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Complex charged particle behavior in dusty plasmas and dust crystals: a new test-bed for nonlinear theories

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Dusty Plasmas (DP) (or *Complex Plasmas*) are large ensembles of interacting particles, consisting of electrons e^-, ions i^+ and massive, heavily charged, mesoscopic-sized defects, i.e. *dust* particulates d^- (or, less often, d^+). The presence of the extra *dust* species has recently been shown to modify the plasma properties substantially and allows for new charged matter configurations, including liquid-like and solid (quasi-*crystalline*) strongly configured phases. These aspects are briefly introduced, at a fundamental level, with emphasis on dust crystal configurations.

The nonlinear aspects of horizontal (longitudinal, acoustic mode) as well as vertical (transverse, optical mode) motion of charged dust grains in a (one-dimensional) dusty plasma monolayer, suspended in a plasma discharge under the combined action of gravity and electrical forces, are discussed. Different types of localized excitations, predicted by nonlinear wave theories, are reviewed and conditions for their occurrence (and characteristics) in DP crystals are discussed. Dust crystals are shown to support nonlinear *kink*-shaped supersonic solitary excitations [1], related to longitudinal (in-plane) dust grain displacement, as well as modulated *envelope localized modes* associated with either longitudinal (in-plane, acoustic) [2] or transverse (off-plane, inverse-optic) [3] oscillations.

Dust crystals consist a highly discrete system, *par excellence*. The occurrence of highly localized *Discrete Breather*-type excitations (Intrinsic Localized Modes) is briefly addressed, from first principles [4, 5, 6, 7]. This possibility opens new directions in nonlinear lattice dynamics– and dusty plasma physics– related research.

The relation to previous results on atomic chains as well as experimental results on strongly-coupled dust layers in gas discharge plasmas is discussed. The relevance of this research to strongly-coupled charged particle configurations, namely Ultracold Plasmas (UCPs) confined in Penning trap experiments [8], is pointed out.

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