Comparing the properties of spontaneous electromagnetic emissions in thermal and non-thermal Kappa distributions using 1.5 D PIC simulations and kinetic theory

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Resumen

Description of space plasma is attained to a hot and diluted ionized gas system. Most kinetic theories about plasmas into the inner Heliosphere considers ineffective Coulomb collisions on high frequency electron scale. Therefore, the Vlasov equation is a rough but powerful plasma kinetic particle description approach to model non-collisional plasma. In this spirit, Vlasov's theory allows the knowledge of the final thermodynamic state in the form of a velocity distribution function (VDF). It is well known in the space plasma community that the morphology of the VDF is attained to non-thermal kinetic features, such as suprathermal tails, temperature anisotropies, field aligned beams, etc [1]. The departure from thermal equilibrium provides a source of electromagnetic fluctuation, which plays a fundamental role in bringing the plasma back to equilibrium in the early stages of the relaxation process when collisions still do not play a main role. Spectrum analysis of this non-thermal feature unveils the way of the final plasma state . In this work, we present spontaneous electromagnetic properties in beta and kappa parameter space through a uniform isotropic high-frequency electron-proton plasma system. We obtained these results through 1.5D PIC (one space and three velocity dimension) electron-proton plasma simulation, loaded with thermal Maxwellian and two non-thermal versions of Kappa velocity distributions (Olbertian and Modified). Besides, following the derivation of general expressions for the plasma fluctuations, we computed analytic expressions for each thermal and non-thermal distribution [2]. Additionally, we found dispersion branches of transverse electromagnetic modes from kinetic theory, which give us new insights of system's dispersion properties. This allows us to evidence consistency between theory and simulations. Our main result shows that the energy of magnetic fluctuation gets enhanced with the decrement of kappa value in the Olbertian case. On the other hand, the Modified case shows even less energy of fluctuations than Maxwellian equilibrium with the decrement of the same parameter. Moreover, the energy of magnetic fluctuation in both Kappa cases has the same behavior with respect to beta parameter, both scales with the increment of beta parameter, but Modified distribution election has less power in the low kappa value range. These features may be used as a proxy to identify the nature of electron populations in space plasmas at locations where direct in-situ measurements of particle fluxes are not available.

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Referencias

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