Preliminary Experiments on Soliton Generation and Detection in Simulated LEO Plasma for Orbital Debris Detection

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Operational satellites are continuously subjected to the threat of orbital debris impacts. Impacts from debris on the order of 0.5 mm to 1 cm can cause mission-ending satellite system failure. (Kessler and Cour-Palais, J. Geophys. Res., 83, 2637) While large pieces of space debris can be continuously tracked, it is impossible to optically track the millions of orbital debris objects that fall below the monitored space debris threshold (5-10 cm).

Orbital debris traveling at supersonic velocities in the naturally occurring plasma at low Earth orbit (LEO) will charge up to the plasma floating potential, and will cause plasma perturbations. These perturbations give rise to a nonlinear plasma wave phenomenon known as a soliton that will travel at velocities well above the plasma ion acoustic velocity, and ahead of the debris objects.(A. Sen et al., Adv. Space Res., 56, 429) Detection of these solitons traveling ahead of orbital debris may reveal the presence of otherwise undetectable, potentially lethal objects.

This talk will present the preliminary results of experiments producing and measuring these soliton waves traveling faster than the ion-acoustic velocity. The NRL Space Chamber produces a flowing background plasma simulating the plasma that orbital debris are subjected to in LEO. The generation of solitons is achieved by applying a voltage pulse to an electrode, and simulates the soliton that may be produced by movement of charged orbital debris through LEO plasma. Detection of the ion acoustic wave and associated nonlinear soliton traveling faster than the ion acoustic velocity measurements will be presented.
Detection of these precursor solitons could form the basis for an early warning/detection system or sensor allowing spacecraft to take necessary maneuvers for collision avoidance before experiencing a potential mission-ending collision.

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