Nonlinear dust charge fluctuations in dusty (complex) plasmas: a Van der Pol-Mathieu model equation

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Dusty (or complex) plasmas are characterized by the presence of massive mesoscopic (micron-sized, typically) particulates ("dust grains"), which is known to modify plasma properties substantially. The electric charge which resides on dust grains is acquired dynamically and may fluctuate in time via a variety of charging processes [1].

In this brief report, the parametric excitation of dust acoustic oscillations due to dust grain charge fluctuations in a dusty plasma is investigated. A three-component model dusty plasma is considered, consisting of negative inertial dust grains (of constant size, mass and charge, for simplicity), in addition to a thermalized (Maxwellian) background of electrons and ions. By employing a fluid plasma description, and assuming a periodic fluctuation of the dust charge Q, a Van der Pol-Mathieu-type hybrid nonlinear oscillator model ordinary differential equation [2] is obtained for the dust number density. An averaging technique provides the framework for an analysis of the dust density evolution in time, via an analytical reduction to an autonomous set of equations for a slowly varying pair of perturbation amplitudes [3]. A phase-space analysis reveals the existence of a fixed point, whose stability is investigated. The phase space portrait is determined numerically, in terms of the interplay between the intrinsic dust plasma frequency $\omega_{d,p}$ and the parametric excitation (dust charge fluctuation) frequency ω_{df}.

References

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