Efficient and stable numerical methods for the generalized and vector Zakharov system

Weizhu Bao
National University of Singapore

Abstract

In this talk, we present efficient and stable numerical methods for the generalized Zakharov system (GZS) describing the propagation of Langmuir waves in plasma. The key point in designing the methods is based on a time-splitting discretization of a Schroedinger-type equation in GZS, and to discretize a nonlinear wave-type equation by pseudospectral method for spatial derivatives, and then solving the ordinary differential equations in phase space analytically under appropriate chosen transmission conditions between different time intervals or applying Crank-Nicolson/leap-frog for linear/nonlinear terms for time derivatives. The methods are explicit, unconditionally stable, of spectral-order accuracy in space and second-order accuracy in time. Moreover, they are time reversible and time transverse invariant if GZS is, conserve the wave energy as that in GZS, give exact results for the plane-wave solution and possesses 'optimal' meshing strategy in 'subsonic limit' regime. Extensive numerical tests are presented for plane waves, solitary-wave collisions in 1D of GZS and 3D dynamics of GZS to demonstrate efficiency and high resolution of the numerical methods.
Finally the methods are extended to vector Zakharov system for multi-component plasma and Maxwell-Dirac system (MD) for time-evolution of fast (relativistic) electrons and positrons within self-consistent generated electromagnetic fields.