Nonlinear Landau Damping and Soliton Braking in the Collisionless Plasma

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In this work, based on Ref. [1], we present a systematic derivation of the generalized Zakharov equations for a collisionless isotropic plasma, taking into account nonlinear Landau damping and relativistic effects,. The conditions under which the generalized system reduces to a nonlinear Schrödinger equation with a nonlocal nonlinear term are discussed. A special regime is also identified in which the local nonlinear term vanishes, leaving only the nonlocal nonlinear term in the nonlinear Schrödinger equation. This corresponds to the pure ion-acoustic regime.

It is shown that the wave–wave–particle interaction leads to the braking of a soliton, which is a particular solution of the nonlinear Schrödinger equation. Numerical calculations were carried out for different values of the characteristic parameters, providing a clear illustration of the soliton braking predicted by the theoretical model.