Nonlinear Wave Excitations By Orbiting Charged Space Debris Objects

Abhijit Sen[1], Sanat Tiwari[1], Sanjay Mishra[1] and Predhiman Kaw[1]
[1]*Institute for Plasma Research, Bhat, Gandhinagar 382428, India*

The dynamics of inactive space objects consisting of dead satellites or parts of destroyed space crafts – collectively referred to as `space debris' - orbiting around the earth have become the subject of much current study in view of their potential threat to active space assets [1]. Since these objects are orbiting in a plasma environment they are likely to get highly charged due to the flow of electron and ion currents on them and due to other charging processes like the photoemission of electrons resulting from the exposure to solar radiation. Such a streaming charged object constitutes a forcing disturbance that is moving with a constant velocity through the plasma and we investigate the nonlinear excitations in the plasma that can occur in such a circumstance. Assuming the debris object to be moving faster than the ion sound speed, which is generally the case in the low earth orbit (LEO) region, and taking into account its charge density contribution in the Poisson equation, we obtain a model nonlinear evolution equation in the form of a forced Korteweg de Vries (fKdV) equation. This equation has been studied earlier in the context of shallow water waves [2,3] and shows a remarkable phenomenon of excitation of advancing solitary waves in the upstream region apart from weak dispersive excitations (wake fields) in the down stream region. The fKdV admits exact analytic solutions for a few specific forms of the forcing term and we present these as well as numerical solutions of the excited waves for arbitrary forcing functions. We discuss the possibility of exciting and detecting such waves in a laboratory set up as well as their relevance and impact for the dynamical study of orbital space debris.

[1] *"Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Program"*, National Research Council, Washington, DC: The National Academies Press, 2011.
[2] T.Y. Wu, *Journal of Fluid Mechanics* **184**, 75 (1987)
[3] S.J. Lee, et. al., *Journal of Fluid Mechanics* **199**, 569 (1989)