2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Surface Plasma Wave in Semiconductor Quantum Plasma with Spin-up and Spin-down Exchange Interaction

Punit Kumar, Nafees Ahmad and Shiv Singh
Department of Physics, University of Lucknow, Lucknow – 226007
e-mail : drpunitlko@gmail.com

The surface plasma wave (SPW) has attracted a noticeable interest of the plasma community in last few years. SPW is a guided electromagnetic mode that propagates along the interface between a conductor and a dielectric. Due to great miniaturization of semiconductors in electronics devices (in which the electron Fermi temperature is low and density is high) thermal de-Broglie wavelength of charge particles can be comparable to the spatial variation of the doping profile. Thus, the typical quantum effects such as the exchange-correlation, the quantum fluctuation due to the density correlation, the degenerate pressure and the electron – ½ spin play a non-negligible role in the electronic components to be constructed in the future. The QHD model, which consists of a set of equations dealing with transport of charge, momentum and energy in a plasma has been introduced to study semiconductor physics. All the prevalent models 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 this paper, we propose a scheme of stimulated SPW excitation in magnetized quantum plasma via stimulated electron-hole recombination in the proximity of the guiding surface using the modified SSE-QHD model taking into account the spin polarization produced due to difference in concentration of spin-up and spin-down electrons. The quantum effects of Bohm potential and Fermi electron pressure have also been included in the analysis. We assume a three layer system: a thin layer of n-type semiconductor sandwiched between a metal and a p-type semiconductor. The p-n junction is forward biased and is within a few microns from the metal surface where SPW is guided. The mechanism of optical gain of the SPW is as follows. The mode structure of the SPW field encompasses the p-n junction. The SPW field stimulates electron-hole recombination producing surface plasmons. The enhanced SPW field induces stronger e-h recombination, thus exponentiating the growth rate of SPW in the initial stage of instability. The dispersion relation and Poynting flux of the SPW in magnetized quantum plasma has been obtained. The optical gain has been calculated and analyzed graphically.

[1] P. A. Andreev, Phys. Plasmas 22, 062113 (2015).
[2] P. A. Andreev, Phys. Rev. E 91, 033111 (2015).