Research plans

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○Hawking radiation as tunneling from higher-dimensional black holes with quantum gravity effects

A generalized uncertainty principle with a minimal measurable length is attracted a lot of interest to consider phenomenological quantum gravity effects. Though the debates on the quantum nature of black holes are crucial and long standing, there is no systematic study by quantum gravity so far to lay a solid theoretical foundation for the arguments. Then some different models of quantum gravity are effective ways to understand gravity behaviors at a sufficiently small scale. The combination of relativistic and quantum effects implies that the conventional notion of distance would break down the latest at the Planck scale. The basic argument is that the resolution of small distances requires test particles of short wavelengths and thus of high energies. At such small scales, the gravitational effects by the high energies of test particles would significantly disturb the spacetime structure which was tried. Then some quantum gravity theories suggest that there would exist a finite limit to the possible resolution of distances, which would be of order the Planck length. From several studies in string theory, such a minimal measurable length would be obtained by a generalized uncertainty principle, which is a quantum gravity inspired modification to the conventional Heisenberg uncertainty principle. Then various types of generalized uncertainty principles have been heuristically derived from thought experiments and are often taken as phenomenological models that would accommodate a minimal length. Generalized uncertainty principles have been applied to some different systems and played an important role to consider its corrections by supposed quantum gravity theories. Motivated by these discussions of generalized uncertainty principles, we are interested in performing in-depth studies of the quantum features of higher-dimensional black hole solutions. Then we focus on the quantum tunneling radiation of charged particles coming from higher-dimensional black holes based on a generalized uncertainty principle. According to the discussion of the Hawking radiation in general relativity, primordial mini black holes in the very early Universe would have been completely evaporated. However, during the final stages of the Hawking evaporation, the semiclassical approach would be expected to break down due to the dominance of quantum gravity effects. If the black holes would not evaporate completely but turn into the remnants at the end of the evaporation process, such remnants might be a constituent of dark matter. It is interesting to investigate how higher-dimensional black holes evolve under a Hawking evaporation process modified by a generalized uncertainty principle. Then we study the evaporation of the higher-dimensional black holes by the tunneling of particles in the framework of the generalized uncertainty principle as one of the quantum gravity effects in the Hawking radiation [26].

○Soliton accelerations, stationary flows and plasma oscillations in a magnetic field

The magnetic field plays important roles in most astrophysical phenomena. It would be possible to generalize the soliton acceleration mechanism [23] in the environment of nonvanishing magnetic field. We propose an acceleration mechanism of charged particles using nonlinear density waves propagating in an ion-electron plasma in a radial magnetic field [27]. Moreover, to explain the observations of the cosmic rays, it is important to investigate the fully nonlinear solutions for the ion-acoustic waves rather than the weakly nonlinear wave solutions described by the Korteweg-de Vries equation. Then we investigate behaviors of such ion-acoustic solitons and shocks in plasma [28], and stationary flows, plasma oscillations and electric fields around compact objects in two-component plasma [29].