Classical "Supersoliton"s In Two Electron Temperature Warm Multi-ion Plasmas

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The large gradient in particle properties and field at the magnetospheric boundary layers act as the free energy sources for instabilities and nonlinear wave growth which leading to the generation of Electrostatic Solitary Waves (ESWs). Signatures of ESWs are observed by the satellite borne electric field instruments which are recorded as localized monopolar, bipolar or tripolar pulses in the electric field (E data). The bipolar structures are mostly interpreted as ion / electron acoustic solitary waves whereas the monopolar structures are interpreted as corresponding double layers (or kink solutions). None of the existing theories are sufficient to explain the existence of tripolar pulses [1].

Recently Dubinov and Kolotkov [2] observed a new kind of nonlinear structure, which shows a definite wiggles in its solitary potential profile and extra wiggles in the bipolar E field structure. They named it as supersolitons or super solitary waves (SSWs). The word 'super' actually coined because of their extra large speed, width and amplitudes. Figure 1(a) shows the typical potential profiles for a "supersoliton" (solid line) vis a vis a regular solitary wave (dashed line) while Fig. 1(b) shows the corresponding electric field profile. The horizontal axis shows the generalised coordinate $\eta = x - Mt$ where M is the Mach no normalised by ion acoustic speed $c_s = \sqrt{\frac{T_e}{m_i}}$, T_e, m_i being the net electron temperature and ion mass respectively and the vertical axes show the normalised electrostatic potential ϕ (electric field E) respectively. The point a^* shows the extra wiggle appearing in a supersoliton.

In our previous works [3]-[4], we have found that, for a compressive (positive amplitude) ion acoustic 'supersoliton', its morphology and characteristics are mainly governed by the presence of a cooler electron species and their relative temperatures and concentrations determine the corresponding existence domain [Ghosh and Iyengar, Physics of Plasma, 2014 ; Steffy and Ghosh, Physics of Plasma, 2016]. In our present work we have investigated the transition of a regular solitary wave to such an wiggled structures. Here we have shown that, unlike the current believe which always necessarily associates 'supersolitons' with a double layer like solutions, there is actually no unique route for the transition of a regular solitary wave to such wiggled structures. Instead, depending on the specific parameter regime, it may transform either abruptly, or continuously, from one type to the other and may not

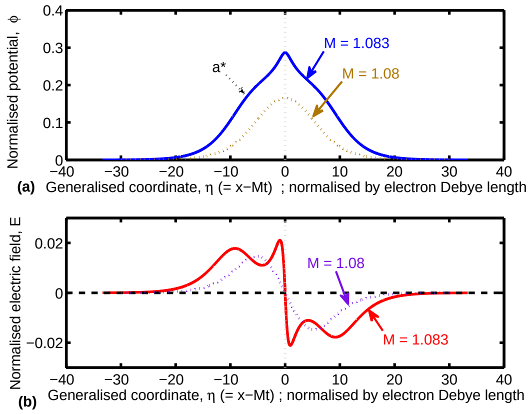

Figure 1: (a) Potential profile, (b) electric field profile of a compressive ion acoustic supersoliton and solitary wave in a two electron temperature warm ion plasma.

have any double layer associated with such transitions. We have further tried to find out whether such structures may be interpreted as a coagulation of more basic nonlinear structures, like a regular soliton and kink solutions. We have also explored the possibility of interpreting more complex ESWs observed in space by such novel type of solutions which has some extra folds, or wiggles, in their usual potential or electric field profiles.

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