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Stability of electromagnetic solitons in relativistic degenerate plasmas

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The nonlinear interaction of intense electromagnetic (EM) waves with relativistic plasmas has attracted much attention in recent years because of their potential applications in the development of the fast ignition in inertial fusion plasmas and x-ray lasers [1-4]. The laser-plasma interaction also provides a varieties of nonlinear phenomena including the formation of solitons [4]. The latter are self-trapped by locally modified plasma refractive index via two effects: the relativistic electron mass increase and the electron density drop by the EM driven poderomotive force. A number of works in the literature can be found dealing with the properties of EM solitons and their stability in relativistic laser plasmas. However, no attempt has been made to investigate the dynamical properties of EM solitons in relativistic degenerate plasmas such as those in astrophysical high-density plasmas [2].

In this work, we study the conditions for the existence of EM solitons, their stability and dynamical properties in the nonlinear interaction of high-frequency linearly polarized EM waves and relativistic degenerate plasmas. Starting from a set of relativistic fluid equations coupled to the Maxwell equations we derive a nonlinear Schroedinger equation with local and nonlocal nonlinearities. We obtain analytic solutions and regions of stability/instability of EM solitons. It is shown that the stability and instability of standing EM solitons depends not only on the soliton velocity and self-frequency shift, but also on the relativistic degeneracy of electrons.

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