GR 6: Cosmology

Time: Tuesday 16:15–18:15 Location: GR-H3

GR 6.1 Tue 16:15 GR-H3

Psi in the sky - the cosmology window on wavelike dark matter — •Cora Uhlemann — Newcastle University, Newcastle-upon-Tyne, UK

Despite the astonishing success of cosmological probes in constraining the LCDM model, the dark matter mass remains one of the least constrained physical parameters. Wavelike dark matter is an intriguing alternative to standard cold dark matter with key particle physics motivations (like the QCD axion or ultralight axion-like particles) and distinct astrophysical signatures. With a simple dynamical model for the evolution of the dark matter wavefunction (Psi), I will demonstrate how to predict the formation of topological defects and granules arising from destructive and constructive wave interference. Together with the wave interference imprint on substructures that leads to exciting and varied probing mechanisms bridging cosmology, astrophysics and particle physics.

GR 6.2 Tue 16:35 GR-H3

The Schrödinger-Poisson Equation in One Spatial Dimension — •Nico Schwersenz[1], Tim Zimmermann[2], Victor Loaiza[3], Javier Madroñero[3], Massimo Pietroni[4,5], Luca Amendola[1], and Sandro Wimberger[4,5] — [1]Institut für Theoretische Physik, Universität Heidelberg, Germany — [2]Institutt for Teoretisk Astrofysikk, Universitetet i Oslo, Norway — [3]Departamento de Física, Universidad del Valle, Cali, Colombia — [4]Dipartimento di Scienze Matematiche, Fisiche e Informatiche, Università di Parma, Italy — [5]INFN, Sezione di Milano Bicocca, Gruppo Collegato di Parma, Italy

Despite the success of Wave-like Dark Matter [1] in explaining cosmological processes, its major issue is the high demand in computational resources. Not only does the non-linear, non-local nature of the underlying Schrödinger-Poisson equation pose a problem, but also the range of scales that have to be resolved. We construct two distinct one-dimensional toy models [2] that are less expensive from a numerical viewpoint, but still provide analogues to the phenomena observed in three dimensions. Our high-precision numerical technique is tested by an independent method. Some exemplary results will be shown for two different ways of treating the transverse dimensions, assuming uniform matter distribution in the first and strong confinement - effectively renormalizing the mass - in the second case.

[1] J. C. Niemeyer, Progress in Particle and Nuclear Physics **113**, 103787 (2020)
[2] T. Zimmermann, N. Schwersenz, M. Pietroni, S. Wimberger, Physical Review D **103**, 083018 (2021)

GR 6.3 Tue 16:55 GR-H3

The Hawking energy of a cosmic observer in linearly perturbed FLRW — •Dennis Stock and Ruth Durrer — Université de Genève, Département de Physique Théorique and Center for Astroparticle Physics, 24 quai Ernest-Ansermet, CH-1211 Genève 4, Switzerland

Addressing cosmological questions exclusively based on observations requires a formulation on the past lightcone of the cosmic observer. In this talk, the question of how to define gravitational energy associated with the past lightcone of a cosmic observer is studied by introducing Hawking's quasi-local energy as a tentative energy measure of the observable Universe. The Hawking energy phenomenologically quantifies energy in terms of light bending. This talk will mainly focus on the relation of the Hawking energy to cosmological observables within linear perturbation theory on an FLRW background.

GR 6.4 Tue 17:15 GR-H3

Influence of cosmological expansion in local experiments — •Felix Spengler[1], Alessio Belenchia[1,2], Dennis Rätzel[3], and Daniel Braun[1] — [1]Intitut für theoretische Physik, Universität Tübingen, Tübingen, Germany — [2]Centre for Theoretical Atomic, Molecular, and Optical Physics, School of Mathematics and Physics, Queens University, Belfast, United Kingdom — [3]Humboldt Universität zu Berlin, Institut für Physik, Berlin, Germany

Whether the cosmological expansion can influence the local dynamics, below the galaxy clusters scale,has been the subject of intense investigations. We consider McVittie and Kottler spacetimes, embedding a spherical object in an expanding Friedmann-Lemaître-Robertson-Walker spacetime as a rough approximation of a local environment immersed in a globally expanding universe. We then calculate the influence of the cosmological expansion on the frequency shift of a resonator moving along different trajectories and estimate its effect on the exchange of light signals between local observers. Our results show the impact of the global expansion on these local experiments and give and upper estimate on the effects we can expect in more realistic conditions below the galaxy clusters scale.

GR 6.5 Tue 17:35 GR-H3

Reaching precision cosmology faster with velocities — •Miguel Quartin — Institute of Theoretical Physics, Heidelberg University, Philosophenweg 16, Heidelberg — Instituto de Física, Universidade Federal do Rio de Janeiro, 21941-972, Rio de Janeiro, RJ, Brazil

We will show how standard candles such as type Ia supernovae and standard sirens can be used as tracers of both density and velocity fields, thus serving a new purpose in cosmology beyond mere distance indicators. We discuss how these new tracers can be combined with galaxy surveys, combining galaxy and supernova position and redshift data with supernova peculiar velocities, obtained through their magnitude scatter. The full method relies on a 6x2pt analysis which includes six power spectra. We proceed then to forecast the performance of future surveys like LSST and 4MOST with a Fisher Matrix analysis, adopting both a model-dependent and a model-independent approach. We compare the performance of the 6x2pt approach to the traditional one using only galaxy clustering and some recently proposed combinations of galaxy and supernovae data and quantify the possible gains by optimally extracting the linear information. We show that the 6x2pt method shrinks the uncertainty in growth of structure parameters significantly. The combined clustering and velocity data on the growth of structures has uncertainties at similar levels to those of the CMB but exhibit orthogonal degeneracies, and the combined constraints yield very large improvements in parameters both at the background and perturbation-level.

GR 6.6 Tue 17:55 GR-H3

First constraints on the intrinsic CMB dipole and our velocity with Doppler and aberration — •Pedro da Silveira Ferreira — Observatório do Valongo, Universidade Federal do Rio de Janeiro, Rio de Janeiro - RJ, Brazil

We test the usual hypothesis that the Cosmic Microwave Background (CMB) dipole, its largest anisotropy, is due to our peculiar velocity with respect to the Hubble flow by measuring independently the Doppler and aberration effects on the CMB using Planck 2018 data. We remove the spurious contributions from the conversion of intensity into temperature and arrive at measurements which are independent from the CMB dipole itself for both temperature and polarization maps and both SMICA and NILC component-separation methods. Combining these new measurements with the dipole one we get the first constraints on the intrinsic CMB dipole. Assuming a standard dipolar lensing contribution we can put an upper limit on the intrinsic amplitude: 3.7mK (95% CI). We estimate the peculiar velocity of the solar system without assuming a negligible intrinsic dipole contribution: $v = (300^{+111}_{-93})$ km/s with $(l, b) = (276 \pm 33,\, 51 \pm 19)^\circ$ [SMICA], and $v = (296^{+111}_{-88})$ km/s with $(l, b) = (280 \pm 33,\, 50 \pm 20)^\circ$ [NILC] with negligible systematic contributions. These values are consistent with the peculiar velocity hypothesis of the dipole.