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RESEARCH ARTICLE

Excitation of ion acoustic waves by self-focused *q*-Gaussian laser beam in plasma with axial density ramp

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Abstract Dynamics of the laser-driven ion acoustic waves (IAWs) in plasmas with axial density ramp has been investigated theoretically. The effect of self-focusing of the laser beam on the power of laser excited IAW has been incorporated. During its propagation through the plasma, the laser beam excites an IAW at frequency ω_{ia} that due to the optical nonlinearity of plasma gets nonlinearly coupled to the laser beam. Using variational theory, semianalytical solutions of the coupled nonlinear wave equations for the pump wave and IAW have been obtained under W.K.B approximation technique. It has been observed that power of the IAW is significantly affected by the self-focusing effect of pump beam.

Keywords *q*-Gaussian · Density ramp · Relativistic plasma · Self-focusing · Ion acoustic waves

Introduction

Plasma is a collection of positively and negatively charged particles moving about so energetically that they do not readily combine. Plasmas are everywhere in the universe [1]. They form the intensely hot gas under high pressure in the sun and the stars, as well as the rarefied gas in interstellar space and in the ionospheric envelope surrounding the earth. Plasmas also exist closer to hand. They are present in the flames of burning fuel and in gas-discharge devices such as neon signs. Plasmas exhibit such an enormous variety of physical effects that physicists have studied their properties for about 200 years. Past research on plasmas, particularly on gas discharges, led to the discovery of the electron and to the elucidation of atomic structure [2].

The current interest in plasmas reflects two principal motives. The first one is technological. An understanding of plasma behavior is crucial to the controlled release of thermonuclear energy [3–6], the attempt to reproduce in a man-made plasma the kind of nuclear reaction found in the sun. Another technical goal is the design of magnetohydrodynamic generators [7], in which electric power is generated by jets of gas plasma traversing magnetic fields. The second broad motive for the study of plasmas is the importance of plasma phenomena in space and in astrophysics. When a plasma is subjected to electromagnetic fields, the motion of the particles is no longer completely random. One important consequence of this imposed order is that a plasmas can transmit certain kinds of waves that are related to electromagnetic waves but that have unique and curious properties. These waves include high-frequency electron plasma waves [8, 9] (EPWs) and low frequency one called ion acoustic waves [10, 11] (IAWs).

IAWs can be excited in plasmas due to their remarkable properties of quasineutrality and collective behavior. Plasma is a state of matter that contains enough heat that atoms lose their individuality. The negatively charged electrons are still attracted by positively charged nuclei, but they are not bound together. This gives a plasma some unusual properties unlike most kind of ordinary matter—solids, liquids and gases—the free floating electrons and ions of a plasma are strongly affected by electric and magnetic fields. Plasma as a whole is quasineutral, but as

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