
Effect of dc-magnetic field on the growth rate of Raman backscattering of X-mode laser in magnetized collisional plasma

ALIREZA PAKNEZHAD

Department of Physics, Shabestar Branch, Islamic Azad University, Shabestar, Iran

(RECEIVED 3 June 2015; ACCEPTED 10 October 2015)

Abstract

Stimulated Raman backward scattering of an X-mode laser beam propagating in a homogenous plasma is studied in the presence of a transverse magnetic field. As the laser propagates in its X-mode in plasma, it decays into an upper hybrid wave and a down-shifted sideband wave. Beating the incident laser with the sideband exerts a nonlinear ponderomotive force acting on plasma electrons driving the excited upper hybrid wave. The incident wave then parametrically couples with the upper hybrid wave to drive the sideband. Using the fluid model and nonlinear current density, the nonlinear ponderomotive force is obtained to find the dispersion relation of the scattered sideband wave and the growth rate of the instability in the weakly relativistic regime. It is shown that the growth rate decreases and the cut-off points in the normalized wave number of the upper-hybrid wave become smaller by increasing the static magnetic.

Keywords: X-mode laser; Magnetized plasma; Ponderomotive force; Growth rate; Weakly relativistic regime

1. INTRODUCTION

Raman scattering is a parametric instability in which an incident light wave decays resonantly into an electron plasma wave and a scattered sideband wave at a shifted frequency. The sideband wave interacts with the pump wave field producing a ponderomotive bunching force which amplifies the original density perturbation created by electron plasma wave leading to the instability and transferring energy into the plasma. This instability is an excellent example of an important nonlinear optical process and decreases the efficiency in inertial confinement fusion (ICF) hohlraums or particle acceleration experiments (Barr *et al.*, 1984b; Kruer, 2000). Raman scattering takes place in the subcritical (underdense) region of the plasma. Occurrence of this instability can potentially prevent laser energy from ever arriving at the critical surface where the enhanced absorption mechanism can operate (Forslund *et al.*, 1975). In an early basic work on scattering instabilities, Drake *et al.*, derived the general dispersion relation in the interaction of high amplitude electromagnetic wave with homogeneous unmagnetized plasma for nonrelativistic case and obtained the linear growth rates for Raman

instability as well as the other parametric instabilities. They show that, in general, stimulated scattering of the incident pump electromagnetic wave is strongest in the backscatter direction (Drake *et al.*, 1974). 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. It has been reported that spontaneous dc-magnetic field of the order of a few Mega-gauss which are easily achieved in laser–plasma interactions and laser-produced plasmas can affect the propagation of both the laser and plasma wave as well as transport coefficients in plasma (Sharma & Dragila, 1988; Nicolai *et al.*, 1994; McKenna *et al.*, 2013). The constant dc-magnetic field could be externally applied or self-generated in the plasma (Bawaaneh, 2006). In the context of ICF, experiments and theory have shown that the self-generated-dc magnetic field is perpendicular to the polarization and propagation vector of the incident laser radiation (Stamper *et al.*, 1978; Grebogi & Liu, 1980; Nabil, 1995). It has been shown experimentally that the self-generated magnetic field rises from 600 kG at the critical density to 2–3 MG around quarter critical density. Then, it drops steeply with decreasing density until it reaches zero at about 0.1 critical density (Nabil, 1995). When an

Address correspondence and reprint requests to: A. Paknezhad, Department of Physics, Shabestar Branch, Islamic Azad University, Shabestar, Iran. E-mail: a.paknezhad@iaushab.ac.ir