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Experiments of Fine Particle Plasmas under Microgravity

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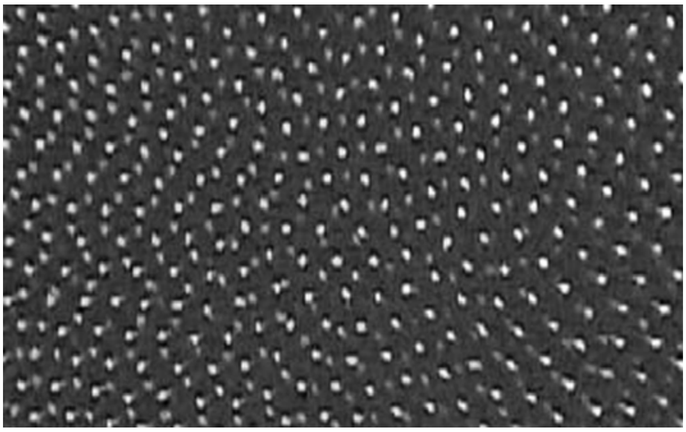

Fine particles in a plasma are highly negatively charged because of the difference in mobility between electrons and positive ions. Since they show behaviors like macroscopic molecular systems, phase transitions can be observed in them. If an attractive force exists between fine particles or a coagulation force exists among them along with their own Coulombic repulsive force, critical phenomena can be observed in fine particle plasmas. The possibility of the observation has been theoretically predicted by two different analyses recently. One is based on the existence of an attractive force between fine particles and the other is based on the model of one-component plasma. The experimental verification of the existence of critical point in a fine particle plasma was interested in the researchers of fine particle plasmas.
Researches on fine-particle plasmas, which are defined as plasmas containing a large amount of negatively charged fine particles, have been actively studied, especially since 1990s, because they are related to interesting and novel physical phenomena as well as serious problems of dust removal in plasma processing. The discovery of crystallization of fine-particle plasmas in 1994 accelerated the research from the viewpoint of solid state physics, like crystal structures, phase transition, lattice vibration, and so on, as describe above. The advantage of analyses of such physical phenomena by fine-particle plasmas is easy observation of behavior of each particle. Particles can be observed by laser light scattering using a CCD camera because their inter-particle distances are in the order of hundred microns.
Their behaviors are affected by the electrostatic force and the ion drag force in a plasma. Under the gravity condition, the gravitational force pulls them downward, and thus they are suspended at the point of balance of the three forces. Consequently, grouped fine particles are arranged in a lower region in a radio-frequency (RF) plasma generated between horizontal parallel plates. If gravitational force is neglected compared with the other two forces, it is expected that fine particles are pushed into plasma and may form a three-dimensional Coulomb crystal around the center of it. However they were pushed outward near the boundary of plasma forming a void. The reason is believed to be that ion drag force surpasses electrostatic force in a plasma. The investigation of the behavior of fine particles under gravity and microgravity is expected to supply helpful information to control their behavior and ordering along with to develop a new fine-particle plasma system.
In this presentation, the structures of Coulomb crystals, the forces acting on fine particles, and the formation of the void are shown mainly by experimental results, as well as the results under microgravity conditions using a drop tower, parabolic flight, and the international space station

are presented.

Keywords: fine particle, plasma, dusty plasma, microgravity, international space station, phase transition