Freak waves in negative-ion plasmas: an experiment revisited

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Extreme events in the form of rogue waves (freak waves) occur widely in the open sea [1, 2]. These are space- and time-localised excitations, which appear unexpectedly and are characterised by a significant amplitude (exceeding 2.5 times the average turbulence level in their environment). Beyond ocean dynamics, the mechanisms underlying rogue wave formation are now being investigated in various physical contexts, including materials science [3], nonlinear optics [4] and plasma physics [5], to mention but a few [6].

Inspired by the ubiquity of this challenging phenomenon, we have undertaken an investigation, from first principles, of the occurrence of rogue waves associated with the propagation of electrostatic wavepackets in plasmas. Motivated by recent experimental and theoretical considerations [7, 8], we have revisited a long-standing problem by focusing on the dynamics of plasmas incorporating negative ions, alongside positive ions and electrons. A multiscale technique is employed to solve the 2-fluid-Poisson system of equations. A nonlinear Schrodinger (NLS) type equation is shown to govern the amplitude of the vector potential. A brief review of existing theories based on non-stationary envelope solutions of the NLS equation is presented, and the variation of their structural properties with the relevant plasma parameters is investigated. This work complements our earlier investigation on electromagnetic rogue waves in plasmas [9, 10].

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