3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Phase dynamics in nonlinear three-wave coupling

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Three-wave interactions reveal the basic elements of the dynamics of nonlinear plasma wave-wave interactions. When no dissipation is present in the system, the integrable dynamics of such conservative systems can be described via Poinsot construction, and the exact solution for the intensity of three coupled waves can be written in terms of elliptic functions. There are two fundamentally different regimes of such reversible and periodic solutions: limit cycle oscillations (LCO) and fixed points (FP). Recent literature emphasizes that phase dynamics play an essential role in nonlinear three-mode coupling. The initial condition for dynamical phase decides which regime the system falls in, and thus controls the exchange of energy between coupling modes.

In this work we show that spatial phase coupling induces formation of phase diffusion, which turns out to be the phase drag effect in the well-established three-wave coupling model. The phase drag is intrinsic to broken symmetry in the nonlinear mode coupling process, and serves as a new mechanism in the nonlinear saturation of three wave systems.

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