Colloque national Action Dark Energy 2022 - 6ème édition

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Auteur: Jean-Charles Cuillandre[1]

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Auteur: Johan Richard[1]

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Auteur: Katarina Krajlic[1]

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Auteur: Julian Bautista[1]

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Auteur: Jonathan Freundlich[1]

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Updates from DESI: towards DESI Y1 galaxy cosmological analyses

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Perfectly parallel cosmological simulations using spatial comoving Lagrangian acceleration

Auteur: Florent Leclercq[1]

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I will discuss perspectives for building accelerated forward data models of galaxy surveys. In particular, I will introduce a perfectly parallel approach to simulate cosmic structure formation, based on the spatial COmoving Lagrangian Acceleration (sCOLA) framework. Building upon a hybrid analytical and numerical description of particles' trajectories, sCOLA allows an efficient tiling of a cosmological volume, where the dynamics within each tile is computed independently. I will show that cosmological simulations at the degree of accuracy required for the analysis of the next generation of surveys can be run in drastically reduced wall-clock times and with very low memory requirements, and discuss perspectives for computing future larger and higher-resolution cosmological simulations, taking advantage of a variety of hardware architectures.

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Constraining spatial curvature with large-scale structure

Auteur: Julien Bel[1]

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We analyse the clustering of matter on large scales in an extension of the concordance model that allows for spatial curvature. We develop a consistent approach to curvature and wide-angle effects on the galaxy 2-point correlation function in redshift space. In particular we derive the Alcock-Paczynski distortion of fσ8, which differs significantly from empirical models in the literature.
A key innovation is the use of the 'Clustering Ratio', which probes clustering in a different way to redshift-space distortions, so that their combination delivers more powerful cosmological constraints. We use this combination to constrain cosmological parameters, without CMB information. In the end we show constraints when combining with CMB and BAO data sets.

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Tomographic Coupled Dark Energy

Auteur: Lisa Goh[1]

Co-auteurs: Adrià Gómez-Valent [2]; Martin KILBINGER [3]; Valeria Pettorino [4]

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We introduce a tomographic coupled dark energy model, an extension of the coupled quintessence model in which coupling strength between the scalar field, playing the role of dark energy, and dark matter particles, is allowed to vary with redshift. We bin the redshifts and let coupling vary within each tomographic bin, subsequently testing 3 different binning regimes where the choice of bin edges were largely motivated by the datasets we have chosen to use. We employ CMB data from *Planck*, the Atacama Cosmology Telescope (ACT) and South Pole Telescope (SPT), as well as a range of low redshifts probes such as measurements of the BAO peak, RSD, latest Type 1a supernovae measurements, cosmic chronometers, and the updated value for H_0 as reported by SH0ES. For the first time, we also utilise weak lensing data consisting of cosmic shear, galaxy clustering and their 3x2pt from the KiDS-1000 and BOSS surveys as late-time probes to constrain coupling strength at low redshifts. We see that in such a tomographic CDE framework, there can be much variation of coupling strength between different epochs, and that it is considerably unconstrained especially at low redshifts. Moreover, we find that favouring a non-null coupling can bring the value of S_8 measured from weak lensing data closer in agreement with *Planck* fiducial cosmology, making weak lensing a powerful probe to constrain such CDE models.

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The multipole expansion of the local expansion rate

Auteurs: Basheer Kalbouneh[1]; Christian Marinoni[1]; Julien Bel[1]

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The failure to converge on a consensus value of Hubble's constant triggered investigations into the reliability of geometric descriptions of the local spacetime that deviate from the standard cosmological metric. The question that arises is whether metrics with lower symmetries, while still simple, provide a reliable description of the data in the local patch of the universe where global uniformity is violated.

We address this problem, from a new angle, by determining the multipole structure of the redshift-distance relation in the local universe. Unexpected symmetries strong textappear whether the expansion field analysis is performed on galaxy or SNIa samples. Implications for the determination of the H_0 parameter will be discussed, and a proposal for a non-standard metric that faithfully describes the local data will be suggested.

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Towards new approaches to cluster detection for cosmology

Auteur: Vincent Reverdy[1]

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Galaxy clusters and dark matter halos constitute a building block of many cosmological analyses. However, amongst simulations and observations, there is a wide variety of definitions of what a cluster is from a physical standpoint that do not necessarily match with each other. On top of that, on the algorithmic side, detection strategies can vary greatly from traditional friend-of-friend approaches to image-based detection using convolutional neural networks. However, the potential of the latter is often hampered by the black-box aspect of it. In this talk, I will present the starting investigations on a new approach to combine the best of both worlds, using physics to guide machine learning algorithms. I will discuss in particular how the task of cluster detection may be reframed as a game on graphs that can be played with algorithms similar to AlphaGo. I will then present a road-map for such project to succeed, the challenges, and what it could bring to both numerical and observational cosmology.

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One-dimensional power spectrum from first DESI Lyman-alpha forest samples

Auteur: Corentin Ravoux[1]

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I will present the one-dimensional Lyman-alpha forest power spectrum measurement using the first data provided by the Dark Energy Spectroscopic Instrument (DESI) (Ravoux et al. in prep.). The data sample comprises quasar spectra at redshift z > 2.1, contained in the DESI Early Data Release (EDR) and the first two months of the main survey. This first set of data already yields an improvement in spectroscopic resolution with respect to the previous eBOSS measurement (Chabanier et al. 2019). I will also briefly provide forecasts for the end of the DESI survey. Coupling this measurement with theoretical predictions from hydrodynamical simulations (Walther et al. 2021) will yield strong constraints on the primordial matter power spectrum, neutrino masses, and dark matter properties.

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Subadditive average distances and quantum promptness

Auteur: federico piazza[1]

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In the presence of important fluctuations in the gravitational field causality can be studied by calculating an "average distance". I will show that such an average distance is "sub-additive" as opposed to standard geodesic distances of a classical spacetime which are always strictly additive.

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Higher Order Weak Lensing Statistics for Euclid

Auteur: Nicolas Martinet[1]

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Recent cosmic shear studies have shown that higher order statistics (HOS) developed by independent teams now outperform standard two-point estimators due to their sensitivity to non-Gaussian features of the large-scale structure. The use of such non-Gaussian estimators is being evaluated in Euclid by the Higher Order Weak Lensing Statistics (HOWLS) team. I will present the most recent results from our team that are part of a key project paper from the collaboration currently under review by the Euclid Consortium Editorial Board. We explore 10 different HOS and show the additional cosmological information they can provide compared to the two-point statistics originally planned for the mission.

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Cosmology with the growth rate of structures using Type Ia Supernovae

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Type Ia supernovae are known to be standard candles, which means that we can infer their distance from their flux measurement and build their Hubble Diagram. Peculiar velocities can be retrieved from the Hubble Diagram residuals, but until now the statistics of SN Ia was too low to use these velocities as a cosmological probe. With the next generation of surveys (LSST, ZTF) the statistics of supernovae will grow in an unprecedented way, making the SN Ia peculiar velocities useful to measure the growth rate and to complement current measurements using galaxy surveys. In this talk, we propose to present our current work on the analysis to measure the growth rate using SN Ia from ZTF, with the methodology and the study of bias estimation and mitigation.

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Dark matter halos shape as a strong cosmological probe

Auteurs: Jean-Michel Alimi[1]; Rémy KOSKAS[2]

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Halo Dark Matter (DM) Formation is a complex process, intertwining both nonlinear gravitational and cosmological phenomena.
One of the manifestations of this complexity is the shape of the resulting present-day DM halos : simulations and observations show that they are triaxial objects. Interestingly, those shapes carry cosmological information; We prove by two different methods that cosmology, and particularly the dark energy model, leaves a lasting trace on the present-day halos and their properties.

- First, we show that the overall shape (when carefully computed) of the DM halo exhibits a different behavior when the DE model is varied. We explain how that can be used to literally "read" the fully nonlinear power spectrum and estimate cosmological parameters (such as σ_8) within the halos' shape at $z = 0$.
- Then, we implement machine learning methods to classify DM halos according to their corresponding cosmology: we associate to each simulated halo, « ellipsoidal » mass and shape profiles. Those are defined to efficiently keep track of the matter distribution anisotropies. Such attributes allow a properly trained learning device to find the dark energy model of the Universe within which these halos have grown. We also study the misleading methodological biases of Machine Learning approaches, aka "Clever Hans effects", and the way to fix them.

To that end, we worked with "Dark Energy Universe Simulations" DM halos: DM halos are grewed in three different dark energy models, whose parameters were chosen in agreement with both CMB and SN Ia data. Although the resulting cosmic matter distribution are thus extremely close from one cosmological model to another, a careful analysis using machine learning methods allowed to discriminate each DM halo according its cosmological model.

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DESI-II

Auteur: Christophe Yeche[1]

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DESI has started its observation program since May 2021. It has demonstrated its ability to complete its program in less than 5 years. From 2025 will begin a phase of transition which will finish in 2028 with DESI-II.

DESI-II will have for first objective to cover a zone in redshift little covered by DESI, in the 2<z<4 range. We will use as tracers of the matter, Lyman-Break Galaxies. The second goal of DESI-II will be to propose at lower redshift, typically 0<z<1, a survey of Luminous Red Galaxies, at very high densities.

I will present the scientific program of DESI-II and the upgrades of the instrument that are also planned.

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Combining gravitational lensing and gravitational redshift to measure the anisotropic stress with future galaxy surveys

Auteur: Isaac Tutusaus[1]

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Galaxy surveys provide one of the best ways to constrain the theory of gravity at cosmological scales. They can be used to constrain the two gravitational potentials encoding time, Ψ, and spatial, Φ, distortions, which are exactly equal at late time within General Relativity. Hence, any small variation leading to a non-zero anisotropic stress, i.e. a difference between these potentials, would be an indication for modified gravity. Current analyses usually consider gravitational lensing and redshift-space distortions to constrain the anisotropic stress, but these rely on certain assumptions like the validity of the weak equivalence principle, and a specific time evolution of the functions encoding deviations from General Relativity. In this talk, I will discuss a recently proposed reparametrization of the gravitational lensing observable, together with the use of the relativistic dipole of the correlation function of galaxies to directly measure the anisotropic stress with a minimum amount of assumptions.

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Stress test for models willing to solve the Hubble tension

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The Hubble tension, given the observed local measurement by SH0ES is known to be one of the major tension that the standard LCDM is facing. The recent results from Pantheon+ combined with the value inferred from SH0ES lead to a value of the reduced cosmological density parameter, ω_m that conflicts with the value inferred from the CMB for the LCDM model. However the situation does not really improve with alterative models twicked to solve the Hubble tension.

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MOS beyond 2030: MSE and WST

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Cosmology with multiple halo sparsities

Auteur: Amandine Le Brun[1]

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The dark matter halo sparsity, i.e. the ratio between spherical halo masses enclosing two different overdensities, provides a non-parametric proxy of the halo mass distribution which has been shown to be a sensitive probe of the cosmological imprint encoded in the mass profile of haloes hosting galaxy clusters. Mass estimations at several overdensities would allow for multiple sparsity measurements, that can potentially retrieve the entirety of the cosmological information imprinted on the halo profile. Here, we investigate the impact of multiple sparsity measurements on the cosmological model parameter inference. For this purpose, we analyse N-body halo catalogues from the Raygal and M2Csims simulations and evaluate the correlations among six different sparsities from Spherical Overdensity halo masses at Δ =200/500/1000 and 2500 (in units of the critical density). Remarkably, sparsities associated with distinct halo mass shells are not highly correlated. This is not the case for sparsities obtained using halo masses estimated from the Navarro-Frenk-White (NFW) best-fit profile, which artificially correlates different sparsities to order one. This implies that there is additional information in the mass profile beyond the NFW parametrisation and that it can be exploited with multiple sparsities. In particular, from a likelihood analysis of synthetic average sparsity data, we show that cosmological parameter constraints significantly improve when increasing the number of sparsity combinations, though the constraints saturate beyond four sparsity estimates. We forecast constraints for the CHEX-MATE cluster sample and find that systematic mass bias errors mildly impact the parameter inference, though more studies are needed in this direction.

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Cosmology with SKA

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