Ateliers action Dark Energy 2022

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AMU

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Galaxy formation without cosmic variance: exploring the universe through the Sibelius-Dark simulation

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Cosmic variance poses limits to the analyses of the physics of the nearby Universe, notably to establish an accurate observational link between halo formation history and galaxy properties. The BORG framework offers a way out by generating constrained initial conditions which reproduce all the Large scale structures in a simulated environment with minimal effects due to cosmic variance. By relying on the physics of gravitational interaction and our knowledge of the Universe on large scales, it can generate an ensemble of plausible samples of the initial conditions of our Universe. That framework unlocks the possibility of studying different models of galaxy formation and their impact on different observed environments. The physical environment is notably responsible for the specific mass accretion history on small-scale structures. The Sibelius-Dark simulation is an effort in that direction. I will showcase some of the results on the mean galaxy properties based on the GALFORM semi-analytic model.

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Shan−Chen interacting vacuum cosmology

Auteur: Natalie Hogg[1]

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In this talk, I will introduce a novel class of interacting vacuum dark energy models, based on recasting the equation of state originally developed in the context of lattice kinetic theory by Shan & Chen (1993) as the coupling between the vacuum and cold dark matter (CDM). This coupling allows the vacuum to evolve and is nonlinear around a characteristic energy scale ρ_*, changing into a linear coupling with a typical power law evolution at scales much lower and much higher than ρ_*. I will illustrate the various possible models that can arise from the Shan−Chen coupling, with several different behaviours at both early and late times depending on the values of the model parameters selected. I will show the first observational constraints obtained on these models, focusing on those in which the nonlinearity of the coupling is relevant at late times. I will show how current observational data is compatible with the Shan−Chen interacting vacuum cosmology but that the H0 and σ8 tensions remain present in this scenario.

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HOD study of emission line galaxies (ELGs) in the Dark Energy Spectroscopic Instrument (DESI) data

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We present the study of the dark matter (DM) halo-galaxy connection of the emission line galaxies (ELGs) in the Dark Energy Spectroscopic Instrument (DESI) survey. We use Halo Occupation Distribution (HOD) models to reproduce the clustering of the DESI survey validation (SV) data. We first present the results of fits to the projected correlation function (wp), and then improvements brought by adding the two-point correlation function monopole and quadrupole to the fit. The projected correlation function has the advantage not to be sensitive to velocities while the monopole and quadrupole are. We add new parameters to the HOD models to take into account the modeling of velocity dispersion when fitting multipoles. Our baseline HOD model, based on previous HOD studies for ELGs, is the Gaussian HOD (GHOD) model which uses a Gaussian function to populate halos with central galaxies and a power law for satellites. We model the NFW (and particle) profiles for satellite positions and study how the concentration definition impacts the modeling of the small scale clustering. We explore other HOD models for central galaxies, such as an asymmetric Gaussian function. For the different models, we give best-fit results for the halo mass functions (HMF), the average mass of the galaxy sample, the satellite fraction, but also the rate between 1 and 2-halo terms. To perform our study, we used the AbacusSummit simulation suite designed for the DESI survey. We use a new and promising HOD fitting method, based on Gaussian processes. This method takes into account the stochasticity of HOD models and allows us to perfom HOD fitting in a reasonable time. The data presented here will be part of the Year 1 (Y1) data release of the DESI collaboration.

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A 3-parameter SHAM for BOSS, eBOSS and DESI tracers

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SubHalo Abundance Matching (SHAM) is an empirical method for constructing galaxy catalogues based on high-resolution N-body simulations. We apply SHAM on the UNIT simulation to simulate SDSS BOSS/eBOSS Luminous Red Galaxies (LRGs) within a wide redshift range of 0.2 < z < 1.0. Besides the typical SHAM scatter parameter σ, we include v smear and Vceil to take into account the redshift uncertainty and the galaxy incompleteness respectively. These two additional parameters are critical for reproducing the observed 2PCF multipoles on 5–25 h^-1 Mpc. The redshift uncertainties obtained from the best-fitting Vsmear agree with those measured from repeat observations for all SDSS LRGs except for the LOWZ sample. We explore several potential systematics but none of them can explain the discrepancy found in LOWZ. Our explanation is that the LOWZ galaxies might contain another type of galaxies which needs to be treated differently. The evolution of the measured σ and Vceil also reveals that the incompleteness of eBOSS galaxies decreases with the redshift. This is the consequence of the magnitude lower limit applied in eBOSS LRG target selection. The projected 2PCFs of our SHAM galaxies also agree with the observational ones on the 2PCF fitting range.

For DESI, we apply this method to the latest LRG and ELG SV3 data. Since the redshift uncertainty distribution obtained from repeats are Lorentzian instead of Gaussian, we changed the format of Vsmear. The clustering prediction is satisfactory and Vsmear is also consistent with the results measured from the repeat observations.

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LyAl-Net: A high-efficiency Lyman-α forest simulation with neural network

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The inference of cosmological quantities needs accurate and large cosmological simulations. Yet, the computational time takes millions of CPU hours for a modest coverage in cosmological scales ($(100Mpc/h)^3$). This ML method could have a decisive impact on the results derived from QSO surveys, e.g., SDSS3/4 data, which has a resolution power of $R = 1500$ and $R = 2000$. But it could be critical for upcoming surveys like WEAVE-QSO with $R = 20000$ in high-res mode. We used the Horizon-NoAGN simulation to train the U-Net, to predict the neutral hydrogen physical properties; density, temperature, and velocities. The flux derived from the predictions is nearly identical to the original flux from simulation with $R \approx 30000$. More generally, the computation of individual fields from the dark matter density agrees well with regular physical regimes of the cosmological field. This approach provides fast and robust numerical simulations, not only for the Lyman-α forest but also a tool for other applications.

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Modeling of High Column Density systems in the Ly-α Forests Correlation Function

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The Lyman-α forest is detected as the series of absorption lines in the quasar spectra, caused by the Lyman-α transitions of neutral hydrogen in the low-density, high-redshift intergalactic medium (IGM). It is a biased continuous tracer of the quasi-linear matter density field, and the auto (cross) correlation function of the forests (with quasars) has been used to detect the Baryon Acoustic Oscillations (BAO) signal. The Damped Lyman-α System (DLAs) is one of the most important systematics in the Lyman-α BAO analysis. DLAs are strong absorption regions in Lyman-alpha forests caused by neutral hydrogen along the sightline with extremely high column densities, usually $log(\mathrm{NHI}) >= 20$. We present an accurate model to characterize the impact of DLAs on the measurement of the Lyman-α correlation function, as well as the BAO fitting.

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The resilience of the Etherington–Hubble relation

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The Etherington reciprocity theorem, or distance duality relation (DDR), describes the relationship between luminosity and angular diameter distances in pseudo-Riemannian spacetimes where photons are massless and photon number is conserved. In this talk, I will show the first joint constraints on H0 and the DDR with percentage accuracy obtained with late-time data, and use this result to construct a consistency check for beyond-ΛCDM cosmological models. I will show that extensions to ΛCDM involving massive neutrinos and additional dark radiation are in perfect agreement with the DDR, while models with non-zero spatial curvature imply DDR violation at the level of ~1.5σ. I will further show that there is a mild 2σ discrepancy between the validity of the DDR and the latest publicly available Cepheid-calibrated SNIa constraint on H0.

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RSD & weak lensing : LCDM is alive and well!

Auteurs: ALAIN BLANCHARD[1]; Jean-Yves HELORET[2]

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The ΛCDM model has successfully passed the confrontation to many observations of cosmological relevances in the past. In recent years, several tensions have been raised up with the increasing accuracy of cosmological data. The amplitude of the matter fluctuations is regarded as one of these serious concerns. We show that redshift space dstorsion from present day surveys provide interesting constraints. The combination of these measurements
with DES3yr results of local probes lead to accurate constraints on the amplitude of the matter fluctuations consistent with the values inferred from the CMB, with a difference too weak to be qualified as a tension. We concluded that a standard ΛCDM model is in reasoable agreement with the amplitude of the matter fluctuations measured at low redshift.

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Void-Lensing as a test of gravity

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Voids are one of the building blocks of large scale structure (LSS) that have been capturing the attention of the community in the last decade. The reasons are that they are, in principle, easy to model, found in low density regions, mitigating much of the complications from non-linearities, present higher densities of dark energy and neutrinos than an average environment in LSS and last but not least, are specially sensitive to modifications to gravity. Weak lensing is an increasingly interesting observable that allows us to directly access the dark matter density field. In this talk I show the current paradigm of the cross-correlation between voids and weak lensing, as well as ideas for optimising this measurement in upcoming spectroscopic surveys and possible next steps in this field.

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Galaxy clustering in modified gravity

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Lyman-alpha forest tomography and cross-correlation with cosmic voids

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The Lyman-alpha (Lya) forest is a unique probe of large-scale matter fluctuations at high redshift (z>2). In this presentation, I will show how to obtain 3D maps of the matter distribution from Lya data using tomographic reconstruction methods. This field was pioneered by deep, small-field observations. Here, I will present the largest tomographic map of matter fluctuations at z>2 over the ~Gpc^3 volume covered by Lya forest from SDSS-IV quasar spectra in the Stripe 82 field [Ravoux, Armengaud et al. JCAP07(2020)010].
I will then present a catalog of high-redshift voids extracted from this map. The associated measurement of the cross-correlation between voids and the Lya forest provides the very first observation

of the matter velocity flow around voids (through RSD effect) at such high redshifts. The data are in good agreement with simulations and well adjusted with a purely linear Kaiser velocity model [Ravoux, Armengaud et al. 2022].

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Next-generation forecasts for screened and unscreened models of modified gravity

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Next-generation galaxy surveys will provide an accurate determination of the growth of large scale structures (LSS) in the Universe as a function of scale and redshift, on top of improved determinations of the background geometry. This will allow us to test, with unprecedented precision, the predictions of the most popular modified gravity models proposed in the literature, that have not been ruled out yet by observations. In this talk we concentrate on models which can be described by the addition of a single scalar degree of freedom to Einstein's GR, with a coupling to matter perturbations. In order to avoid the tight solar-system constraints, most of these models need some sort of screening mechanism to recover GR at very small scales, and we can classify these models by the presence or not of one of these mechanisms. In this work we will present constraints by future experiments on some particular models, which we will classify by models being screened, namely f(R), DGP and k-Mouflage and unscreened models, in this case the popular Jordan-Brans-Dicke model. We will explain the different observables measured by future missions such as Euclid and Rubin and the impact of linear and non-linear scales and how this propagates onto the final constrained on the model parameters.

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UNIONS: The impact of systematic errors on weak-lensing peak counts

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The Ultraviolet Near-Infrared Optical Northern Survey (UNIONS) is an ongoing deep photometric multi-band survey of the Northern sky. As part of UNIONS, the Canada-France Imaging Survey (CFIS) provides r-band data which we use to study weak-lensing peak counts for cosmological inference.

In this talk I will explain how I assess systematic effects for weak-lensing peak counts and their impact on cosmological parameters for the UNIONS survey. In particular, I will present results on local calibration, metacalibration shear bias, baryonic feedback, the source galaxy redshift estimate, intrinsic alignment, and the cluster member dilution.

For each uncertainty and systematic effect, I will describe our mitigation scheme and the impact on cosmological parameter constraints. I obtain constraints on cosmological parameters from MCMC using CFIS data and MassiveNuS N-body simulations as a model for peak counts statistics.

This work investigates for the first time with UNIONS weak-lensing data and peak counts the impact of systematic effects and I will present the different results obtained.

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Neutrinos and simulations

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TBD Neutrinos