Interpretation of non-conventional coherent structures in magnetospheric plasma system

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One of the natural laboratory for the study of solitary waves is the Earth's magnetosphere. The large gradient in particle properites at the magnetospheric boundary layers initiate the perturbation which leads to the generation of solitary waves. These structures propagate either parallel or perpendicular to the local magnetic field. The E-field bipolar structures moving parallel to the background magnetic field (Electrostatic Solitary Waves (ESWs)) are observed ubiquitously in different magnetospheric boundary regions. The satellite electric borne instruments recorded the signatures of ESWs as bipolar (two half sinusoids of opposite polarity), monopolar (one half sinusoid) and tripolar (two half sinusoids of one polarity with an intervening half sinusoid of opposite polarity) pulses in the Electric Field (E-field) data. High resolution satellite borne instruments, however, identified more kinds of composite and complex organized structures such as offset bipolar pulse (ofbp) (Fig. 1(a)) [1, 2, 3], paired monopolar pulse (mpp) (Fig. 1(b))[1] and wiggled bipolar (Fig. 1(c)) [4] E-field structures. For both an ofbp and an mpp, the distance between the two peaks are relatively large compared to the characteristic width of the each peak. The fine difference between an ofbp and mpp lies in the finite slope of the E-field connecting the two lobes for the former. An mpp, on the other hand, is a pair of two simple monopoles with opposite polarities while the slope of the electric field connecting the two poles goes ideally to zero. In case of wiggled bipolar pulses, it is characterized in having subsidiary peak in both positive and negative lobes of a smooth bipolar pulse.

Till date, none of the satellite expedition could identify the significance of these structures and they have remained mostly unnoticed for a long time. In spite of their sporadic reports and a strong indication that they may appear consistently and regular at different parts of the Earth's magnetosphere, the theory of such non-conventional E-field structures received a comparatively scant attention. This lacuna motivated us to explore a more generic interpretation for those structures.

In our work, two electron temperature warm multi-ion plasma which is quite significant in magnetospheric studies have been analyzed by using the conventional Sagdeev pseudopotential technique. Apart from the regular solitary wave solution, this model supports different kinds of extra nonlinear structures like Flat Top Solitary Wave (FTSW) and Super Solitary Wave (SSW). FTSW is characterized with a Sagdeev pseudopotential curve which meets the zero axis with almost a grazing incidence at the maximum amplitude [6] giving its potential profile a 'top hat' structure while SSWs are a new class of nonlinear structure which is characterized by having three local extrema between the undisturbed conditions and the amplitude [5]. After detailed analysis of the E-field and potential profile, it has been found that the analytically solved FTSW solutions and SSWs are consistent with the ofbp and the wiggled bipolar pulses, respectively. The proposed theory not only explains the unique morphology of the E-field data but also provide a more generic interpretation for those structures which are eventually correlating the mathematical description of a coherent nonlinear dynamical structure with the satellite observations.

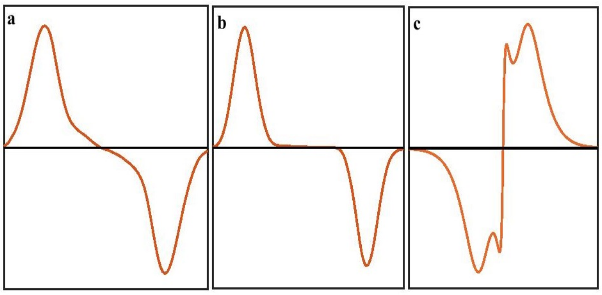

Figure 1. Schematic diagram of (a) offset bipolar pulse, (b) paired monopolar pulse , and (c) wiggled bipolar pulse

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