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ORIGINAL ARTICLE

On existence conditions of dust-acoustic solitary waves in a plasma with positively charged dust

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Abstract Dust acoustic (DA) solitary wave existence conditions are investigated for positively charged dust particles in the presence of nonthermal electrons. Once Sagdeev pseudo-potential derived through fluid equations, for large amplitude DA waves, the lower limit on Mach number is calculated analytically using the necessary condition for the solitary waves existence. The double layers conditions provides the upper limit on Mach number. This allowed us to numerically investigate the effect of the temperature, density and nonthermal parameters on the solitary waves' characteristics. The present study is devoted to a complex plasma subject to ultraviolet radiations such as the one in the lower earth's ionosphere.

Keywords Solitary waves · Complex plasma · Ionosphere

1 Introduction

Bringing by the development of the nonlinear theory, the lexicon of nonlinear science includes two new concepts: chaotic behaviors of dynamic systems and localization of dynamical variables. Some novel concepts came into use such as solitary waves, solitary vortices, and solitons. The latter are spacially localized waves with fascinating properties and results from the equilibrium between the nonlinearity which tends to localize the signal and the dispersion which tray to spread it (Peyrard and Dauxois 2004). From mathematical point of view, a soliton can be defined as a solution of a nonlinear partial differential equation that exhibits the following properties (Wazwaz 2009):

1. the solution should demonstrate a wave of permanent form;
2. the solution is localized, which means that the solution either decays exponentially to zero, or converges to a constant at infinity;
3. the soliton interacts with other solitons preserving its character.

Acoustic waves in plasmas are an interesting example that shows how solitons may occur in the different natural environment such as the earth atmosphere, where the observed coherent solitary structures are interpreted in terms of a nonlinear phenomenon known as wave collapse (Trines et al. 2007). Of the particular plasma medium that attracts growing attention is complex plasma. The dust particles play an important role in such a plasma, subject to different charging process like particles collection, secondary emission, thermionic emission and photoelectrons emission. It is possible to have the dust particle negatively or positively charged, sometimes both charged particles can coexist (Smiley et al. 2003). The ionosphere is the largest accessible naturally-occurring complex plasma which contains positively charged dust. The latter results from electrons photoemission at the dust surface. This is the consequence of the fact that work function of dust grains is lower than that of pure water ice, as it is the case near the mesopause (Havnes 2002). Under the impact of solar wind, in the interplanetary medium, the dust grain particles can emit electrons from the dust surface leading to positively charged dust (Mann 2008).

Solitary structures have been widely investigated in plasmas with nonthermal distribution (Alinejad 2010). Exact pseudo-potential derived from analytical form and numerical solution have shown that the nonthermal distribution modified solitary waves (Chatterjee and Roychaudhury 1995; Cairns et al. 1995a). For some values of the nonthermal parameter there is no soliton (Pakzad 2009). The ion

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