Weak turbulence analysis of wave spectra in plasmas containing a population of particles with power-law velocity distributions

L.F. Ziebell[1], S.F. Tigik[1], L.T. Petruzzellis[1], R. Gaelzer[1], P.H. Yoon[2]

[1]Instituto de Física, Universidade Federal do Rio Grande do Sul, Brazil

[5]Institute for Physical Science & Technology, University of Maryland, USA and School of Space Research, Kyung Hee University, South Korea

Observations have shown that plasma particles in the solar wind frequently display power-law velocity distributions, which can be isotropic or anisotropic. Particularly, the velocity distribution functions of solar wind electrons are frequently modeled as combination of a background Maxwellian distribution and a non-thermal distribution which is known as the "halo" distribution, eventually added of a smaller population of energetic particles with field-aligned velocities, which is known as the "strahl" distribution. Motivated by these observations, we consider a tenuous plasma with Maxwellian ions and with electrons described by a summation of an isotropic Maxwellian distribution and an isotropic kappa distribution, and utilize the formalism of weak turbulence theory to discuss the spectra of electrostatic waves which must be present in such a plasma, satisfying conditions of quasi-equilibrium between processes of spontaneous fluctuations and of induced emission. The analysis is made considering different values of the kappa index of the electron distribution, and different values of the relative number density of the electrons associated to the kappa distributions. By taking into account effects due to electromagnetic waves into the weak turbulence formalism, we investigate the electromagnetic spectra which satisfy conditions of "turbulent equilibrium", in the presence of a fraction of electrons described by kappa distributions, and also the time evolution of the wave spectra and of the electron velocity distribution, which occurs in the case of the presence of an electron beam in the electron distribution. The numerical analysis made using the equations of weak turbulence theory allows for separate analysis of the effect of different mechanisms on the evolution of the system, namely the analysis of spontaneous fluctuation, induced mechanisms, three-wave decay, and scattering. For the numerical analysis, we also consider the influence of different values of parameters like the "plasma parameter" and the ratio of electron and ion temperatures, on the initial spectrum of electrostatic waves and on the evolution of the system.

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