RESEARCH TRAINING GROUP Models of Gravity

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The Universe as a medium - Observables from modified dispersion relations as traces of quantum gravity

Abstract

Elementary test particles, such as photons and neutrinos, probe the geometry of spacetime on length scales which are inverse proportional to their energy. Thus the higher the energy of the particles, the smaller the length scale probed. Quantum gravity effects are expected to become relevant at the Planck scale and hence particles with energies closer to the Planck energy should interact stronger with the quantum nature of gravity than lower energetic ones. Therefore, the propagation of high energetic particles through spacetime may deviate from their predicted behavior by classical general relativity.

This convincing pictorial idea can be formalized in terms modifications of the general relativistic dispersion relations, physical point particles have to obey. Applied to media, in which the propagation of light, for example, can be described by non local Lorentz invariant electrodynamics and a corresponding dispersion relations, this approach works very successfully.

Famous proposals how to implement modified dispersion relations (MDRs) in the context of quantum gravity are so called Rainbow-Gravity, Doubly/Very/Deformed/DeSitter Special Relativity, kappa-Poincare Curved Momentum Spaces or Relative Locality. However they all employ a flat spacetime geometry.

In this talk I will construct modified dispersion relations covariantly on curved spacetimes in terms of Hamilton functions, discuss the resulting position and momentum dependent spacetime geometry, and will derive observables, in which traces of quantum gravity may manifest themselves. For homogeneous and isotropic Hamiltonians I discuss the so called lateshift and redshift effects, while for spherically symmetric Hamiltonian we study innermost circular trajectories for photons. Compared to the predictions of general relativity these observables become a stronger dependence on the four momentum of the particles involved, which in principle is detectable with future observatories.