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Excitation of pinned solitons in a flowing dusty plasma

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Pinned solitons are a special class of nonlinear solutions that move with the same velocity as the forcing object and thereby remain pinned to the object. A well-known hydrodynamical phenomenon, they have been shown to exist in numerical simulation studies [1] but to date have not been observed experimentally in a plasma. We report experimental observations on the excitation of pinned solitons in a flowing complex plasma. The experiments are performed in a π- shaped Dusty Plasma Experimental (DPEx) [2] device (as shown in Fig. 1) where a DC glow discharge Ar plasma is created in between a disc shaped anode and a long tray shaped cathode. A dusty plasma is then formed using poly-dispersive kaoline particles. A floating copper wire mounted radially on the cathode creates a sheath around it in the plasma environment and acts as a charged object for the flowing dusty plasma fluid. The flow of dust cloud is initiated by lowering the potential of the charged object from ground potential and the flow speed is controlled precisely by connecting the wire from grounded potential to various intermediate potentials including floating potential.

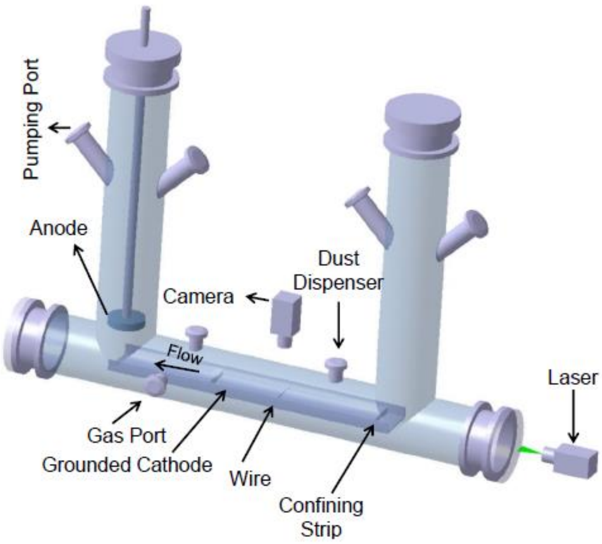

Fig. 1. A schematic diagram of Dusty Plasma Experimental (DPEx) setup.

It is found that for particular discharge conditions and critical velocities of the fluid flow, high amplitude non-linear pinned solitons get excited. The amplitude, width and number of the excited structures are studied for different flow velocities of the dust cloud. It is noticed that with the increase in the flow velocity, the amplitude of the stationary structures increases whereas the number increases from one, two to many (shown in Fig. 2). These solutions are distinct from previously observed non-stationary precursor solitons [3] and constitute a new class of driven nonlinear structures.

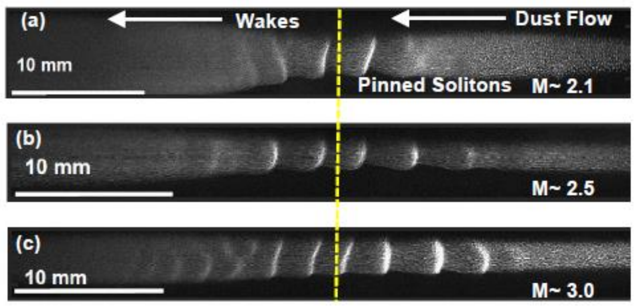

Fig. 2. Typical image of excitation of (a) double (b) four and (c) Many pinned solitons along with the wakes. The yellow dashed line represents the location of the charged object.

The experimental observations are compared with special solutions of a model forced-Korteweg de Vries (f-KdV) equation and found to be in good qualitative agreement. The potential applications of such excitations in the context of solar wind interaction with planets and satellite interaction with ionosphere plasmas are discussed.

References

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[2] S. Jaiswal, P. Bandyopadhyay, and A. Sen, Rev. Sci. Instrum. **86** ,113503 (2015)

[3] S. Jaiswal, P. Bandyopadhyay, and A. Sen, Phys. Rev. E **93,** 041201(R) (2016)