Electron-ion collision effect on the growth rate of Raman backscattering instability in the interaction of X-mode laser with magnetized plasma

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Raman scattering is a parametric instability in which an incident light wave decays resonantly into an electron plasma wave and a scattered light wave. This instability decreases the efficiency in ICF or particle acceleration experiments [1]. Raman scattering process in the transversely magnetized plasma includes the decay of an electromagnetic pump wave into an upper hybrid wave and two scattered daughter waves [2,3]. The laser and the sidebands exert a nonlinear ponderomotive force on electrons driving the upper hybrid wave. Raman backward scattering (RBS) is significant for a number of reasons. As the RBS mode grows to large amplitude, it can trap background plasma electrons, thus heating the plasma and creating a fast tail on the electron distribution. In our previous theoretical study [3], we considered the interaction of linearly polarized laser with transversely magnetized cold plasma and investigated the RBS instability and found an explicit expression for the temporal growth rate of the instability. We show that in cold transversely magnetized plasma, the growth rate of RBS instability increases by increasing the external magnetic field. In another similar study, Liu et al. [4] developed 1D Vlasov-Maxwell numerical simulation to examine RBS instability in unmagnetized collisonal plasma. Their results show that Raman backward scattering will be enhanced by electron-ion collisions. Our purpose in the present work is to investigate the RBS and find the growth rate of instability in the interaction of X-mode laser with homogenous warm magnetized plasma when, relativistic, ponderomotive and collision nonlinearities are simultaneously operative. As a matter of fact, when laser propagates through plasma, a longitudinal electrostatic field is generated due to the panderomotive force acting on plasma electrons, and this makes the laser beam to be extraordinary which is called X-mode laser. Here, we consider homogeneous plasma which is embedded in a uniform external magnetic field perpendicular to both, the direction of propagation and electric vector of the radiation field. Nonlinear wave equation is set up and Fourier transform method is used to solve the coupled equations describing RBS instability to obtain the growth rate. Thermal effects of plasma electrons and effect of the electron-ion collisions are examined in this research. In our study, we neglect the self-focusing and filamentation effects. These effects may enhance the growth rate [5]. So, our resulting analysis is only valid for times short compared to the characteristic evolution time of the pump laser (laser duration).

References

[1] Barr H.C., Boyd T., Gordon F., Berwick S., “Stimulated Raman scattering in plasmas produced by short intense laser pulses.”, Laser and Particle Beams **13**, 4, 525-537 (1995).
[2] Paknezhad A., “Third harmonic stimulated Raman backscattering of laser in a magnetized plasma”, Phys. Plasmas, **20**, 092108 (2013).
[3] Paknezhad A. and Dorranian D., “Nonlinear backward Raman scattering in the short laser pulse interaction with a cold underdense transversely magnetized plasma”, Laser and Particle Beams,, **29**, 373–380 (2011).
[4] Liu Z. J., Zhu S. P., Cao L. H., Zheng C. Y., He X. T., and Wang Y., “Enhancement of backward Raman scattering by electron-ion collisions”, Physics Plasmas **16**, 112703 (2009).
[5] Saini N.S and Gill T.S., “Enhanced Raman scattering of a rippled laser beam in a magnetized collisional plasma”, Laser Part. Beams **22**, 35–40 (2004).