Synergistic Power of Combined Cosmological Observables

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LPNHE

Recueil des résumés

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Resolving the baryonic uncertainty in cosmic shear with the kinematic Sunyaev-Zel'dovich effect

Auteur: Emmanuel Schaan[1]

[1] *SLAC National Accelerator Laboratory*

Galaxy lensing measurements from surveys like Euclid and the Rubin and Roman observatories contain a wealth of information on the nature of dark matter, dark energy and the neutrino masses. However, on the smallest scales that contain most of the statistical power, our ability to extract this information is limited by our knowledge of the distribution of baryons around galaxy halos. I will present ways to use the cosmic microwave background to localize the baryons, via the kinematic and thermal Sunyaev-Zel'dovich effects, in order to alleviate the baryonic uncertainty and make the most from galaxy lensing datasets.

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Cosmology from CMB and galaxy surveys from space

Auteur: Giulio Fabbian[1]

[1] *Institut d'Astrophysique Spatiale (IAS)*

Cosmology is entering a new high precision era with the beginning of the operations of next generation ground-based CMB experiments (Simons Observatory, SPT) and galaxy surveys (Euclid, Rubin, DESI). These experiments will deliver high-sensitivity data sets on large sky fractions and will enable us to constrain cosmology and astrophysics on all scales.
In this talk I will focus on how galaxy surveys from space can play an important role in this endeavor. I will first discuss the Quaia catalog, the largest quasar catalog produced to date, derived from data of the Gaia mission. I will show how this catalog can be used to constrain primordial and late-time universe physics in combination with Planck and ACT data, and will give prospects on the improvement expected for this catalog by future Gaia data releases. I will then discuss the status of Euclid and on the cross-correlation analyses with CMB probes carried out for the first Euclid Q1 data release. I will then conclude giving prospects for future Euclid data releases, outlining synergies with additional samples (e.g. AGNs) that can be extracted from Euclid data.

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DESI Lyman-alpha forest: BAO and growth of structures

Auteur: Eric Armengaud[1]

[1] *IRFU - CEA*

I will present an overview of current cosmological results from the DESI Lyman-alpha forest sample: BAO, a precise Alcock-Paczynski measurement from the 3D full-shape correlations (arxiv:2509.15308), and first measurements of the growth of structures. I will also show first Lya forest measurements using LBG spectra from DESI, instead of quasars (arxiv:2507.21852).
I will show how the Lya forest will be used in synergy with other LSS probes at z>2, to calibrate photo-z and test Dark Energy models.

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Adapting data survey analyses to beyond LambdaCDM cosmological models

Auteur: Marie-Noëlle Célérier[1]

[1] *Observatoire de Paris*

Large carried out, ongoing and future surveys such as Planck, Euclid, DES, DESI, Rubin, ACT, SPT, S4, are all designed to determine the cosmological parameters defined in the framework of the standard LambdaCDM model of Universe. Now, it is becoming widely acknowledged that this model suffers tensions and anomalies which suggest that LambdaCDM is not the last word in cosmology. In a recent work, we have proposed to use the Szekeres inhomogeneous solution of General Relativity to represent the late lumpy universe while keeping FLRW-like spacetimes to model its early region. This new cosmological model will have to be constrained by the data obtained by the same large surveys, but the parameters will be different. Therefore, the analyses to be performed will have to be adapted to the new model. We are aware of the huge amount of work that this implies, but, in the era of precision cosmology and with the help of neural networks, such a task has to be seriously considered. We will sketch out here possible ways to complete it.

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STRAWBERRY: Finding haloes in the gravitational potential

Auteur: Tamara Richardson[1]

[1] *Donostia International Physics Centre*

Dark matter haloes are the end product of cosmological structure formation. Produced through the gravitational collapse of initial density perturbations, these objects are considered to be self gravitating and virialised. Nonetheless, standard methods, used to both detect and analyse these structures in simulations, produce objects that are not virialised requiring the inclusion of an additional external pressure to ensure their stability. The need for this term has been shown to simply be a selection artefact, and only arises due to the inclusion of newly accreted particles that are not yet bound to haloes.
Recently, it has been proposed that a more physical description of dark matter haloes could simplify observations and models that rely upon this definition, most notably the halo mass function, the halo profile and the halo model for the non-linear two-point correlation function. However, due to the relatively large computational cost of current methods to perform this binding check, these studies have been limited to studying only small samples of haloes.
In this work, we present a novel, physically motivated approach based on the boosted gravitational potential. In practice, after directly reconstructing the effective local potential landscape felt by particles inside and surrounding a halo, the question of binding simply becomes: does a certain particle have a sufficient energy to escape this potential? As a result, this computationally inexpensive technique allows the production of large catalogues of virialised haloes, paving the way for future large sample studies of these objects and their properties.

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Pixel-Level Synergy: Merging Euclid and LSST/Rubin for Precision Cosmology

Auteur: Jean-Luc Starck[1]

[1] *CosmoStat, CEA Paris-Saclay*

Euclid and LSST/Rubin will soon deliver unprecedented cosmological datasets.
Euclid provides exquisite spatial resolution but limited spectral coverage.
LSST/Rubin offers deep, multi-band imaging across wide areas.
For optimal science, these complementary strengths must be combined.
Euclid requires Rubin colors for accurate photometric redshifts.
Rubin, in turn, needs Euclid's resolution for robust source deblending.
A joint analysis at the pixel level maximizes the scientific return.
we introduce a novel multiband deconvolution technique aimed at improving the resolution of ground-based astronomical images by leveraging higher-resolution space-based observations. The method capitalizes on the fortunate fact that the Rubin r, i, and z bands lie within the Euclid VIS band. We illustrate the effectiveness of our method in terms of resolution and morphology recovery, flux preservation, and generalization to different noise levels. This approach extends beyond the specific Euclid-Rubin combination, offering a versatile solution to improving the resolution of ground-based images in multiple photometric bands by jointly using any space-based images with overlapping filters.

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The CLASS framework for computing cross-correlation spectra.

CLASS offers a powerful framework to compute cross-correlation C_l spectra. I will review what is already implemented. Also, to give a feeling of how one should proceed to implement more cross-correlations, I will review the general structure leading to the calculation of all C_l's. I will also mention how the Limber approximation is implemented inside CLASS. Finally, I will mention how the python user of the classy interface may extract from CLASS either directly the C_l's, or the building blocks allowing to build one own's Limber-approximated spectrum.

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Multi-survey cosmology from galaxy clustering and weak lensing

Auteur: Anna Porredon[1]

[1] *CIEMAT*

The inferred cosmological information is most robust when multiple probes are combined. Two of the most sensitive probes of the large-scale structure of the universe are galaxy clustering and weak lensing. I will present new cosmological results combining those two probes (in a so-called 3x2pt analysis) using DESI DR1 spectroscopic data for the galaxy clustering and weak lensing data from the DES, KiDS and HSC surveys. Last, I will discuss prospects of future cross-survey analyses from this combination of probes.

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Growth rate measurement with SNIa peculiar velocity and galaxy density fields

Auteur: Corentin Ravoux[1]

[1] *LPC Clermont-Ferrand CNRS/IN2P3*

Using supernovae of type Ia for inferring the growth rate of structure (fσ8) has seen a significant gain in interest in recent years. In particular, maximizing the potential of fσ8 constraints can be achieved by coupling peculiar velocity estimators with the underlying density field. I will present a recent software called flip (Ravoux et al. 2025, https://arxiv.org/abs/2501.16852), allowing to perform this measurement with a likelihood-based method. The mathematical framework on which flip is based allows the reproduction of all the previous models of field covariance for velocities and densities in an algorithmically optimized way with Hankel transforms. Furthermore, the flip software contains improvements such as the simultaneous inference of all nuisance parameters (including velocity estimators), accounting for redshift dependence, and extending field covariance models. An earlier software version was used to prove the feasibility of measuring fσ8 on ZTF simulations (Carreres et al. 2023). Currently, flip is being tested to measure fσ8 with Pantheon+ data, in LSST simulations (Rosselli et al. 2025, Carrerres et al. 2025), and on simulations coupling ZTF SNIa with DESI galaxy field (Ravoux et al. in prep.). I will give a general presentation of the flip software, its core concepts, and the results associated with the previously mentioned studies.

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A new probe: kSZ velocity reconstruction of DESI galaxies with ACT DR6 and opportunities.

Auteur: Edmond Chaussidon[1]

[1] *Lawrence Berkeley National Laboratory*

The kinetic Sunyaev-Zel'dovich (KSZ) effect (Doppler boosting along the line of sight of CMB photons by electrons that have non-zero bulk velocity) induces a non-zero density-density-temperature bispectrum, that can be used to reconstruct the large-scale velocity field using the so-called "kSZ tomography"technique. In this presentation, I will first detail how we can reconstruct the velocities from the kSZ effect, and will present the first measurement of galaxy-velocity power spectrum of the different DESI tracers and how this methodology can be easily translated to phomoetric sample (like Euclid or LSST). In particular, I will show a **high significance detection** with luminous red galaxies (SNR ~ 20), and will report the **first detection** of kSZ effect with emission line galaxies (SNR ~ 7) and quasars (SNR ~ 7). Finally, I will present the constraint on the primordial non-Gaussianity parameter (fnl_loc) with these new observables and how they will improve the galaxy-galaxy measurement alone.

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CMB + BAO + SN: Bayesian Model Comparisons and Cross-Dataset Tensions

Auteur: Lukas Hergt[1]

Co-auteurs: Douglas Scott [2]; Matthieu Tristram [1]; Sophie Henrot-Versillé [1]

[1] *IJCLab, IN2P3, CNRS*

[2] *UBC*

We present a unified assessment of Bayesian Model Comparisons and Cross-Dataset Tension/Consistency for the (still) standard ΛCDM model and some minimal extensions (curvature Ω_K, sum of neutrino masses $\sum m_\nu$, constant w or dynamic w_0, w_a dark energy) in light of data from the cosmic microwave background (CMB), baryon acoustic oscillations (BAO), and supernovae (SN). Our analysis highlights how specific combinations drive or relieve tensions.

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4MOST-Cosmology Redshift Survey: Overview

Auteur: Aurélien Verdier[1]

Co-auteur: Antoine Rocher

[1] *Ecole Polytechnique Fédérale de Lausanne (EPFL)*

The Cosmology Redshift Survey of the 4-metre Multi-Object Spectroscopic Telescope (4MOST-CRS) will provide the most extensive spectroscopic redshift catalogue of galaxies and quasars over 5700 deg² in the southern hemisphere.
As targets for the 4MOST-CRS, we present a selection of a sample of Bright Galaxies (BG) and Luminous Red Galaxies (LRG) in the redshift ranges $0.1 < z < 0.5$ and $0.4 < z < 1$, respectively.
We will also show the synergistic power with DESI and the possibility to provide redshifts to big cosmological surveys as Euclid, LSST, CMB experiments and radio interferometers

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Probe combination in Euclid

Auteur: Isaac Tutusaus[1]

[1] *ICE/IRAP*

After a successful launch in 2023, and the beginning of the scientific survey last year, Euclid has become the first stage IV photometric survey in operations. In addition to all the cosmological probes that can be considered from Euclid's photometric observations, a spectroscopic survey is also being performed, allowing us to add even more probes to a combined analysis from Euclid data alone. In this talk I will present the current predictions for a combined analysis with the main Euclid probes, namely spectroscopic galaxy clustering and 3x2pt (photometric galaxy clustering, weak lensing, and galaxy-galaxy lensing), paying special attention to how the combination of different probes enables us to break different degeneracies and achieve better constraints on the cosmological model under study.

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Simulation-Driven Calibration of SZ Inference Pipelines

Auteur: Boris Bolliet[1]

[1] *Cambridge*

SZ signals (clusters, y-map, tSZ/kSZ cross-correlations) are now well detected. Yet, cosmological constraints have been notoriously hard to extract and astrophysical implications difficult to interpret. As we gather huge amounts of new data, these challenges become increasingly more important to tackle. In this talk we will present ongoing efforts in building inference frameworks to bring SZ observables into the realm of robust cosmological and astrophysical probes.

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Splitting the Matter Density Parameter Ωm into Three Regimes: Geometry, Growth and Early-Universe

Auteur: Felicitas Keil[1]

Co-auteurs: Alain Blanchard [1]; Isaac Tutusaus [2]

[1] *IRAP Toulouse*

[2] *ICE-CSIC/IEEC, IRAP Toulouse*

To test the consistency of the flat ΛCDM model, we perform a multi-messenger parameter split of the present-day matter density Ω_m into three different regimes. The first regime concerns the geometrical expansion and thus cosmological distances. The second regime is based on the formation and growth of structures in the universe due to gravitational instabilities. As an extension to earlier studies, we also consider a third regime which concerns the early universe before recombination. This allows for a separate evolution of the matter density in every regime.
In this talk, I will present a joint analysis combining weak lensing and galaxy clustering (3x2pt) data from the Dark Energy Survey (DES), cosmic microwave background (CMB) data from Planck, Supernovae Type Ia (SNIa) data from Pantheon+ without cepheid calibration and redshift space distortions (RSD) from a combination of spectroscopic surveys.
In our preliminary results, we find a strong correlation between Ω_m in the early and in the geometric regime. However, both of these have a mild tension with the growth regime, 2.3σ between the early and the growth Ω_m and 2.2σ between the geometry and the growth Ω_m.

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De-lensing the CMB to constrain primordial gravitational waves from the South Pole

Auteur: Julien Carron[1]

[1] *Université de Genève*

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Gravitational lensing of the CMB is both a interesting probe of large-scale structures in our Universe, as well as an hindrance to constraints on a background of primordial gravitational waves from inflation.
I'll start reviewing recent results on CMB lensing, and proceed to discuss prospects on the tensor-to-scalar ratio. In particular, SPT-3G and BICEP (SPO) have collected now enough data to achieve, in principle, 3 times better constraints on r than currently published (sigma(r) \sim 0.003 vs 0.009 now)), thanks to de-lensing. I'll discuss initial lensing work on these extremely deep maps towards this objective.

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Insights from new CMB lensing and kSZ velocity measurements with the Atacama Cosmology Telescope and beyond

One of the most powerful tests of our cosmological model and of new physics is to determine the growth of large-scale structure with time. Motivated by this and by reports of tensions in structure growth and neutrino mass measurements, in the first part of my talk I will show state-of-the-art determinations of cosmic structure growth using CMB gravitational lensing measurements from the Atacama Cosmology Telescope (ACT). I will discuss the implications of our ACT DR6 lensing results

for the validity of our standard cosmological model, for key cosmological parameters, and for upcoming lensing analyses with the Simons Observatory.
I will also present first measurements of a new probe of cosmic structure and the early universe: the cosmic velocity field reconstructed from the kinetic SZ (kSZ) scattering effect. After showing our early measurements of this signal with ACT, I will explain why such velocity measurements may soon be the key to reliable measurements of primordial non-Gaussianity from large-scale structure.

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TBD

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Combining low and high redshift supernovae: a review of the middle rung in the cosmic distance ladder

The cosmic distance ladder is a combination of overlapping astronomical methods used to measure distances in the universe, starting from nearby objects and extending to the farthest visible distances. In its modern and most precise implementation it combines parallaxes, two standard candles (Cepheids and Type Ia supernovae), and BAO standard rulers.

This measurement is at the center of two widely discussed tensions in the cosmological model: the now one-decade old Hubble tension whose significance exceeds 5 sigmas, and the recently-noticed ~3σ deviation from ΛCDM expectations in the distance-redshift relation.

The measurement of the luminosity ratio between low- and high-redshift supernovae constitutes the middle—and arguably weakest—rung of this ladder. In this contribution we review potential weaknesses in this measurement and present the LEMAITRE project, an ongoing effort to strengthen this rung by delivering a new, independent sample of Type Ia supernovae to the Hubble diagram and a fully rewritten, end-to-end analysis pipeline.

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Self-consistent CMB secondaries in the FLAMINGO simulations

Secondary anisotropies in the cosmic microwave background (CMB) contain a wealth of cosmological and astrophysical information. However, cleanly separating the individual contributions of the various kinds of anisotropies from each other can be a very challenging task, owing to uncertainties in their spatial, temporal, and spectral dependencies. Realistic mock simulations of the CMB sky are invaluable for testing our methods of separating out the various signals and for making like-with-like comparisons between theory and observations. Previous mocks have relied mostly on dark matter-only simulations with various prescriptions for "painting on" astrophysical signals. Here we present a new set of mocks based on the FLAMINGO suite of cosmological hydrodynamical simulations, where the various anisotropies (tSZ, kSZ, screening, CIB, lensing, radio sources) are derived directly from the properties of the matter, gas and accreting black holes in the simulations. We show that the simulations can reproduce various observational constraints with high accuracy.

We also show how these signals depend on cosmology and feedback modelling, and we predict interesting cross-correlations between some of the signals that differs significantly from that predicted by previous mocks.

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Inferring star-formation history via cross-correlations of Euclid's photometric clustering and shear and the cosmic infrared background

Auteur: Jiakang Han[1]

Co-auteurs: Giulio Fabbian ; Marina Migliaccio ; Stefano Camera [2]

[1] *University of Turin*

[2] *The University of Turin*

The cosmic infrared background (CIB), emitted by dust heated during star formation, traces the buildup of stars across cosmic time. By separating the CIB contributions from galaxies at different redshifts, we can map the star-formation history.
In this work, we cross-correlate Planck CIB maps with Euclid galaxy clustering and weak lensing data, using halo-model templates to measure the bias-weighted star formation rate density (\b\rho_{sfr}) as a function of redshift.
Simulations and Fisher analyses show that Euclid will significantly tighten constraints on (\b\rho_{sfr}) and extend this measurement to higher redshifts.

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Dinner