A Mathieu equation for dust charge dynamics in multi-component dusty plasmas

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Dusty plasmas are characterized by the presence of massive mesoscopic (micron-sized, typically) particulates ("dust grains"), whose charge may vary in time via a plethora of charging processes [1]. Although the electric charge residing on the dust grains is often thought to be negative, due to the high electron mobility (compared to the ionic one), positive and negative dust coexistence is witnessed in space and laboratory plasmas [2].

In this brief report, the parametric excitation of dust acoustic oscillations due to dust grain charge fluctuations in a dusty plasma is investigated. A four-component plasma consisting of positive and negative inertial dust grains (of constant size, mass and charge, for simplicity), in addition to a thermalized (Maxwellian) background of electrons and ions is considered. By employing a two-fluid plasma description, and assuming a periodic fluctuation of the dust charge Q, a Mathieu-type nonlinear oscillator model ordinary differential equation [3] 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 [4]. 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 (charge fluctuation) frequency γ.

References

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