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Theory of Quasi-mode Parametric Decay in Plasmas

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Parametric decay instability (PDI) is a kind of nonlinear wave-wave interaction, which significantly influence the wave accessibility and heating in plasmas. In fusion plasmas, the parametric process is typically displaying as quasi-mode decay, such as nonlinear landau damping or ion cyclotron harmonic decay. [1] For these quasi-mode decays, the previous kinetic theory [2] for PDI, where quasilinear treatments are adopted for the pump as well the daughter branches, is not valid any longer. In electrostatics case, a kinetic-fluid mixed approach [3] can be employed to deal with quasi-mode decay. However, in electromagnetic case, a complete nonlinear kinetic framework should be established. In our recent works, a nonlinear kinetic theory of parametric instabilities is developed, [4] meanwhile, different approaches containing nonlinear treatments are numerically solved and compared. As an example, the PDI during the injection of low hybrid wave in plasma is investigated within the full electromagnetic framework.[5] Moreover, the theory is applied to analyze the PDIs in laser-plasma and the relation of the quasi-mode parametric decay and the so-called stimulated Compton scattering (SCS) is discussed.

[1] For example: B. J. Ding, P. T. Bonoli, A. Tuccillo, et al, Nucl. Fusion 58, 095003 (2018); S. G. Baek, G. M. Wallace, P. T. Bonoli, et al, Phys. Rev. Lett. 121, 055001 (2018). R. Cesario, L. Amicucci, A. Cardinali, et al, Nat. Commun. 1, 55 (2010)
[2] C. S. Liu and V. K. Tripathi, Phys. Rep. 130, 143 (1986).
[3] For example: A. Zhao and Z. Gao, Nucl. Fusion 53, 083015 (2013); R. Cesario, L. Amicucci, A. Cardinali, et al, Nucl. Fusion 54, 043002 (2014).
[4] Z. Liu, Z. Gao and A. Zhao, Physics of Plasma 26, 042117 (2019).
[5] Z. Liu, Z. Gao and A. Zhao, Physics of Plasma 27 (2020) in press.

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