3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Spatio-temporal evolution of Buneman instability: A Particle-in-cell simulation study

Sudip Sengupta[1], Roopendra Singh Rajawat[2]
[1] Institute for Plasma Research, [2] School of Applied and Engineering Physics, Cornell University
email:sudip@ipr.res.in

A current carrying plasma constitutes an ideal laboratory for investigating various kinds of streaming instabilities associated with an electron beam plasma system. Buneman instability, which is one of the most elementary electrostatic instabilities associated with the streaming of electrons with respect to ions, is found to be responsible for both electron and ion acceleration in laboratory as well as in astrophysical plasmas. The mechanism of production of energetic ion beams in some laser driven ion acceleration schemes have been attributed to relativistic version of Buneman instability. In this work, spatio-temporal evolution of Buneman instability has been investigated, both in the non-relativistic and relativistic regimes, using an in-house developed particle-in-cell (PIC) code.

Starting from the excitation of the instability till its quenching and beyond, extensive comparison between PIC simulation and fluid/kinetic model of Buneman instability have been carried out. In the non-relativistic regime, at the quasilinear and at the final saturation point of the instability, well known results on the scaling of the ratio of field energy density to initial beam kinetic energy density with electron to ion mass ratio and initial beam velocity, have been demonstrated convincingly, possibly for the first time using a PIC code. Further, beyond the final saturation point, coherent modes which are electron phase space holes coupled to large amplitude ion solitary waves are excited. Using known theoretical models, these coherent modes have been identified as coupled hole-solitons (CHS's) [2].

In the relativistic regime, simulation results firstly show that the growth rate of Buneman instability reduces due to relativistic effects, and secondly at the quasilinear saturation point, the ratio of field energy density to initial beam kinetic energy density, scales inversely with the square of the Lorentz factor associated with the beam. These novel results have been found to be in quantitative agreement with the scalings derived using fluid theory [1].

References:

1. Roopendra Singh Rajawat and Sudip Sengupta, Phys. Plasmas **23**, 102110 (2016).
2. Roopendra Singh Rajawat and Sudip Sengupta, Phys. Plasmas **24**, 122103 (2017).