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Brillouin backward scattering in the nonlinear interaction of a short-pulse laser with an underdense transversely magnetized plasma

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Abstract

Brillouin backward scattering is investigated in the interaction of linearly polarized short laser pulse with a homogenous underdense transversely magnetized plasma by taking into account the relativistic and nonlinearity effects up to third order. The plasma is embedded in a uniform magnetic field perpendicular to both of propagation direction and electric vector of the radiation field. Temporal growth rate of instability is calculated by using of the nonlinear wave equation. Results are significantly different in comparison with lower order computations. The growth rate of Brillouin backward instability shows a decrease due to the presence of external magnetic field, while relativistic and higher order nonlinearities due to the external magnetic field, give rise the Brillouin backward scattering instability.

Keywords: Brillouin scattering; Growth rate; Ion acoustic wave; Magnetized plasma; Ponderomotive force; Underdense plasma

1. INTRODUCTION

Short-pulse lasers may be potentially useful as a time and space resolved diagnostic for inertial confinement fusion (ICF) experiment (Hinkel *et al.*, 1995). In the interaction of intense short-pulse laser with a plasma, the electron cloud is instantly and without thermal losses receiving the acceleration in the laser field by direct conversion of nearly 100 percent of laser energy into mechanical motion and accelerate up to 10^{20} cm/s^2 (Hora, 2012). When the plasma is heated by relativistic laser beam, it may excite the natural modes of vibration of the plasma, that is, the electron plasma wave and ions waves. This electron plasma wave can have a very high phase velocity (on the order of the velocity of light), and so can produce very energetic electrons when it damps. Such electrons can preheat the fuel in laser fusion applications. During this process, various parametric instabilities (filamentation, stimulated Raman scattering, stimulated Brillouin scattering, etc.) take place and due to this, energy of high power laser beam is not efficiently coupled to the plasma (Kruer, 1996; Purohit *et al.*, 2008). Brillouin scattering occurs in the interaction of picosecond laser pulse with a plasma that involves the coupling of large amplitude light wave into a scattered light wave plus an ion acoustic wave (IAW). Previous researches have shown that this scattering leads to an instability with specific growth rate in plasma. Stimulated Brillouin scattering (SBS) plays an important role in laser-plasma interaction as it produces a backscattered light and therefore this process is one of the real threat to the inertial confinement fusion research. The control of the SBS instability remains as one of the key issues for the success of the laser fusion. SBS in a plasma is the decay of an incident (pump) light wave into a frequency downshifted (Stokes) light wave and an ion-acoustic wave (IAW) (Yin *et al.*, 2007). In this process, laser light interacts with an ion acoustic wave and is scattered backward. The scattered wave and the laser pump exert a ponderomotive force on the electrons, driving the acoustic wave (Kar *et al.*, 2002). SBS is important in the ICF experiments because it scatters the laser beams away from the target, thereby reducing the energy available to drive the compressive heating of the nuclear fuel. Also, in the case of backward SBS, it causes laser's reflection and leads to a net energy loss (Chen *et al.*, 1985; Kruer, 1998; Jaimana *et al.*, 1998; Bernhardt *et al.*, 2010). The SBS instability occurs over a wide range of electron density up to the critical layer (Kruer, 1998). For most plasma conditions and laser intensities of interest in linear regime, the

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