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STRONGLY COUPLED COULOMB SYSTEMS OF CHARGED DIAMAGNETIC PARTICLES IN NONUNIFORM MAGNETIC FIELD: LABORATORY AND MICROGRAVITY EXPERIMENTS

Abstract

Studies of strongly coupled Coulomb systems (SCCS) have a considerable interest in various fields of science and technology. Using such structures of charged dust particles, one can investigate the processes of phase transitions, waves, and instabilities on kinetic level. For confinement and investigation of strongly coupled systems of charged dust particles, we propose to use a trap based on the known possibility of the levitation of diamagnetic bodies in a nonuniform steady-state magnetic field. The experiments in laboratory were performed with setup that consisted of dc electromagnet, probe for dust charging, illuminating lamp and CCD camera for registration of particles position and motion. The particle material was graphite with a value of diamagnetic susceptibility of -0.000003 cm3/g. The particle's sizes were varied from 10 mcm to 1.5 mm. In the gap between the electromagnet poles the steady magnetic field was generated with gradient of 10 T/cm. The volume of the region of stable levitation was about 2 mm3.

The levitating particles were charged using an electric probe. Experiments revealed that few particles (with size about 100 mcm) remained in the region of levitation and formed a stable Coulomb cluster. Under microgravity conditions the region of stable levitation might be substantially expanded. For the investigation of Coulomb clusters of diamagnetic particles in nonuniform steady-state magnetic field the experimental setup with the region of stable levitation about 400 cm3 and magnetic field gradient of 0.1 T/cm was produced. Preliminary experiments were carried out on the board of International Space Station with carbon particles with sizes of 100, 200, 300 and 400 mcm in the argon under atmospheric pressure. The preliminary analysis of the experiments allowed us to determine the formation of large cluster of carbon particles in the magnet trap: a number of particles in the cluster was about 2000. From the balance of electrostatic and magnetic forces the dust charges were evaluated. The charge value for the particles with size of 300 mcm was 200000 e under particle surface potential of 1 V. This work was supported by the Research Program of the Presidium of the Russian Academy of Sciences “Thermophysics and Mechanics of Extreme Power Actions and Physics of Highly Compressed Matter” and by the Russian Foundation for Basic Research, Project No. 10-02-90056 and Project No. 10-02-01428.