Abstract

Study of some recently developed quantum kinetic models, by employing these models for linear wave analysis, is the primary purpose of this dissertation. We have focussed here that how these newly developed models take into account the quantum effects that arise due to electron degeneracy, quantum Bohm-potential and spin quantum effects related to electron paramagnetism.

In the first part of the work presented in the thesis, we have studied an electron-positron-ion degenerate Fermi gas, with or without the Madelung term. We have proposed the existence of a new type of zero-sound wave that exhibit a damping character in contrast to the usual undamped zero-sound waves, present in a degenerate electron-ion plasma. In an electron-hole-ion plasma, we have found new type of longitudinal quantum sound waves that have no analogies in quantum electron-ion plasma. The excitation of these quantum sound waves by a low-density monoenergetic straight electron beam has also been examined. In the second part of the work, we have focussed on the electron spin paramagnetic effects. Employing the non-relativistic spin quantum kinetic theory, we have studied the effect of electron spin on the kinetic Alfvén waves in an electron-ion plasma. We deduce that the usual kinetic Alfvén waves are modified via spin quantum effects of electrons. The dimensionless parameters that determine the relative importance of the electron spin become prominent at higher densities. It is found that the kinetic Alfvén wave frequency decreases due to the electron spin contribution in the kinetic limit while in the inertial limit they are almost unaffected in a hot magnetized plasma. A drawback of the non-relativistic spin quantum kinetic theory is that it does not capture spin effects for electrostatic wave modes. To remove this drawback, we have derived a general dispersion relation for electrostatic modes by employing recently developed weakly-relativistic quantum kinetic theory of spin quantum plasmas. This model contains weakly-relativistic spin effects such as Thomas precession, the polarization currents associated with the spin and also the spin-orbit coupling. It turns out that for strictly electrostatic perturbations the non-relativistic spin effects vanish, and the modification of the classical dispersion relation is solely associated with the relativistic terms. Several new wave modes appear due the electron spin effects. As a particular example, we have studied weak-relativistic effects for Bernstein waves in a fully degenerate plasma and proposed the existence of new waves due to the electron spin effects, that have frequency close to the Bernstein wave frequency.