GR 15: Cosmo III

Time: Friday 11:00–12:20 Location: ZHG008

GR 15.1 Fri 11:00 ZHG008

Self-similarity of small-scale cosmic structures — •Matthias Bartelmann — Institut für Theoretische Physik, Universität Heidelberg

Based on the saddle-point method within kinetic field theory, and independently on the asymptotic analysis of solutions of the Liouville equation, it has been possible to show that the power spectrum of cosmic density fluctuations necessarily develops an asymptotic behaviour with the wave number k proportional to k^{-3}. I will outline the arguments leading to this result, and discuss implications for virialization and for the self-similarity of cosmic structures.

GR 15.2 Fri 11:20 ZHG008

Velocity statistics of cosmic large-scale structure from Hamiltonian particle dynamics — •Marvin Sipp — Institut für Theoretische Physik, Universität Heidelberg, Deutschland

We present a novel approach to analytically calculating the evolution of velocity statistics of cosmic large-scale structure in cold dark matter.

It is based on a path-integral formulation for the Hamiltonian dynamics of an ensemble of classical particles, specialised to the self-gravitating case on an expanding background. Density and momentum statistics can be extracted by applying suitable operators to the generating functional. The full theory contains the complete phase-space information of the interacting particle ensemble. In practice, we solve the free theory and include interactions perturbatively, reminiscent of other statistical or quantum field theories. The theory can be reformulated in terms of macroscopic fields, leading to an efficient partial resummation of the microscopic perturbative series. Going to higher orders in this perturbation theory is equivalent to integrating higher moments of the BBGKY hierarchy. We thus avoid the shell-crossing problem of standard Eulerian perturbation theory (without introducing effective parameters), allowing for the generation of vorticity in initially irrotational systems and making our framework particularly interesting for studying the evolution of velocity statistics.

We show how n-point momentum statistics can be extracted from the free theory, how gravitational interactions can be included and partially resummed, and present the resulting two-point statistics of the momentum density and density-momentum cross-correlations.

GR 15.3 Fri 11:40 ZHG008

Orientation systematics in the multi-messenger inference of the Hubble constant — •Michael Müller — Universität Greifswald, Greifswald, Germany

Multi-messenger observations of coalescing binary neutron stars are a direct probe of the expansion history of the universe and carry the potential to shed light on the disparity between low- and high-redshift measurements of the Hubble constant H_0. To measure the value of H_0 with such observations requires pristine inference of the luminosity distance and the true source redshift with minimal impact from systematics. A significant uncertainty in the measurement of the former with gravitational waves (GWs) arises from the poorly constrained orientation of the merging binary system relative to the observer. However, observations of the electromagnetic (EM) counterpart emission from the highly collimated relativistic jet, present in the post-merger phase, can provide strong constraints on the orientation of the source and thus inform the distance inference from the GW data. In **arXiv:2406.11965**, we investigate the consequences of a potential disparity between system orientations obtained from the EM and GW data, which, if not carefully treated when combining observations, can bias the inferred value of H_0. Already small misalignments of $3° - 6°$ between the inherent system orientations for the GW and EM emission can bias the inference by $\mathcal{O}(1 - 2\sigma)$ if not taken into account. I will discuss complications with the interpretation of the system orientation in the post-merger phase and present a summary of the core findings of this investigation.

GR 15.4 Fri 12:00 ZHG008

FLRW Constants of the Motion and the Issue of Their Fine-tuning — •Marc Holman — Utrecht University, Utrecht, Netherlands

It seems to be contended at times that quantum gravity considerations could in principle provide justification for a "blindfolded creator" view on the initial value of the curvature parameter, Ω, in FLRW models. That is, even though there are no sound classical motivations for adopting a uniform probability distribution on initial values of Ω, according to such a line of thought, there could in principle exist quantum gravity motivations to that extent. Here it is shown explicitly - in agreement with previous assertions made by the author - that for the radiation- and dust-filled FLRW models of nonzero curvature, a uniform measure on Ω for Planck-scale initial conditions necessarily entails large amounts of fine-tuning in FLRW constants of the motion. This means that, unless there exist specific reasons for fine-tuning these physical constants, a flatness problem in the fine-tuning sense does not exist, whether quantum gravity motivated or not. Time permitting, comments will also be made on more recent arguments, which purport to establish the existence of a flatness problem in the above sense using Bayesian analysis.