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A Nonlinear Fluid Model for Weak Double Layers and Electrostatic Waves in the Solar Wind

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Weak double layers (WDLs) and coherent electrostatic waves in the range of frequencies above the proton plasma frequency, f_{pi}, and smaller than or of the order of the electron plasma frequency, f_{pe}, have been observed in the solar wind at 1 AU. A soliton model, which treats the solar wind plasma as a fluid of hot protons and hot α particles streaming with respect to protons, and suprathermal electrons having a κ-distribution, is found to sustain slow and fast ion-acoustic solitons and double layers. The slow ion-acoustic mode is a new mode that occurs due to the presence of alpha particles. This mode can support both positive and negative solitons and double layers. The slow ion-acoustic mode can exist even when the relative streaming, U_0, between alphas and protons is zero, provided alpha temperature, T_i, is not exactly equal to 4 times the proton temperature, T_p. An increase of the κ- index leads to an increase in the critical Mach number, maximum Mach number and the maximum amplitude of both slow and fast ion-acoustic solitons. The fast ion-acoustic mode can support only positive potential solitons. The predicted amplitudes and widths of slow ion-acoustic double layers are found to be in an excellent agreement with the observed amplitudes and widths of WDLs. The fast Fourier transform (FFT) of the ion-acoustic solitons/DLs would produce a broadband spectrum with a main peak between 0.35 kHz to 1.6 kHz, and $E = (0.01 – 0.7)$ mV m^{-1} which are in excellent agreement with the observed electric fields $\sim (0.0054 – 0.54)$ mV m^{-1} associated with the low-frequency waves observed in the solar wind at 1 AU. It is proposed that WDLs and low-frequency coherent electrostatic waves, observed by *Wind* spacecraft in the solar wind at 1 AU [1], might be generated by the slow and fast ion-acoustic solitons and double layers.

1. A. Mangeney, C. Salem, C. Lacombe, J. L. Bougeret, C. Perche, R. Manning, P. J. Kellogg, K. Goetz, S. J. Monson, and J. M. Bosqued, “WIND observations of coherent electrostatic waves in the solar wind” (1999), *Ann. Geophys.*, **17**, 1999, pp. 307–320.