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Growth of Beam–Plasma Instability in Spin-Polarized Quantum Magnetoplasma

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The interaction of electron beam with plasma, has been a focus of studies conducted by physicists. When an electron beam propagates in plasma, it induces a return current which neutralizes the beam current and is carried by the plasma electrons. As a result, the system undergoes various instabilites like Multi-stream, Two-stream, Filamenation and Weibel that can disrupt beam propagation. Two-stream mode is formed when the wave vector becomes aligned with the direction of beam propagation. For the electron-beam plasma system in the non relativistic regime, beam-plasma mode grows faster than any other mode. The beam-plasma instability of energetic electron beam in plasma may be used for ohmic or turbulent plasma heating purpose in fast ignition of inertial or magnetic confinement fusion devices.

The plasma, where the inter-particle distance approaches the de-Broglie wavelength, or the temperature goes below the Fermi temperature, plasma particles obey Fermi-Dirac statistics and degeneracy starts playing a significant role. In such cases, study of quantum effects become important due to the important applications of quantum plasma ranging from plasmonics, astrophysics, ultracold plasmas, inertial confinement fusion (ICF), future generation compression based plasma experiment, quantum well to quantum x-ray free electron laser and laser-solid density plasma experiments. There is a great motivation to investigate collective phenomenon in quantum plasma where Bohm potential, Fermi pressure and electron spin as well as certain quantum electro-dynamical effects have been accounted for. The dynamical effects of electron spin have been analyzed using both the fluid and the kinetic approaches. The beam-plasma streaming instability in dense quantum plasma is especially important to understand since the electron beam shows new features in quantum plasma which are absent in classical plasma. The instability in quantum plasma [1-5] has been investigated for the case of electron-poisitron quantum plasma [6], dusty quantum plasma [7] and magnetized multi-stream plasma [8].

The wave instabilites driven by electron streaming effects has been well studied in quantum plasma without accounting the electron spin effects. In degenerate plasma the role of electron spin can not be neglected as it effects the wave instabilites and is a cause of new wave phenomenon [9-11]. To study the electron spin effects in plasma, the quantum hydrodynamic (QHD) model for electron spin-1/2 was presented [12,13]. The authors assumed the plasma species to have an average spin -1/2, ignoring the interaction between the spin-up and spin-down electrons which is the violation of Pauli's exclusion principle. In the present paper, the plasma electrons have been taken to be two different species in the presence of an ambient magnetic field. The application of strong magnetic field induces a differnce in the concentration of spin-up and spin-down electrons resulting in spin polarization [14,15]. The study of instabilites induced by electron streaming taking into account the spin polarization in degenerate quantum magnetoplasma has not been repoted so far.

In the present talk, using the modified SSE-QHD model the two-stream instability for a circularly polarized electromagnetic wave propagating through a high density magnetized quantum plasma has been presented. Spin-up and spin-down electrons have been taken to be separate species of particles and spin-spin interaction picture has been developed. The effects of quantum Bohm potential, electron Fermi pressure and spin have also been taken into account. The dielectric constant tensor using which the dispersion relation of two-stream as well as the beam-plasma instability has been obtained. The results indicate that quantum effects and thermal effects play important roles alongwith the spin polarization produced by the spin interaction of spin-up and down species of the electron. The critical wave number for beam-plasma instability in magnetized quantum plasmas has also been described in the paper and effect of spin polarization has been analyzed.

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