Filamentation of a short laser pulse in magnetized quantum plasma with spin polarization

Punit Kumar and Nafees Ahmad

Department of Physics, University of Lucknow-226007, India.

The study of electron beam-wave interaction in the presence of background plasma has attracted a lot of interest over the past few decades. This interaction has widespread application in a number of area including inertial confinement fusion (ICF), plasma microwave electronics, x-ray burst sources, free electron lasers, cyclotron auto resonance maser oscillator, the solar corona and accelerator physics. As is well known that when an electron beam propagates in a plasma, it will induce a return current in the plasma, carried by plasma electrons, to keep neutralization of the system. The interaction results in filamentation. In plasmas, when the de Broglie wavelength of the charge carriers is comparable to the dimension of the plasma system, quantum mechanical effects are expected to play a major role in the behaviour of charged plasma particles. The QHD model, which consists of a set of equations dealing with the transport of charge, momentum and energy in a plasma is the most widely used model to describe quantum effects in plasma. In recent years, quantum effects have proved to play a crucial role in ultrasmall electronic devices, laser plasmas and dense astrophysical plasmas. Filamentation in quantum plasma have been studied by various authors but all the previous studies considered electrons as a single fluid of macroscopically averaged spin-1/2 plasma. The earlier papers did not show a full picture and didn't took spin-up and spin-down interaction force into account. Very recently, a modified separate spin evolution (SSE) treatment of electrons in accordance with Pauli equation has been developed [1,2].

In the present paper, using the modified SSE-QHD model we have studied the filamentation of a short laser pulse in a magnetized quantum plasma. 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 direction of the external field has been taken to be along the direction of electron beam propagation in the first case and oblique in the second case. The dispersion for both the cases have been obtained and growth rate evaluated. The numerical analysis for growth rate has been carried out. The results of both the cases have been compared and analysed. Comparison has also been done with earlier studies and the difference is critically analysed and interpreted.

[1] P. A. Andreev, Phys. Plasmas 22, 062113 (2015).

[2] P. A. Andreev, Phys. Rev. E 91, 033111 (2015).