistent across both methods, with only minor variations, confirming the reliability of the analysis regardless of the chosen data vector. These results demonstrate that the improvements in DR2 yield reduced statistical uncertainties while maintaining robustness to modeling choices, estimator selection, and systematic treatments.

- **Combined constraints from DESI BAO and Full-shape analyses**

Author: Daniel Forero Sánchez - ICC-UB

Abstract: The Dark Energy Spectroscopic Instrument (DESI) has produced the largest cosmic map to date, offering groundbreaking insights into dark energy. While the current best baryon acoustic oscillation (BAO) analysis uses three years of data, the latest full-shape analysis relies on only one year. In this work, we combine the Year 1 (full-shape) and Year 3 (BAO) datasets to derive the most stringent large-scale structure (LSS) constraints on cosmology to date. We investigate optimal strategies for merging these datasets and assess whether their

covariance can be safely neglected without biasing the results. Our findings provide critical guidance for future cosmological analyses with DESI and other next-generation surveys.

- **Cosmology from DES BAO and SN**

  Author: Santiago Avila - CIEMAT (Madrid)

  Abstract: The Dark Energy Survey (DES) recently released the final results of its two principal probes of the expansion history: Type Ia Supernovae (SN) and Baryonic Acoustic Oscillations (BAO). In this work, we explore the cosmological implications of these data in combination with external Cosmic Microwave Background (CMB), Big Bang Nucleosynthesis (BBN), and age-of-the-Universe information. The BAO measurement, which is $\sim 2\sigma$ away from Planck-ΛCDM predictions, pushes for low values of Ωm compared to Planck in contrast to SN which prefers a higher value. We identify several tensions among datasets in the ΛCDM model that cannot be resolved by including either curvature or a constant dark energy equation of state. In w0waCDM, the tensions are alleviated and we find a 3.2σ deviation from ΛCDM for DES BAO and SN in combination with Planck. For the combination of all the background cosmological probes considered (including θ^* from Planck), we still find a deviation of 2.8σ from ΛCDM. This work provides further evidence for non-ΛCDM physics or systematics, which is consistent with recent claims in support of evolving dark energy. https://arxiv.org/abs/2503.06712

Weak Lensing (I)

- **Weak lensing cosmology beyond two-point with Euclid and Rubin LSST**

  Author: Daniela Grandón - Leiden University/Universidad de Valparaíso

  Abstract: tba

- **The future of cosmological inference**

  Author: Alessio Spurio Mancini - Royal Holloway, University of London

  Abstract: In this talk I will demonstrate how recent advances in machine learning are enabling a new paradigm for cosmological inference, capable of scaling efficiently to the extremely high-dimensional parameter spaces required to achieve unprecedented control of systematics. At the core of this approach is COSMOPOWER, our neural-network library for cosmological emulation. Combined with differentiable and probabilistic programming, scalable gradient-based sampling, and decoupled Bayesian model selection, this framework allows full Bayesian analyses—including both parameter estimation and model comparison—in a fraction of the time required by traditional methods.

I will illustrate the power of this paradigm with applications to Stage IV survey configurations, including analyses in 150-dimensional spaces that remain inaccessible to standard techniques. I will then show how field-level cosmological inference enables robust model comparison, offering unprecedented accuracy in distinguishing between dark energy models. In particular, I will discuss how a field-level analysis of Euclid cosmic shear data could provide a decisive test of the recent DESI hints of dynamical dark energy, beyond the reach of power spectrum–based approaches.

Finally, I will present recent additions to COSMOPOWER, which transform it into an end-to-end, fully differentiable library for cosmological inference, paving the way for fully uncertainty-aware analyses of forthcoming Euclid data.

- **Non-Gaussian likelihoods for weak lensing and beyond**

Author: Veronika Oehl - ETH Zurich

Abstract: The two-point correlation function is a standard tool in cosmology, yet its estimators have intrinsically non-Gaussian likelihoods—even for Gaussian fields. This non-Gaussianity is most evident on the large scales targeted by stage-IV weak lensing surveys, where Gaussian approximations will break down. Such effects already matter: stage-III data hint at deviations from Gaussianity and the persistent S8 tension underscores the importance of accurate likelihood modeling.

We present a framework for computing exact correlation-function likelihoods for spin-2 fields, directly relevant for cosmic shear. These distributions show significant skewness, systematically shifting parameter inferences (e.g. biasing the mean of S8 by up to 2% under stage-III conditions). To move beyond exact low-dimensional cases, we introduce a Gaussian copula model that efficiently captures non-Gaussian dependence in high-dimensional correlation data andwhich can straightforwardly be used in Bayesian analyses.

More generally, our results illustrate how both correlation structure and likelihood shape impact posterior constraints. Copula-based approaches open a path to flexible, accurate modeling not only for weak lensing but for a wider range of cosmological probes.

- **The ESA-Euclid mission : status and expectations towards Data Release 1**

Author: Maritn Crocce - Institute for Space Science (ICE-CSIC)

Abstract: The ESA-Euclid (www.euclid-ec.org/) satellite was launched in July 2023 and is expected to become a key Stage IV player in the field of dark-energy studies by measuring weak lensing, baryon acoustic oscillations (BAO) and redshift-space distortions (RSD) over 14,000 deg2 for 6 years using two instruments, VIS (visible) and NISP (near-infrared spectrometer and photometer). In particular, it will measure the shapes of 1.5 billion galaxies down to magnitude 24.5 and the precise redshifts of over 30-40 million emission-line galaxies in the redshift range 0.9 to 1.8. Euclid brings together spectroscopic and imaging data analysis in a single mission for the first time. Euclid has been observing in survey mode since Feb 2024,

covering over 3,000 deg2 at nominal depth by now, reaching the expected 30 gals/arcmin2. In this talk, I will present the current status of different Euclid datasets and their analysis pipelines towards the cosmological analysis with the first year of data planned for 2026.

- **Preparing for Galaxy Cluster Detection through Weak Lensing with Euclid**

Author: Alberto Manjón García - Universidad Politécnica de Cartagena (UPCT)

Abstract: Weak gravitational lensing is a sensitive probe for detecting galaxy clusters, but it requires observing a large number of background galaxies to yield scientifically-meaningful results. This obstacle can be overcome thanks to the higher sensitivity as well as the large-area coverage of present and future wide-field surveys. A prime example is the Euclid telescope, which will map approximately 14,000 deg^2 of the sky, measuring the shapes of billions of galaxies.

I would present the results of a blind galaxy cluster detection challenge, where the performance of nine detection algorithms was analysed in 1200 deg^2 of synthetic Euclid-like weak lensing observations. The relative efficiency of these methods was assessed by matching their detections to known synthetic clusters with S/N¿2, adopting two different matching procedures. The purpose of the challenge was to identify strategies for improving galaxy cluster detection via weak lensing in the upcoming Euclid data releases. Based on their individual performance and how they complement one another, we pre-select four methods, which are based on different techniques, such as optimal filtering (AMICO-WL), Gaussian filtering (DoG), aperture-mass filtering (O21), or multi-scale wavelet detection (W234). Individually, these algorithms reach approximately 10% completeness for a mean purity of 90%, but, combined, they reach about 18%. When extrapolating the results of this work to Euclid Data Release 1, we would expect to detect approximately 2500 galaxy clusters via weak gravitational lensing.

After the challenge deadline, I continued exploring ways to improve the performance of the Double Gaussian (DoG) filtering method, achieving a significant increase in completeness at 90% purity. I would also present these results.

Weak Lensing (II)

- **The Dark Energy Survey Legacy: Cosmology from Y6 3×2pt**

Author: Giulia Giannini - Institute of Space Sciences (ICE-CSIC)

Abstract: I will present the Dark Energy Survey (DES) Year 6 3×2pt cosmology analysis — the definitive legacy result from DES. Using the full six-year dataset, we jointly analyze galaxy clustering, galaxy–galaxy lensing, and cosmic shear within a unified framework. I will summarize the key advances in data processing, redshift calibration, measurement validation, and modelling, and discuss the implications of this analysis for our understanding of the dark

universe.

- **DES Y6: cosmology from cosmic shear**

  Author: Simon Samuroff - IFAE

  Abstract: I will give an overview of the soon-to-be-public Dark Energy Survey Y6 cosmic shear analysis. The largest of the Stage-III surveys, DES Y6 will very soon provide the highest signal-to-noise measurement of cosmological weak lensing to date. I will begin with an overview of the process taking us from DES images to cosmological inference. I will highlight some of the challenges, and differences in approach relative to DES Y3. Survey timelines permitting, I will then spend the bulk of the talk discussing the Y6 cosmic shear cosmology results. I will consider what these data tell us about the standard model of cosmology, as well as how they compare to various forms of external data. This will include a discussion of the tests we have done to ensure internal consistency, and of the contribution of various forms of modelling uncertainty (redshift error, baryon feedback, intrinsic alignment etc)

- **Magnification modelling for DES Y6 galaxy clustering and galaxy-galaxy lensing cosmology**

  Author: Elisa Legnani - IFAE Barcelona

  Abstract: Gravitational lensing magnification affects the observed spatial distribution of galaxies and must be accounted for to avoid biases in cosmological probes of large-scale structure. I will present the methodology used to evaluate its impact on the Dark Energy Survey Year 6 (DES Y6) galaxy clustering and galaxy-galaxy lensing analyses. We quantify the redshift-dependent magnification bias using the Balrog synthetic source injection catalog, accounting for the complexity of the galaxy sample selection function. We investigate the impact of magnification on cosmological constraints by testing different priors on magnification bias parameters. Our results show that magnification is a significant systematic for the Y6 fiducial lens sample (MagLim++) and must be addressed. Additionally, we demonstrate that including clustering cross-correlations between lens bins in the analysis enhances constraints on magnification parameters, enabling the use of uninformative priors. While magnification has minimal effect on the precision of cosmological constraints, neglecting it introduces parameter biases that can exceed statistical uncertainties, making its correction critical for current and future weak lensing surveys.

- **KiDS-Legacy: Cosmic shear constraints from the complete Kilo-Degree Survey**

  Author: Benjamin Stölzner - Ruhr University Bochum

  Abstract: Weak gravitational lensing of distant galaxies is a key probe of the large-scale

structure of the Universe. In this talk, I will present the latest cosmological constraints from the cosmic shear analysis of the fifth and final data release of the Kilo-Degree Survey, dubbed KiDS-Legacy, and discuss their implications for the S8 tension. Additionally, I will present joint cosmological constraints with complementary probes of the late Universe and review the internal consistency of the KiDS-Legacy dataset.

Theoretical Cosmology (I)

- **Gravitational Waves from Topological Defects**

Author: Jose J. Blanco-Pillado - IKERBASQUE & EHU Quantum Center, Physics Department, UPV/EHU

Abstract: In this talk, I will introduce the basic concepts of topological defects formed during cosmological phase transitions in the Early Universe. After reviewing their main properties and evolution, I will discuss the stochastic background of gravitational waves they generate and its distinctive observational signatures. Particular attention will be given to the prospects for detecting these signals with current and future gravitational wave observatories.

- **Can the Topology of the Universe Affect the CMB?**

Author: Javier Carrón Duque - Instituto de Física Teórica (IFT-CSIC)

Abstract: Cosmological observations traditionally assume an isotropic and homogeneous infinite Universe. However, a growing number of large-scale anomalies and dipoles in the literature suggest the need to revisit these assumptions. A physically well-motivated explanation for these anomalies is the impact of the Universe's topology. Even in a flat Universe, a non-trivial topology can introduce anisotropic correlations in the Cosmic Microwave Background and other observables. In this talk, I will present recent and ongoing work of the COMPACT collaboration on the observational effects of the Universe's topology. I will discuss the specific, testable predictions for the CMB temperature and, time allowing, how we also expect it to affect the Large Scale Structure. I will also talk about the current challenges and how advancements in data analysis and future measurements can help us reveal the global shape of the Universe.

- **The Shape of Space in Polarized Light**

Author: Mikel Martin Barandiaran - IFT UAM-CSIC

Abstract: While the standard cosmological model assumes a flat, simply-connected, infinite universe, the possibility of having a non-trivial spatial topology is still a viable scenario that

is potentially detectable in the not so distant future. For the past few decades, the cosmic topology community has almost exclusively focused on scalar-sourced temperature correlations in the cosmic microwave background (CMB) to look for hints of the shape of the Universe, whereas the effect of non-trivial topologies in CMB polarization has been widely unattended. In this talk, I will present some of the latest results of the COMPACT collaboration on scalar and tensor perturbations in Euclidean topologies. In particular, I will show how the breaking of statistical isotropy and/or parity naturally leads to the appearance of non-zero EB and TB correlations without the need to introduce any parity-violating microphysics (e.g., axions) and how the correlation patterns in tensor perturbations seem to contain more "information" than scalar perturbations about the shape of the Universe.

- **Unveiling Dark Satellites: Numerical Modelling and Implications for Gamma-Ray Dark Matter Searches**

Author: Miguel A. Sánchez-Conde - Madrid Autonomous University & IFT UAM-CSIC

Abstract: A prediction of the standard LCDM cosmological model is that dark matter (DM) halos are teeming with numerous self-bound substructure, or subhalos. At small scales, subhalos may host no stars/gas at all and thus may not have visible astrophysical counterparts. The existence and precise properties of these 'dark satellites' represent important probes of the underlying cosmological model. Also, they may play a key role on the search for DM via its annihilation products. In this talk, I will present current numerical work to characterize with unprecedented detail the subhalo population of Milky Way-sized halos. I will then summarize the recent efforts we made to search for them in gamma-ray data and to set constraints on the nature of the DM particle using these elusive targets.

- **Cosmological implications of an Axion-Like Majoron**

Author: Antonio J. Cuesta - Universidad de Córdoba

Abstract: Theories beyond the Standard Model of particle physics generally predict the existence of scalar fields whose excitations manifest as axion-like particles. One such field is the majoron, which is an eV-scale neutrinophilic pseudo-Goldstone boson that is created in the oscillations of photons to axions in the presence of a primordial magnetic field. As the Universe cools down to a temperature below the majoron mass, they decay transferring their energy to the neutrino sector. This axion-like majoron has interesting consequences for Physical Cosmology, in particular, for observables related to background expansion, big bang nucleosynthesis, and large scale structure.

Theoretical Cosmology (II)

- **Primordial Black Holes**

  Author: Florian Kühnel - TU Dortmund & LMU Munich

  Abstract: None

- **The prospect of thermalisation for axion inflation**

  Author: Sukannya Bhattacharya - IFT Madrid

  Abstract: Inflationary models equipped with axion and gauge sectors coupled by the Chern-Simons coupling exhibit an array of interesting signals such as chiral gravitational wave spectrum and light primordial black holes, and are therefore promising candidates to be tested with next generation gravitational wave surveys. However, due to tachyonic growth of the Abelian or non-Abelian gauge fields during inflation, the self-coupling of these fields becomes important and raises the question of whether such interactions can lead to thermalisation during inflation. In this talk, I will present a conservative limit on the model parameters for axion $SU(2)$ inflation to be cold. The result shows a clear boundary in the parameter space beyond which this inflationary scenario can be warm, so that inflationary fluctuations are then to be treated as approaching/reaching thermalisation. I will also present a thermalised $U(1)$ axion inflation scenario, where the model parameters are constrained with CMB observations.

- **Testing fundamental cosmological assumptions: multi-messenger constraints on the Distance Duality Relation**

  Author: Matteo Martinelli - INAF - OAR

  Abstract: The persistent tensions in modern cosmology necessitate a critical examination of its foundational assumptions. The Distance Duality Relation (DDR), which links the luminosity distance to the angular diameter distance, serves as a powerful, model-independent probe for new physics. In this talk, I will present the latest observational constraints on potential violations of the DDR and forecast the significant improvement in sensitivity expected from upcoming surveys. I will particularly focus on the synergy between electromagnetic tracers, such as Type Ia Supernovae, and gravitational wave standard sirens. I will demonstrate that this multi-messenger approach is not only key to tightening constraints, but it is also crucial for distinguishing between the underlying physical mechanisms that could violate this fundamental relation.

- **Addressing H0 and S8 tensions within f(Q) cosmology**

Author: Carlos G. Boiza - University of the Basque Country

Abstract: We investigate the viability of f(Q) gravity as an alternative framework to address the H0 and S8 tensions in cosmology. Focusing on three representative f(Q) models, we perform a comprehensive Bayesian analysis using a combination of cosmological observations, including cosmic chronometers, Type Ia supernovae, gamma-ray bursts, baryon acoustic oscillations, and CMB distance priors. Our results demonstrate that most of these models can yield higher values of H0 than those predicted by ΛCDM, offering a partial alleviation of the tension. In addition, one model satisfies the condition Geff ¡ G, making it a promising candidate for addressing the S8 tension. However, these improvements are accompanied by mild internal inconsistencies between different subsets of data, which limit the overall statistical preference relative to ΛCDM. Despite this, f(Q) gravity remains a promising and flexible framework for late-time cosmology, and our results motivate further exploration of extended or hybrid models that may reconcile all observational constraints.

- **Modeling the Non-linear Regime of Angular Redshift Fluctuations**

Author: Alba Crespo Pérez - Institute of Astrophysics of the Canary Islands (IAC)

Abstract: Angular redshift fluctuations (ARF) are a recently introduced cosmological observable (Hernández-Monteagudo, Chaves-Montero, & Angulo, MNRAS, 2021) shown to exhibit several significant properties: complementarity with spatial clustering in two dimensions; sensitivity to parameters such as galaxy bias, cosmological growth rate and inflationary local non-gaussianity; and robustness against both multiplicative and additive systematics. Up until now, the entirety of the theoretical description of ARF has been limited to the first order of cosmological perturbation theory, where only linear terms in the density contrast of matter or halos, as well as in the peculiar velocities and gravitational potentials, are considered. This linear approximation imposes a restriction to large scales, hence discarding valuable cosmological information contained in shorter-wavelength matter modes below the non-linear scale $1/k_{NL} \sim 60$ Mpc/h, which is expected to be highly significant.

Given that the sensitivity to cosmological parameters provided by ARF on scales larger than 60 Mpc/h is already comparable to that achieved by other analyses using different standard statistics, where notoriously smaller scales, down to 25 Mpc/h, are included, it is promising to extend the theoretical modeling of ARF into the moderately non-linear regime.

In this work, we present a physically-motivated parametric model for the non-linear regime of ARF, also applicable to galaxy clustering or angular density fluctuations (ADF), as well as to both dark matter and galaxy populations. By fitting this model to N-body simulations using Markov Chain Monte Carlo (MCMC) algorithms, we infer the parameter values that best reproduce the angular power spectrum coefficients extracted from the simulations across different redshifts and Gaussian shell widths, taking into account the tomographic nature of these cosmological observables. Our results show that the implementation of this model significantly improves the agreement between theoretical predictions and simulation measurements of ADF and ARF, thus enabling the use of ARF as a cosmological probe on smaller scales.

- **Tensor Backreaction in Chromo-Natural Inflation Systems: Evolution and Signatures**

Author: Cristóbal Zenteno Gatica - Instituto de Física Teórica UAM-CSIC

Abstract: In the context of axion inflation coupled with SU(2) gauge fields, commonly called chromo-natural inflation, the gauge fields' interaction with the axion acts as an extra friction term. Aside from making inflation last more e-folds of evolution, this friction also sources the scalar and tensor sectors for the perturbations, generating a particular gravitational wave signal along with curvature perturbations. On the chromo-natural evolution, this axion-gauge interaction generates a strong backreaction from the gauge tensor sector to the background evolution. This build-up to a strong backreaction regime which is independent of the potential and almost unavoidable (unless there is severe fine-tuning of the system's parameters). The effect of this backreaction leads to a particular evolution of the gauge VEV, which passes through a period of large curvature perturbations generation to reach a recently described, well-defined, new attractor evolution. In this work, we studied the most general scenarios, which show compatibility between the CMB constraints and the evolution from a weak to a strong backreaction regime. Additionally, we consider a pure natural potential for our numerical solver of the system. We also examine the gravitational wave signal (both direct and scalar-induced) and the PBH production generated due to this particular inflationary evolution.

CMB / Large Scale Structure

- **The future of CMB lensing with Planck and LiteBIRD**

Author: Miguel Ruiz-Granda - IFCA (CSIC-UC)

Abstract: Cosmic microwave background (CMB) photons are deflected by large-scale structure through gravitational lensing. This secondary effect introduces higher-order correlations in CMB anisotropies, which are used to reconstruct lensing deflections. This allows mapping the integrated matter distribution along the line of sight, probing the growth of structure, and recovering an undistorted view of the last-scattering surface. Gravitational lensing has been measured by previous CMB experiments, with Planck's 42σ detection being the current best full-sky lensing map. LiteBIRD will reconstruct the next full-sky lensing map using mostly polarization information and will improve Planck's map by reaching a SNR of 49σ to 58σ detection over 80% of the sky, depending on the final complexity of polarized Galactic emission. In this talk, we show that the combination of Planck and LiteBIRD will yield the best full-sky lensing map in the 2030s, providing a detection of 72σ to 78σ over 80% of the sky, almost doubling Planck's sensitivity. This will create numerous opportunities for applications of the lensing map, ranging from cosmological parameter estimation to cross-correlation studies and internal delensing. For instance, the combination of Planck + LiteBIRD will improve the S8 constraint by a factor of 2 compared to Planck, and Planck + LiteBIRD internal delensing will improve LiteBIRD's tensor-to-scalar ratio constraint by 6%.

- **Exploring Statistical Isotropy in Planck Data Release 4: Angular Clustering and Cosmological Parameter Variations Across the Sky**

  Author: Christian Gimeno Amo - Instituto de Física de Cantabria (IFCA)

  Abstract: The origin of small deviations from statistical isotropy in the Cosmic Microwave Background (CMB)—the so-called CMB anomalies—remains an open question in modern cosmology. In this work, we test statistical isotropy in Planck Data Release 4 (PR4) by estimating the temperature and E-mode power spectra across independent sky regions. We find that the directions with higher local bandpower amplitudes in intensity are clustered for multipoles between 200 and 2000 with clustering probabilities consistently below 1

- **Optimal delensing of CMB B modes with stage-IV CMB and galaxy survey**

  Author: Kishan Deka - National Center for Nuclear Research, Poland

  Abstract: In the era of high precision Cosmic Microwave Background (CMB) anisotropy measurements, detection of the primordial gravitational waves (PGW) will be one of the main goals of the upcoming CMB experiments. To make it possible precise cleaning of the CMB maps from diffused contamination coming from polaried galactic emission and CMB gravitational lensing effect is needed. We investigate the impact of galactic foregrounds in lensing reconstruction and delensing for CMB-S4 like experiment providing a complete pipeline for such experiment. In this work, we pay special attention to forecast constraints for the amplitude of the primordial gravitational waves and their sensitivity to different foreground models with varying complexity. Accurate modelling of non-Gaussian galactic foregrounds is crucial for unbiased estimation of the amplitude of primordial tensor modes.Additionally, we explore optimal methods of delensing CMB B-modes using tomographic cross-correlation between CMB and large-scale structure tracers. Using simulated Legacy Survey of Space and Time (LSST) catalogues we show how photometric redshift errors affect constraints on tensor-to-scalar ratio.

- **Simultaneous modelling of the multi-wavelength universe for multi-probe cosmology**

  Author: Irati Lizaso Berrueta - DIPC

  Abstract: Stage IV cosmological surveys, with their unprecedented precision, require theoretical models of matching accuracy to fully exploit the information available on small scales. In this regime, higher-order statistics offer powerful cosmological insights, but cannot be predicted using analytical methods, so we rely on simulation-based models. We present a suite of lightcones constructed from the BACCO simulations, spanning a broad range of cosmological parameters and baryonic physics. This is done using the cosmological rescaling technique combined with the baryonification algorithm, enabling fast and flexible generation of realistic mock data across a wide parameter space. Each lightcone includes a comprehensive set of projected observables, such as weak lensing convergence and shear, thermal and kinetic Sunyaev–Zeldovich effects (tSZ, kSZ), the cosmic infrared background (CIB), line intensity maps

(e.g., CO, [C II]), and galaxy catalogs. These lightcones are ideal for cross-correlation studies and inference using non-Gaussian statistics, providing a crucial tool for exploiting the full statistical power of current and upcoming surveys like Euclid or LSST.

- **Testing modified gravity with simulated galaxy catalogues**

Author: Marc Alemany Gotor - Institute of Space Sciences (ICE)

Abstract: With the age of precision cosmology upon us thanks to the so-called stage-IV surveys, the feasibility of detecting subtle gravitational deviations from general relativity is increasingly possible. Using modern N-body simulations, we can make forecasts about the capacity of our analysis methods to discern gravity models. The Hu-Sawicki model, a type of $f(R)$ gravity, is an alternative gravitational model that is compatible with our current observations of gravity and capable of explaining the origin of the accelerated expansion of the Universe. Our objective is to assess whether the assumption of ΛCDM, in the analysis of a Universe where gravity is described by f(R) would result in a bias in our inferred cosmology. We used a pair of twin simulations consisting of two galaxy mocks where gravity is described by either GR or $f(R)$. We applied a Bayesian parameter inference analysis using 3x2pt and using conservative scale-cuts to exclude small scales of the modelling. We measured the bias in the recovered cosmology for the f(R) mock and used the twin GR mock to better characterise the recovered bias. We found that a statistically significant bias appears in the inferred parameters of ΛCDM when applying our pipeline to the f(R) mock data. This bias suggests that the assumption of GR would lead to substantial errors in our inferred cosmological parameters. In addition, we find that such a bias would be particularly impactful in S_8 measurements, opening the avenue to explore the so-called S_8 tension as an issue in our modelling of gravity.

Posters

Flash talks I

- **Foreground Mitigation Strategies for Accurate r Estimation from CMB B-Modes**

Author: Aliza Mustafa - SISSA

Abstract: he tensor-to-scalar ratio r from CMB B-mode polarization is a key probe of cosmic inflation. Its estimation, however, is strongly challenged by Galactic foregrounds, primarily dust and synchrotron emission. Standard blind component separation methods, such as the Needlet Internal Linear Combination (NILC), can leave residual foreground contamination that biases the estimate of r (Wolz et al. 2024). In this work, we present advances to NILC tailored for Simons Observatory (SO) data, now being collected. Our improvements include: i) Foreground marginalization using a template of foreground residuals, ii) Deprojection of

specific moments of foreground emission and iii) Adaptive optimisation of sky domains We validate these techniques on realistic SO simulations and demonstrate that they substantially reduce bias and improve the robustness of r estimation. This brings us closer to a reliable detection of primordial B-modes—the smoking gun of inflation..

- **LiteBIRD's view on the relativistic SZ effect: a parametric fitting method to obtain the electron gas temperature of galaxy clusters**

Author: Vipul Prasad Maranchery - Italian Space Agency, University of Rome Tor Vergata

Abstract: We present a forecast of the capability of the upcoming Cosmic Microwave Background experiment LiteBIRD to detect the relativistic Sunyaev-Zeldovich (rSZ) effect and measure the electron gas temperature (Te) of selected galaxy clusters. Our analysis focuses on high-signal-to-noise ratio clusters with a large angular size ($\theta 500$) to enhance the sensitivity to the signal. Following the approach of Remazeilles et al., 2020, we implement a moment expansion of the rSZ signal for a set of pivot temperatures ($\bar{T}_e$) and use a Constrained Internal Linear Combination (CILC) component separation method to extract two maps: the Compton-y map and the temperature modulated Compton-y map, $y(T_e - \bar{T}_e)$. Subsequently, we employ a parametric fit using the statistical framework Cobaya to jointly extract the thermal SZ parameter, y0, and the electron temperature, Te. This fitting assumes a predefined spatial profile template for the cluster's gas pressure. We also present the forecast of the average electron gas temperature of the galaxy clusters in the sky by stacking the rSZ signal at cluster positions. For this analysis, we consider two sets of simulations: LiteBIRD-only and LiteBIRD combined with Planck.

- **Machine learning applied to the subtraction of the foregrounds from Cosmic Microwave Background data**

Author: Dheeraj Vittal Shenoy - University of Cantabria

Abstract: We use a machine learning approach to perform the subtraction of foregrounds from the Cosmic Microwave Background (CMB) polarisation sky. The model used is based on convolutional neural networks with a U-net architecture that is applied to a set of realistic simulations of the CMB sky as seen by current and future CMB experiments. In addition to the CMB, the simulations include the most relevant foreground components in polarisation, i.e. synchrotron radiation, thermal dust and the anomalous microwave emission. The training data have been simulated using the Python Sky Model (PySM). The results are promising allowing a good recovery of E and lensing B-modes.

- **A pixel-based Neural Network method for CMB component separation in polarization**

Author: Valentina Franco Velásquez - Universidad de Oviedo

Abstract: The detection of the primordial B-mode polarization in the Cosmic Microwave Background (CMB) is one of the most compelling goals in modern cosmology, as it would provide strong evidence for an inflationary period. Achieving this requires accurate component separation techniques to disentangle the cosmological signal from astrophysical foregrounds and instrumental noise. In this work, we present the development of a method based on Neural Networks (NN) to address this challenge. The proposed approach is pixel-based, making it independent of the underlying sky geometry and thus suitable for working directly on spherical data. It is designed to recover the different sky components, including the CMB and polarized galactic components. In the first step, we apply this method to simulated observations from a next-generation CMB experiment, presenting some preliminary results on its performance.

- **Characterizing the properties of the atmospheric emission in the 10-20 GHz range with QUIJOTE data**

Author: Apolline Chappard - IAS/IAC

Abstract: The QUIJOTE MFI instrument (2012-2018) observed the sky at four frequency bands, 11, 13, 17, and 19 GHz, at 1 degree angular resolution. For ground-based Cosmic Microwave Background experiments like QUIJOTE, the atmosphere is the main source of contamination in the data. Using the entire database of MFI observations, we characterised the correlation properties of the atmospheric signal in those frequency bands. This analysis involved performing the cross-correlation function of time-ordered data (TOD) between the signals of QUIJOTE's horn measuring at the same frequency. Moreover, we investigated the cross-power spectrum of atmospheric signals at 20, 30, and 40 GHz. We found that the atmosphere stays stable for a period of around 1 to 2 hours and that the atmosphere follows a Kolmogorov spectrum. This information will help improve the current sky models at these frequencies. It could be used in further MFI reanalyses or to prepare future observations at these frequencies (e.g., Tenerife Microwave Spectrometer).

Flash talks II

- **Constraining PNG from density-split galaxy clustering**

Author: Celia Merino León - UCM/CIEMAT

Abstract: Measuring Primordial Non-Gaussianities (PNG) is one of the main goals of current and future galaxy surveys such as Euclid, DESI, SphereX or SPEC-S5. Throughout our work, we study the feasibility of classifying halos or galaxies by local density as a method for detecting PNGs. As a main goal, we want to test the hypothesis of previous works defining unclustered (bias-zero) tracers as optimal for PNG measurements. To do this, we use the PNG-UNITsim simulations to test for the first time this method in non-Gaussian simulations. We will divide

these simulations into density bins, from which we will compute the power spectrum of halos and matter. We measure the scale-dependent bias induced by PNG and fit the linear bias (b1) and the PNG parameters (b_ϕ, p, or f_{NL}). First, we find that local density classification involves a significant deviation from the standard Poisson shotnoise case. Additionally, through our analyses, we conclude that the local density classification method is not optimal for detecting PNGs, since the results obtained from it are compatible with Gaussian initial conditions, that is, with $b_\phi = 0$. Therefore, we refute the proposals of previous authors who suggested that local density classification was optimal for detecting PNGs and find it less adequate than standard mass-selected samples, which have a much larger PNG response. This work remarks the need for large PNG simulations to improve our analysis techniques.

- **Study of galaxy clustering using J-PAS mapping data**

Author: Juan Francisco Vallalta Rueda - Universidad de Valencia

Abstract: We report the first preliminary measurement of galaxy clustering using the initial internal data release of Javalambre Physics of the Accelerating Universe Astrophysical Survey (J-PAS), leveraging its unique set of 56 narrow band filters to investigate how galaxy clustering depends on luminosity and redshift over the range 0.2¡z¡1.0. From an effective area of $\simeq 27 \deg^2$ and a sample of $\simeq 230000$ galaxies down to iAB ¡ 22.5, volume limited subsamples were defined by rest frame g band thresholds in bins of $\Delta z=0.2$. For each subsample, the projected two-point correlation function was measured and modelled as a power law $\xi(r)=(r/r0)\gamma$, yielding the real space clustering parameters r0 and γ. We infer the galaxy bias and study its evolution with luminosity. Systematic uncertainties were quantified via the standard jackknife method and by varying the line-of-sight integration limit πmax. Results demonstrate a clear monotonic increase of r0 with galaxy luminosity at fixed redshift and a strong dependence of bias on luminosity. We show that our results are in agreement with previous analyses using both photometric and spectroscopic data. These findings highlight the power of deep narrow band imaging for precision clustering studies, provide a test of the J-PAS data quality and underscore the significant cosmological potential of the full J-PAS survey.

- **Unified emulator pipeline for alternative clustering statistics**

Author: Mathilde Pinon - DIPC

Abstract: Current standard approaches to analyze galaxy clustering data predominantly rely on two-point statistics, which fail to capture higher-order moments of the galaxy density field. While N-point correlation functions in principle capture additional information, they remain expensive measure and challenging to model. In recent years, a variety of new physically-motivated observables have been developed, with the aim of retaining more information from the observed density field at a reasonable computational cost. Popular examples are count-in-cell statistics, density-split statistics, wavelet-based statistics, void statistics or Minkowski functionals, for instance. As most of these statistics lack a complete analytical model, recent works rely on simulation-based emulators. In DESI, the Alternative Clustering Methods

(ACM) topical group has developed a unified emulator pipeline for these alternative statistics, based on N-body simulations reproducing the DESI LRG sample, allowing to compare constraints in similar settings.

- **The Alhambra Survey: galaxy distribution at the smallest scales**

Author: Elena González Martínez - Universidad de Valencia

Abstract: We use data from the Advanced Large Homogeneous Area Medium-Brand Redshift Astronomical (ALHAMBRA) survey to study the spatial distribution of galaxies within their host dark matter halo. ALHAMBRA is a photometric survey with a multi-filter system designed to obtain accurate and reliable photometric redshifts ($\sigma < 0.014(1+z)$) for a large number of galaxies, making it specially fit to study galaxy clustering at small scales. Specifically, we measure the projected correlation function $w_p(r_p)$ in a redshift range of $0.15 < z < 1.00$ in order to constrain the relation between galaxies and the underlying dark matter distribution at small scales. To do so, we use the Halo Occupation Distribution (HOD) approach. Previous works on the same topic have observed a steeper inner slope in the density profile of halos than that predicted by the widely used Navarro-Frenk-White (NFW) profile, which has shown to be a good fit on larger scales. We account for this effect by adding the free parameter γ to the density profile, which allows the inner slope to vary. We use Bayesian inference, and specifically the Markov chain Monte Carlo (MCMC) method, to obtain the correlations and posterior distribution functions of the HOD and density profile parameters. We do so for different galaxy samples based on stellar mass thresholds and redshift. Our results agree with previous works and they also show a possible evolution of the parameters with redshift, although this observation is limited by the computational cost of the method.

- **The new era of Directional Neighborhood Fitting (DNF): From LSST to Euclid via RAIL and CosmoHub**

Author: Laura Toribio San Cipriano - CIEMAT

Abstract: Photometric redshifts (photo-z's) are a key component for cosmological studies, essential for probes like baryon acoustic oscillations (BAO), weak lensing, and galaxy clustering. Photo-zs enable distance estimation when spectroscopic redshifts are unavailable. Accurate and reliable photo-z predictions will be crucial for exploring the large-scale structure of the Universe with current and upcoming cosmological surveys such as the Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) and Euclid.

The Directional Neighborhood Fitting (DNF) algorithm estimates redshifts from photometric data. It has been successfully used in projects like DES and has been selected as one of the five photo-z candidate methods for LSST. In this contribution, we present a new era for the DNF algorithm, making it more accessible and user-friendly for the scientific community.

We introduce the implementation of DNF within the RAIL (Redshift Assessment Infrastructure Layers) framework. RAIL provides a modular, scalable pipeline infrastructure for training and

applying photo-z estimators at scale, originally developed to support LSST-DESC workflows. Beyond LSST, we are also integrating DNF into CosmoHub, a data distribution and analysis platform, to facilitate photometric redshift computation for other large surveys such as Euclid.

In addition, the DNF code is publicly available through our GitHub repository. This multi-platform availability (through RAIL, CosmoHub, and GitHub) enables DNF to serve a broader community and adapt to various survey needs, promoting reproducibility, scalability, and accessibility in photometric redshift science.

- **Characterisation of the HOD redshift and magnitude evolution from magnification bias observations**

Author: Juan Alberto Cano Díez - University of Oviedo

Abstract: Magnification bias, the apparent excess of high-redshift sources near foreground mass structures caused by weak gravitational lensing, provides a powerful tool to constrain both Halo Occupation Distribution (HOD) models and key cosmological parameters. Following previous studies, we investigate this effect by measuring the cross-correlation between high-redshift submillimeter galaxies (SMGs) from the H-ATLAS survey and a foreground sample of SDSS galaxies with photometric redshifts in the range $0.1 < z < 0.7$, aiming to probe the HOD of the lens population and its evolution with redshift and luminosity. For each redshift-magnitude bin, the weak-lensing signal is interpreted within the halo model formalism, using Markov Chain Monte Carlo techniques under a flat ΛCDM cosmology to obtain posterior distributions of the HOD parameters. We also compare different HOD prescriptions to refine previous methodologies and improve constraints on galaxy-halo connections.

- **Detecting Protoclusters with the Multi-scale Algorithm CARTHAGO**

Author: Aaron Vinagre-Maqueda - Universidad Politécnica de Cartagena

Abstract: Protoclusters are extended overdensities of galaxies in the distant Universe that eventually collapse into massive galaxy clusters. The environments of these structures play a key role in shaping galaxy evolution. Moreover, the assembly and gravitational collapse of protoclusters provide valuable constraints on cosmological models. We have developed a novel algorithm, CARTHAGO, designed to detect galaxy protoclusters using a multi-scale approach. Thanks to this methodology, the algorithm can identify extended large-scale structures of varying sizes and morphologies. In this work, we apply CARTHAGO to the COSMOS2020 catalogue and compare the detected structures with those obtained in simulations, in order to better understand the nature of our findings. We also confront our detections in COSMOS2020 with previously reported protoclusters in the literature. From the simulations, we find that galaxy clusters act as tracers of protoclusters at redshifts $1 < z < 2$, and we detect extended structures surrounding several clusters. Finally, we apply our algorithm to the Euclid Q1 survey, where we identify several large-scale structures, some of which we present here.

Flash talks III

- **DESI and Gravitational Wave Constraints on α-attractor quintessential Inflationary Models**

  Author: Changcheng Jing - IFT-UAM

  Abstract: Alpha-attractor quintessential models provide a unified framework for inflation and dark energy. With suitable parameters, the scalar field becomes dynamical in the late Universe, consistent with DESI results. At the same time, the presence of a stiff epoch between inflation and radiation domination enhances the primordial gravitational-wave background at high frequencies, potentially enabling the detection of primordial gravitational waves with future space-based detectors like DECIGO. In this work, we investigate the reheating dynamics and gravitational-wave signatures of the Alpha-attractor quintessential model, focusing in particular on the impact of reheating and inflationary parameters on the amplitude and shape of primordial gravitational waves. Using data from Planck, ACT, DESI DR2, and Pantheon+, we constrain both the inflationary parameter space and the parameters governing reheating.

- **Galaxy Rotation Curves from Self-Consistent Gravitational Energy Distributions**

  Author: Van Nieuwenhove Rudi - Independent researcher (previously at SCK-CEN, Belgium)

  Abstract: This paper introduces a novel gravitational configuration—designated a geon—arising as a solution to the Einstein field equations. The solution describes a stable, extended, and localized energy distribution that self-consistently generates its own gravitational field. A key feature of this configuration is that its pressure equals minus its energy density, mirroring the vacuum equation of state. We analyze the geon's internal structure and demonstrate its compatibility with observed galactic rotation curves. Using the Milky Way as a representative case, we compute the velocity profile induced by the geon and show excellent agreement with observational data across a broad range of galactic radii—without invoking additional dark matter. Derived profiles of mass density, gravitational potential, radial pressure, and tangential pressure reveal the internal force balance that stabilizes the configuration. Beyond galactic rotation, the geon's Gaussian-like density profile naturally reproduces the flat central density cores observed in dwarf galaxies, offering a compelling resolution to the core-cusp problem. Moreover, the early formation of geons after the Big Bang provides a framework for the rapid emergence of massive galaxies, consistent with recent observations from the James Webb Space Telescope. These results suggest that geons may serve as the gravitational scaffolding for galaxy formation and as a viable alternative to cold dark matter, potentially unifying several cosmological phenomena within a single theoretical framework.

- **Sign-Switching Dark Energy: Background Evolution, Perturbations, and Observational Constraints**

Author: Beñat Ibarra Uriondo - Basque Country University-EHU

Abstract: We investigate a class of dynamical dark energy models characterised by a sign-switching cosmological constant, transitioning from negative values in the early Universe to positive values at low redshifts. This framework includes both discontinuous and smooth sign-changing scenarios, encompassing models such as the Λ_sCDM, which features an abrupt transition, as well as the LΛCDM, SSCDM, and ECDM models, each with a generalised ladder-step or smooth evolution. We conduct a detailed theoretical analysis of their background dynamics using cosmographic parameters and the statefinder hierarchy and examine the nature of singularities associated with sign transitions. Complementarily, we perform a full linear perturbation analysis from the radiation era onward, solving the evolution of the matter density contrast, gravitational potential, growth rate, and matter power spectrum under initial adiabatic conditions. These predictions are systematically compared with those from the standard ΛCDM model. To test these models against observations, we perform Bayesian parameter estimation using Cobaya, combining data from CMB, BAO, SNeIa, and GRB. This analysis provides comprehensive observational constraints on this class of smooth sign-switching dark energy scenarios.

- **Can PBHs explain Pulsar Timing Array and JWST latest results?**

Author: Diego Martín González - Universidad de Salamanca

Abstract: Primordial Black Holes (PBHs) as dark matter constituents came into focus with the measurement of gravitational waves by the LIGO and Virgo collaborations. More recently, observations such as the detection of BHs of 10^7 solar masses at redshifts z 10 by JWST, and the amplitude of the gravitational wave background measured by Pulsar Timing Arrays, are difficult to explain within the standard ΛCDM cosmology. We propose that if halos contain a significant fraction of PBHs with a wide mass spectrum, their dynamical evolution would be fast enough to account for both the systems observed by JWST and the gravitational-wave amplitudes measured by PTAs.

- **Quantum modified inertia**

Author: Jonathan GILLOT - FEMTO-ST

Abstract: This work investigates modified inertia through a new model that introduces both maximum and minimum acceleration limits (arxiv.org/abs/2507.11524). A dynamical framework is formulated within special relativity, leading to direct astrophysical implications, particularly for explaining galaxy rotation curves. The inclusion of a minimum acceleration greatly reduces the amount of dark matter needed to match these curves. Conceptually, the proposed model differs from standard Modified Newtonian Dynamics (MOND). With a minimum acceleration bound, the modified inertia aligns closely with many observed galaxy rotation curves and the radial acceleration relation, outperforming MOND in the 10-10 m s-2 range. Furthermore, the model predicts that the minimum acceleration evolves with redshift.