Colloque national DARK ENERGY - 2ieme édition

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Institut d'Astrophysique de Paris

Book of Abstracts

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The Dark Side of Gravity and the Acceleration of the Universe

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Dark Gravity theories are extensions of General Relativity aiming at a stable anti-gravitational sector. The most natural extension of GR in presence of a flat non dynamical background turns out to be such a Dark Gravity theory and it is able to reproduce GR predictions extremely well in many sectors except that it avoids true Black Hole Horizon as well as Big-Bang singularity. The symmetries of the theory lead to an alternative understanding of the acceleration of the universe without using any form of Dark Energy.

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A microscopic model for an emergent cosmological constant

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We argue that discreteness at the Planck scale (naturally expected to arise from quantum gravity) might manifest in the form of minute violations of energy-momentum conservation of the matter degrees of freedom when described in terms of (idealized) smooth fields on a smooth spacetime. In the context of applications to cosmology such 'energy diffusion' from the low energy matter degrees of freedom to the discrete structures underlying spacetime leads to the emergence of an effective dark energy term in Einstein's equations. We estimate this effect using a (relational) hypothesis about the materialization of discreteness in quantum gravity which is motivated by the strict observational constraints supporting the validity of Lorentz invariance at low energies. The analysis yields a cosmological constant of the order of magnitude of the observed value without fine tuning.

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Cosmology with a varying vacuum refractive index

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As initially proposed by H.A. Wilson, then R.H. Dicke, the curved spacetime in a stationary gravitational field can be equivalently interpreted as being due to a spatial change of both the vacuum refractive index and the inertial masses in a Euclidean metric. Dicke further extended this framework to explain the cosmological redshift, assuming a flat and static Euclidean metric but a vacuum index increasing with time.
In a recent published paper (X. Sarazin et al., Eur. Phys. Journal C, (2018) 78:444; arXiv:1805.03503), we have investigated Dicke's formalism in the modern observational cosmology era showing that it can, remarkably, reproduce not only the cosmological redshift but also the evolution of the CMB energy density and the cosmological time dilation of the supernovae light curves. We have shown in addition that the type Ia supernovæ data are well fitted by a vacuum index varying exponentially as $n(t) = exp(t/\tau_0)$, where $\tau_0 = 8.0 + 0.2{-}0.8$ Gyr. Hence the time-dependent scale factor $a(t)$ of the curved spacetime metric in standard cosmology, including the dark energy, can be replaced by a static metric with a vacuum refractive index increasing exponentially with time.
There are three important interests with this formalism. First, the apparent acceleration of the expansion is naturally obtained with an exponential variation of the vacuum index. Secondly, this solution corresponds to the absence of a beginning in the universe evolution and a speed of light infinitely large in an infinitely distant past, thereby solving the horizon problem without the necessity to recourse to the inflation epoch. Finally, given the ab initio flat Euclidean metric used, the observed flatness of the Universe does not require any fine-tuning here.
The main experimental consequence of this formalism is that the cosmological redshift should affect any atom, with a relative decrease of the energy levels of about $-2\ 10^{-18}\ s^{-1}$. Possibilities for an experimental investigation of this prediction are discussed.
The present study is far from being complete. BAO anisotropies in the CMB must still be formulated in this new framework with possible time dependence of the gravitational constant (which was one of the prime motivations of Dicke).

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SUGAR : A New Model of Type Ia Supernovae for Cosmological Analyses

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Type Ia Supernova (SNIa) distance measurement for cosmology is based on a well-established observational paradigm that two main effects explain their variabilities in luminosity: stretch (link

to intrinsic properties), and color (link mainly to dust extinction). However, after correcting the luminosity of both stretch and color, an intrinsic scatter in luminosity and a correlation of Hubble residuals with host properties are observed. It indicates that the standard scheme lacks some ingredients and could potentially bias cosmological contraints.
The approach presented here, is to revisit the spectral diversity of the SNIa with the help of the Nearby Supernova Factory data consisting of hundreds of spectrophotometric time series, and to build a new SED model, SUGAR (SUpernovae Generator and Reconstructor) extending the principles of the current model used:SALT2. Our principal findings are that the spectral diversity exhibits 2 new intrinsic components, and that the color law is confirmed to be compatible with extinction by dust. Taking these new variabilities into account, we are able to derive a SED model which matches closer the observed spectra than SALT2 does, and which improves the distance measurement. We will present the derivation of this model, its applicability for photometric time series, and its consequences for cosmology.

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Testing for the environmental dependence of the growth rate

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The growth rate of cosmic structures is a powerful quantity to probe gravitational interactions and dark energy. In the late-time Universe the growth rate becomes non-linear, making it more difficult to probe, but also makes it in principle a source of additional cosmological information than its linear counterpart. In this talk, I will discuss why it becomes interesting to probe the growth rate in regions of different density, as well as recent developments in measuring the growth rate using RSD around voids.

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Hubble Constant Controversy and astrophysical bias

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I will present the Hubble Constant controversy, that is, the different direct or indirect measurements of the Hubble Constant and how some are in significant tension. Then I'll present our current work on astrophysical bias in Type Ia Supernova distance measurements and explain how such effect could explain the aforementioned tension.

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Time dependent dark energy

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Taking apart cosmological constant, being constant by definition, physics of dark energy may lead to its time dependence. In the simplest case time dependence of the homogeneously distributed comological energy can be implemented in the model with cosmological term and unstable dark matter, decaying after the first objects are formed and contributing the homogeneously distributed energy density by invisible relativistic decay products. Dark enery can be dependent on the Hubble constant in some power and nontrivial features of such models are also considered.

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Can laboratory experiments help to characterize Dark Energy?

Authors: Aurelien Hees[1]; Michel Abgrall[1]; Sebastien Bize[1]; Pacome Delva[1]; Jocelyne Guéna[1]; Olivier Minazzoli[2]; Benjamin Roberts[1]; Etienne Savalle[1]; Yevgeny Stadnik[3]; Peter Wolf[1]

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In several theoretical scenarios, a scalar field is introduced to model dark energy. While some properties of this scalar field can be constrained by cosmological observations, certain properties like its coupling with the standard model fields can be searched for with local experiments such as the ones testing for the universality of free fall and the ones using atomic clocks. Such measurements have recently been used successfully to search for scalar ultra-light dark matter candidates. In this talk, I will present some of the scalar dark matter models [1] that have been searched for using local experiments and briefly review some of the measurements that have been used to constrain these models [2,3]. Then, I will make a comparison between some dark matter and dark energy models and show how local experiments can be useful to provide additional constraints on some dark energy models.

[1] Arvanitaki, A., et al, Phys. Rev. D 91, 015015, 2015
[2] Hees, A. et al, Phys. Rev. Letters 117, 061301, 2016
[3] Hees, A. et al, Phys. Rev. D 98, 064051, 2018

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Théories tenseur-scalaire: où en sommes nous?

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Les théories tenseur-scalaire offrent un cadre formidable pour tester les éventuelles limites de la relativité générale. Elles sont des modifications de la théorie d'Einstein qui pourraient rendre compte de la présence d'énergie noire dans l'univers par exemple.
Je vous propose de présenter tout d'abord la construction d'une très grande classe de théories tenseur-scalaire qui a fortement été étudiée ces dernières années: ce sont les théories DHOST. Je présenterai ensuite quelques applications phénoménologiques de ces théories en astrophysique et en cosmologie. Enfin, je discuterai la viabilité physique de ces théories pour décrire l'énergie noire…

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Results on extensions to LamdaCDM models with Dark Energy Survey

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The Dark Energy Survey is one of the largest ongoing survey probing the late universe, specially through galaxy clustering and weak gravitational lensing. The data from the first year of DES observations were used to constrain the LambdaCDM model in 1708.01530, combining clustering and weak lensing measurements from the same experiment for the first time. We used this combination of data to constrain extended cosmological models considering a time varying dark energy equation of state or deviations from general relativity, among others. I will present these new results, specially focusing on the extensive analysis we performed to treat systematics.

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Systèmes binaires : l'approche de la théorie effective

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Dans cette présentation, je parlerai de la théorie effective de Goldberger et Rothstein pour obtenir les équations régissant un système binaire. Je montrerai comment elle peut être adaptée à une théorie tenseur-scalaire en mettant en avant les points sur lesquelles ces théories diffèrent de la relativité générale.

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Testing a curvature model using Fisher forecasts for a Euclid-like spectroscopic Survey

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One of the main prediction of inflationary cosmology is the spatial flatness of the universe. The combination of observed CMB fluctuations with SNIa observations and BAO leads to a prediction of the spatial curvature parameter lower than 1e-4. Observations have shown the acceleration of the expansion of the universe revealing the existence of two dark component : the dark matter and the dark energy. According to general relativity as the geometrical tensor is set equal to the matter energy tensor, the curvature parameter is uniquely related to it's energy content. It is therefore possible to test the general relativity at the background level by considering two independent parameters : a dynamical curvature related to the universe energy content, and a geometric curvature related to its curvature, which have both worse constraints than in the GR case.
Euclid, a medium Class ESA mission will give a better understanding of the expansion of the Universe by determining the dark energy equation of state (launching in 2021). In order to accomplish this mission, Euclid will measure the shape over more than one billion galaxies and tens of millions

spectroscopic redshifts, for the Galaxy Clustering and Weak Lensing, two independent cosmological probes. This presentation will mainly focus on the estimation of the constraints we can provide on the dark energy equation of state parameters and on the two curvature parameters using forecasts with a Fisher approach. These constraints determined by modeling a Euclid-like spectroscopic survey will be compared with constraints obtained from present day data.

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Testing gravity and dark energy with galaxy-galaxy lensing and redshift-space distortion in the CFHT Stripe-82 and CFHTLS

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The combination of GGL and RSD allow to break the degeneracy between the growth rate parameter f and the matter density Ω_m. In this talk, I will present our results obtained with the BOSS/CMASS sample at redshift $z = 0.57$, and the weak-lensing over an area of 338 deg^2. Using an ensemble of joint lensing and clustering lightcones, we also characterize the statistical properties of the E_G gravity test estimator, and find that it has an asymmetric PDF, leading to potential biased conclusions. The individual estimates of f and Ω_m provides a new way to understand the nature of dark energy.

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A deep learning approach for the classification of supernovae and the estimation of photometric redshifts

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Future large surveys like the Large Synoptic Survey Telescope (LSST) aim to increase the precision and accuracy of observational cosmology. In particular, LSST will observe a large quantity of well-sampled type Ia supernovae that will be one of the major probe of dark energy. However the spectroscopic follow-up for the identification of supernovae and the estimation of redshift will be limited. Therefore new automatic classification and regression methods, that exploit the photometric information only, become necessary .
We have developed two separate deep convolutional architectures to classify supernovae light curves and estimate photometric redshift of galaxies. PELICAN (deeP architecturE for the LIght Curve ANalysis) is designed to characterize and classify light curves from a spectroscopic training dataset small and non-representative of the testing dataset. It takes as input only multi-band light curves. PELICAN is able to detect 85% of type Ia supernovae with a precision higher than 98% from a training database composed of 2,000 LSST simulated light curves of supernovae.
The second Convolutional Neural Network (CNN) is developed to estimate photometric redshifts and associated probability distribution functions (PDFs) of galaxies. We have tested it on the Main Galaxy Sample of the 12th data release of the Sloan Digital Sky Survey. It takes as input 64x64 ugriz images and is trained with 90% of the statistics. We obtained a standard deviation σ for (zspec-zphot)/(1+zspec) of 0.0091 with an outlier fraction of 0.3%. This is an improvement over the current state-of-the-art value (σ ~ 0.0120) obtained by Beck et al. (2016, MNRAS, 460, 1371).

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Combiner les grands relevés avec le CMB: pourquoi et comment // Combining large-scale surveys and the CMB: the why and the how

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Grâce aux mesures de lentillage gravitationnel et de clustering des galaxies, la prochaine génération de grands relevés (Euclid, LSST) posera des contraintes sans précédent sur l'Univers récent. D'autre part, des observations CMB de haute qualité (Planck et futures expérience) sont capables d'imposer des contraintes strictes sur l'Univers primordial. Je montrerai comment la combinaison et la corrélation croisée de ces deux sondes peuvent considérablement améliorer les contraintes sur les paramètres cosmologiques, en particulier pour les modèles non-standards. Je présenterai une méthode que j'ai développée pour effectuer des prédictions théoriques de cette combinaison, permettant de mélanger des contraintes d'expériences existantes et futures.

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Through weak lensing and galaxy clustering, next-gen large scale surveys (Euclid, LSST) will yield unprecedented constraints on late-time cosmology. On the other hand, high-quality CMB observations (Planck and future CMB experiments) can – and already do – put tight constraints on the early Universe. I will show how combining and cross-correlating those two probes can significantly improve constraints on cosmological parameters, especially for non-standard extensions. I will present a method I developed to perform forecasts of this combination, allowing to mix seamlessly constraints from existing and future experiments.

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Cosmology with galaxy surveys : the impact of non-linearity

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One of the main challenges for cosmological analysis of future galaxy surveys is the non-linearity of the evolution of the large scale structure (LSS). Among the consequences of this non-linearity is the development of non-Gaussianity of the density field. And this non-Gaussianity yields new covariance terms for our observables, additional to the classical Gaussian variance that we have been used to. I will talk about these non-linear sources of errors particularly for analysis of galaxies and clusters : their origin, when do they become important, and how they make Gaussian forecasts far too optimistic for surveys like Euclid. Among them is the so-called super-sample covariance (SSC) that I will comment on in particular. I will show that SSC cannot be calibrated from the data itself or from simulations with classical covariance methods (jackknife, sims with a fixed cosmology), but I will show how to treat it analytically and realistically, i.e. with an arbitrary survey geometry. Finally I will describe a recent SSC approximation that I devised. It should allow the community to account for SSC in a numerically fast and simple way, through a modification of existing Gaussian pipelines, without needing extra elements compared to the prediction of usual LSS power spectra.

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Cosmic Homogeneity as a standard Ruler

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In the era of the upcoming stage IV surveys, the sky will be more revealing than ever. In this talk, I will put the homogeneity scale in the general cosmological context. I will show how one can use the homogeneity scale as a standard ruler to learn about the large scale structures.

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E pur si muove! A proposal for a real-time detection of our acceleration through space

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High-precision astrometric experiments might constrain our proper acceleration through space via real-time observations of the change in the aberration of sources at cosmic distances.
The cosmological component of this aberration drift signal, the non-inertial motion generated by the large-scale distribution of matter, can in principle be detected by
astrometric surveys. It can provide interesting consistency tests of the standard model of cosmology, it may set independent constraints on the amplitude of the Hubble constant and the linear growth rate of cosmic structures,
and it may also be instrumental in searching for evidences of new physics beyond the standard model. We present the formalism of this novel cosmological test, discuss the physics to which it is sensitive and show simulated forecasts of the accuracy with which it can be implemented.

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The interplay between Dark energy & modified gravity on the amplitude of matter fluctuations discrepancy between CMB and Galaxy Clusters.

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In the frame of the dark energy colloquium, we investigate the impact of a dark energy different from fiducial ΛCDM, on a discrepancy on the amplitude of matter fluctuation σ_8 found between local and deep probes. In particular between local, X ray, or near universe, SZ detected cluster counts samples and deep CMB temperature and polarization angular correlation spectrums.
We perform our analysis using MCMC techniques, leaving, along with the relevant dark energy and cosmological parameters, the cluster calibration factor free to vary in a model independent approach. We then confront the dark energy equation of state parameter w to a modified gravity phenomenological parameter, the growth index γ, in their ability to alleviate the tension. We also show cases were we allow massive neutrinos to vary as well as adding further constraints from other secondary probes like BAO or SNe.

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Les amas dans le scenario LCDM.

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Le modèle LCDM est un succès remarquable de la cosmologie moderne, rendant compte des principales observations du champ cosmologique, ses six paramètres de base étant maintenant mesurés avec une précision de l'ordre du pourcent. L'abondance des amas détectés par effet SZ est toutefois très en deçà des prédictions du modèle normalisé aux fluctuations mesurées par Planck. L'origine de cette tension est donc une question importante: soit il s'agit d'un biais de la calibration des masses d'amas (paramétrée par le facteur $1 - b$) soit il s'agit du signe d'une physique au-delà du modèle LCDM minimal. Deux extensions simples ont été étudiées : la présence de neutrinos massifs et un modèle simple de gravité modifiée avec un taux de croissance en γ. Les comptages locaux d'amas X et les comptages SZ ont été utilisés combinés avec le CMB. Aucune corrélation notable n'apparait entre la masse éventuelle des neutrinos et la calibration $1 - b$. Au contraire, dans le modèle γ, une corrélation nette apparait entre $1 - b$ et γ, mais la valeur de γ est contrainte par les comptages SZ. La calibration reste contrainte ($1 - b = 0.57 \pm 0.06$) à une valeur inférieure à la valeur adoptée par Planck ($1 - b \sim 0.8$).

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Plan

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Probing oscillating cosmic field with neutrons

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