Two-dimensional Melting of Dust Crystal in Plasma: Simulations, Diagnostics and Experiments

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The charged dust system represent a non-neutral or quasi-neutral systems (dusty plasmas) containing micron-sized particles of a substance with electrical charges up to 10^2-10^5e. As a result of strong interaction, the dust particles may form the ordered structures of liquid and crystal types. The laboratory dusty plasma is the unique object for studying the structures, phase transitions and transport phenomena on the "kinetic level".

Here we present the new results of the study of the phase transition in two-dimensional crystallike dust structures suspended in plasma.

Two-stage melting is observed experimentally in a confined monolayer of dust particles under their "kinetic" heating in weakly ionized rf discharge plasma. The experimental results have revealed the existence of hexatic phase as well as solid-to-hexatic phase and hexatic-to-liquid transitions. The pair correlation and bond-angular correlation functions, the number of topological defects, the pair potentials and the excess entropy are measured and analyzed. The spatial distribution of pair interparticle interaction forces was recovered by the original method based on solving the inverse problem using Langevin equations. The bond-orientational correlation functions show a clear solid-to-hexatic-to-fluid transition, in perfect agreement with the Berezinskii-Kosterlitz-Thouless-Halperin-Nelson-Young theory, and the ensemble's entropy demonstrates sharp change around transition. The measured phase-state points with the theoretical phase diagram of two-dimensional Yukawa system have been obtained.

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