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RESEARCH ARTICLE

# Stimulated Raman scattering of self-focused elliptical $q$-Gaussian laser beam in plasma with axial density ramp: effect of ponderomotive force

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**Abstract** The phenomenon of stimulated Raman scattering (SRS) of elliptical $q$-Gaussian laser beams interacting nonlinearly with underdense plasmas has been investigated theoretically. When an intense laser beam with frequency $\omega_0$ propagates through plasma, due to the nonuniform irradiance over its cross-section d.c component of ponderomotive force becomes active. Due to this ponderomotive nonlinearity of plasma, the laser beam gets coupled with a preexisting electron plasma wave (EPW) at frequency $\omega_{ep}$. The nonlinear interaction of pump beam with EPW produces a back scattered wave at frequency $\omega_s = \omega_0 - \omega_{ep}$. Using variational theory semi-analytical solution of the set of coupled nonlinear wave equations for the three waves (pump, EPW and scattered) has been obtained under W.K.B approximation technique. It has been observed that power of the scattered wave is significantly affected by the self-focusing effect of pump beam.

## Introduction

After transistor, laser [1] is considered to be the most successful pieces of apparatus born from 20th century science. When laser made its debut in 1960 people considered it to be solution which is searching for its problem. Since its invention the impact of laser on our lives has changed with time, and still is changing. Now, laser is ubiquitous in every aspect of life: from super market bar-code scanners, security checkpoints, CD writers to high end applications like medical diagnosis and surgery, inertial confinement fusion. The extent of diversity in the applications of laser can be estimated from the fact that same instrument is being used to produce highest [2] as well as lowest temperature [3] on earth i.e., the instrument can heat as well as can cool down. Laser has played an important role in revealing true beauty of interaction of light with matter through the appearance of several new phenomena. This spans a gamut from parametric instabilities [4–6] to several self action effects like self-focusing [7], self-channelling [8], self-phase modulation [9], etc. Being extremely complex and rich in physics, these nonlinear phenomena have potential to engage researchers for several upcoming years. Therefore, for the better under-standing of light matter interactions several researchers are making conscious efforts to improve upon the understanding of these nonlinear phenomena. These efforts have collectively laid the foundation of an entirely new branch of science known as laser plasma interactions.

Raman scattering occurs due to interaction of light with optical phonons. Equivalently, we can see that it is the scattering of light due to quantized molecular vibrations of the medium (Fig. 1). Basically, Raman scattering is an inelastic scattering in which an incident photon with energy $h\nu_L$ produces a scattered photon with energy $h\nu_S$ while the remaining energy $h(\nu_L - \nu_S)$=$h\Omega$ results in the vibrational excitation of the molecule. Thus, Stokes component of the Raman scattering corresponds to creation of an optical phonon. The frequency $\nu_S$ corresponding to the scattered photon is called Stokes frequency and is smaller than the incident light frequency by an amount equal to that of generated phonon.

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