COEXISTENCE OF SOLID AND LIQUID STATES IN A HARMONICALLY CONFINED DUSTY PLASMA

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Dusty plasmas have been long employed as a testbed for studying wave and transport processes, phase transitions, and general kinetic phenomena in solids and liquids. The unique properties of a dusty plasma which lie in its thermodynamic openness, dissipativity, and nonreciprocity of particle interactions under certain conditions lead to the complexity of its phase diagram. Up to date, a phase diagram of dusty plasma systems is often limited to the model approach of strongly screened Yukawa particles.

In the present work, we focus on the effect of electrostatic confinement, wake interaction, and structural nonuniformity [1, 2] on the scenario of a phase transition in a dusty plasma system. In the simulations, two types of experimental dusty plasma structures are considered: a "pancake"-like structure, which is denoted as a monolayer, and a structure with a complex geometry that has a 3D central section and a quasi-2D peripheral section. Nonreciprocal interaction of particles is calculated by two methods: via the widely used point-wake model and via the potential obtained from the kinetic equation for electrons and ions of plasma and a dust particle [3].

We show that both in the monolayer and in the structure with 2D and 3D sections the stationary coexistence of the liquid central part and the solid peripheral part is observed. This is, first, due to the spatial nonuniformity of the systems arising from the action of confinement and, second, due to the nonreciprocal character of particle interactions which leads to the development of wave instabilities. Analysis of instabilities leading to the melting of the central section is provided. Local melting criterion is formulated that allows identifying the melting conditions for each separate subsystem of a dusty plasma structure. Obtained results are important for the theory of phase transitions in dusty plasmas and reveal similarities between dust particles and active agents in active matter [4].

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