Electrostatic mode envelope excitations in warm pair ion plasma with a small fraction of uniform and stationary positive ions – application in e-p-i and doped fullerene plasmas

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We investigate the nonlinear propagation of electrostatic wave packets in electron-positron-ion (e-p-i) plasmas, or pair- (eg. fullerene) ion plasmas in the presence of a small fraction of uniform and stationary positive ions. A two-fluid plasma model is employed. Electrostatic mode propagation parallel to the external magnetic field is considered. The temperature ratio among the two species is left arbitrary in the analysis, although a natural choice of unity was focused upon and discussed extensively. Two distinct electrostatic modes are obtained, namely a quasi-ion-thermal lower mode and a Langmuir-like optic-type upper one, as in pure pair plasmas, in agreement with previous experimental observations and theoretical studies of equal-temperature pair plasmas. Considering small yet weakly nonlinear deviations from equilibrium, and adopting a multiple scale technique, the basic set of model equations is reduced to a nonlinear Schrödinger equation for the slowly varying electric field perturbation amplitude.

The analysis reveals that the stability range of lower (acoustic) mode increases as the positive-to-negative-ion (or positron-to-electron) density ratio increases, so this quasi-thermal mode may propagate in the form of a dark-type envelope soliton (i.e. a potential dip, or a density void) modulating a carrier wave packet for small wave-numbers, even up to nearly twice the characteristic Debye wave-number, for fixed value of the positive-to-negative-ion (or positron-to-electron) temperature ratio σ . On the other hand, the upper mode is modulationally unstable, and may thus favor the formation of bright-type envelope soliton (pulse) modulated wave-packets in the wave-number region mentioned above. These dependence of these results on the positive-to-negative-ion (or positron-to-electron) density and temperature ratios is investigated. In specific, one may anticipate that a local coexistence of positive ions (or positrons) with a colder, say, population of negative ions (or electrons), viz. $\sigma < 1$ ($\sigma > 1$), may critically affect the stability profile of electrostatic modes, for instance by stabilizing the lower mode (which is unstable near $\sigma = 1$), or by destabilizing the lower mode (which is stable near $\sigma = 1$).

References

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