Abstract

Motivated by the phenomenon of jet quenching observed in relativistic heavy-ion collisions, we compute the collisional energy loss of a test parton propagating through a quark-gluon plasma in which the momentum distribution is anisotropic. Consequently, the system, which is assumed to be weakly coupled, is unstable due to chromomagnetic plasma modes. To derive a spectrum of the collective modes, which is needed for the energy loss calculations, we have considered distributions with all degrees of deformation along the beam axis from extremely prolate - infinitely elongated, through isotropic to extremely oblate - infinitely squeezed in the beam direction. In every case we have calculated analytically or numerically the dispersion curves for the full spectrum. Unstable modes are shown to exist in all cases except that of isotropic plasma. We have derived the conditions on wave vectors for an existence of these instabilities. We have also discussed stable modes which are not limited to small domains of wave vectors and therefore have an important influence on the system's dynamics. The spectrum of the collective excitations is further used to calculate the energy loss of a high-energy parton scattering elastically. The approach, which is formulated as an initial value problem, is designed to study an unstable plasma, but it also reproduces the well known result in case of equilibrium plasma. As examples of unstable plasmas, the extremely prolate and oblate systems are considered, and two classes of initial conditions are discussed. When the initial chromodynamic field is uncorrelated with the colour state of the parton, the magnitude of the energy losses is comparable to that in an equilibrium plasma of the same density. When the initial chromodynamic field is induced by the test parton, it can be either accelerated or decelerated depending on the relative phase factor. With a correlated initial condition, the energy transfer grows exponentially in time and its magnitude can much exceed the absolute value of energy loss in equilibrium plasma. The energy loss is not only time dependent but it is also strongly directionally dependent. Consequences of our findings for the phenomenology of jet quenching in relativistic heavy-ion collisions are briefly considered.

This thesis is based on the following original publications:

1. M. E. Carrington, K. Deja, and S. Mrówczyński, *Plasmons in Anisotropic Quark-Gluon Plasma*, Phys. Rev. C **90**, 034914 (2014)

2. K. Deja and S. Mrówczyński, *Complete Plasmon Spectrum of Two-Stream System*, to appear in Acta Phys. Pol. B; arXiv 1503.08861

3. M. E. Carrington, K. Deja, and S. Mrówczyński, *Energy Loss in Unstable Quark-Gluon Plasma*, to appear in Phys. Rev. C; arXiv 1506.09082