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Numerical study of nonrelativistic and relativistic ion and electron holes in plasmas[1]

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We present analytical and numerical studies of the formation and dynamics of electron and ion holes in a collisionless plasma [1]. Both nonrelativistic [2,3] and relativistic [4,5] electron and ion holes are considered. Stationary and non-stationary solutions for the electron and ion holes are obtained on the basis of non-isothermal particle distribution functions that are different from the Maxwellian. Analytical solutions for the holes are then used as initial conditions in simulations to investigate the dynamics and stability of those phase space holes. Our results reveal that both the electron and ion holes are robust, and interacting holes show an interesting dynamics in which they sometimes merge to form new and stable holes. Furthermore, we consider the trapping of intense electromagnetic waves in relativistic electron holes [6], accounting for the combined effects of the relativistic ponderomotive force driven electron density depletion and relativistic electron mass increase in the electromagnetic fields. We present conditions under which the trapping of localized electromagnetic waves in relativistic electron holes occur. It is found that the electrons can be accelerated to ultra-high (MeV to GeV) energies by localized potential of relativistic electron and ion holes. The relevance of our investigation to intense laser-plasma interaction experiments and to astrophysical settings is discussed.

References

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