Experiments and simulation on multi-component strongly coupled plasmas

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Strongly coupled plasmas (SCP) consist of multi-component ions are known to exist in core of Heavy planets and crust of neutron stars. It is important to know the structure of multi-component SCP (MSCP) for studying nuclear reaction rate in high density stars. We report experiments and simulations of MSCP by using charged particles confined in insulating oil.

Simplified MSCP system is established by charging fine particles using an external voltage and confining in the insulating oil with DC electric field.

This system does not suffer from the complexities such as effect of electron shielding and plasma flow in the plasma dust. The experimental set-up is shown in Fig.1. The DC voltage of few kV is applied on the parallel plate where the lower and upper electrodes are made of sus and ITO coated glass.

The silica fine particles of diameters 3, 5, 10, 15micrometer are placed on the lower electrode and charged up by the DC voltage. The charge of the particles is proportional to (diameter of particle)ˆ5/2. For the harge of the 15micrometer particle ˜3x10ˆ2 electron charge. The fine particles composed of two different diameters are charged up and go upward and toward center by the electric field and finally confined at the surface of the oil by the surface tension to form 2 dimensional SCP. For the case of 5 and 10micrometer mixture of the particles, each component, they are segregated and the each components form their own crystal structures (Fig.2). The structures of MSCP have been investigated based on the energy principle of the static states, however it is unknown whether those structures can be achieved or not by the particle dynamics. Here, we treat the dynamic process of the structure formation of MSCP by a computer simulation. When the particle of larger charge (larger diameter) is accumulated in the center of the confinement potential, the static potential energy of the mixture system become lower.

Therefore, we put initially 5micrometer particles at the center region and 10micrometer surrounding and calculate the time behavior of the particles as shown in Fig. 3(a). It is observed that the 5micrometer particles flow out and those mixture tends to segregate. However, in some region, the smaller particles are surrounded by the larger ones and stay longer time. The detailed comparison between simulation and experiments are now underway.

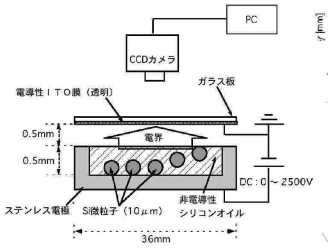


図１　油液中の荷電粒子閉じ込め

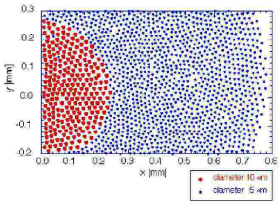
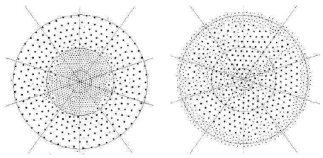


図２　24 時間後の 5,10μm 直径の微粒子の分布



(a)初期分布　(b)時間経過後の分布

図３　粒子シミュレーションによる 5,10μm 直径微粒子の混合分布