Experimental observations of fore-wake phenomena in between two charged objects in flowing dusty plasmas

Pintu Bandyophadhyay, Krishan Kumar, Swarnima Singh and Abhijit Sen

Institute for Plasma Research, A CI of Homi Bhabha National Institute, Gandhinagar, India

Fore-wake excitations ahead of a rapidly moving object in a fluid, a spectacular phenomenon in hydrodynamics that has often been observed ahead of moving ships or speed boats near the coast, has surprisingly not been investigated in plasmas where the fluid model holds good for low frequency excitations. Very recently, some of these fore-wake structures *e.g.* precursor and pinned solitons have been observed in laboratory dusty plasma experiments when the dust fluid is made to flow over a charged object [1-3]. An open and interesting question to ask is what will happen to these fore-wake structures when they are excited in between two charged objects in a flowing dusty plasma. To address this question, we have conducted experiments in an inverted Π-shaped dusty plasma experimental device in which the dusty plasma is created in a DC glow discharge argon plasma using micrometer sized kaolin particles [4]. Two copper wires at variable distances are installed radially on the cathode to serve as charged objects. A single gas injection technique is employed to generate a flow in the dust fluid. Precursor solitons and wake structures are excited by each of the charged objects when the dust fluid flows supersonically over them. In the frame of the fluid, the solitons propagate in the upstream direction, whereas the smaller amplitude wake structures propagate in the downstream direction. A soliton, excited by one of the objects, interacts with the wake structure generated by the other object in the region between the two charged objects. After the interaction, the amplitude and velocity of the soliton increases whereas its width decreases [5]. In another set of experiments, the wave gets trapped in between the wires when their separation is kept below a critical value of 2 cm [6]. For a long time (of the order of a few seconds), the trapped-wave structure retains its identity. The amplitude of the wave crests and the distance between them remain constant with the dust fluid flow velocities. A forced Korteweg-de Vries equation driven by two sources is used to model our experiments and its numerical solutions are shown to reproduce well the main features of our experimental results.

References:

1. Surabhi Jaiswal, P. Bandyopadhyay, and A. Sen, Phys. Rev. E, 93, 041201(R) (2016).
2. Garima Arora, P. Bandyopadhyay, M. G. Hariprasad, and A. Sen, Phys. Plasmas **26**, 093701 (2019).
3. Garima Arora, P. Bandyopadhyay, M. G. Hariprasad, and A. Sen, Phys. Rev. E, **103**, 013201 (2021).
4. S. Jaiswal, P. Bandyopadhyay, and A. Sen, Rev. Sci. Instrum., **86**, 113503 (2015).
5. Krishan Kumar, P. Bandyopadhyay, Swarnima Singh, and A. Sen, Submitted in Phys. Plasmas, (2023).
6. Krishan Kumar, P. Bandyopadhyay, Swarnima Singh, and A. Sen, Phys. Plasmas **29**, 123703 (2022).