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Precursor solitons in a flowing complex plasma

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The subject of precursor solitons, namely nonlinear long-lived pulse excitations emitted in the fore-wake region of fast moving charged particles in plasmas have not received much attention in plasma physics although solitons have been widely studied for a long time. These excitations, that have been seen in the past in neutral fluid experiments, can occur ahead of supersonically moving charged objects or as fore-wakes when a supersonically moving plasma hits a charged stationary object. In this talk, we will report on the first experimental observation of precursor solitons in a flowing dusty plasma [1]. The nonlinear solitary dust acoustic waves (DAWs) are excited by a supersonic mass flow of the dust particles passing over an electrostatic potential hill. In a frame where the fluid is stationary and the hill is moving the solitons propagate in the upstream direction while wake structures consisting of linear DAWs are seen to propagate in the downstream direction. The experiments have been carried out in a U-shaped Dusty Plasma Experimental (DPEx) [2] device where kaolin particles immersed in a DC discharge argon plasma form a dusty plasma and a floating wire mounted on the cathode creates a potential hill. The dust flow is induced by sudden changes in the hill height and the solitary structures are seen only for supersonic flows and up to an upper limit of the flow. A theoretical model description of the phenomenon based on the forced Korteweg – de Vries equation is provided and physical implications of such precursor excitations in a variety of practical situations such as space debris detection [3], fore wake phenomena in solar wind interactions with planets and plasma heating in charged beam induced inertial fusion schemes are discussed.

References:

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