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Preliminary Experiment on Dust Critical Phenomena by Using High Density Plasma
高密度プラズマを用いた微粒子プラズマの臨界現象実験

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Yukawa particles in ambient neutralizing plasma are known to show a critical behavior where the inverse isothermal compressibility vanishes predicted by Totsuji. To reveal the critical point in the dust plasma, it is preferable to have electron density of $10^{10-11}cm^{-3}$ [1-2] as is higher than that in conventional experiments. We developed to create relatively high density plasma by using surface magnetic field confinement system. We obtained electron density of more than $10^{10}cm^{-3}$ with hollow density profile. The dust density fluctuation measurement in the plasma is now under way.

1. Introduction

Dust plasmas are one of Yukawa one-component plasmas (OCP) and are have been need to study fundamental phenomena caused by long range inter-particle interaction such as Coulomb solidification [3-4].

Liquid-solid phase transition in Yukawa OCP has well studied by colloid and dust plasma experiments, but recently critical phenomena in liquid-gas plasma in dust plasmas are studied theoretically by Totsuji [1-2]. It is predicted to observe the critical point where the inverse isothermal compressibility vanishes, in the electron density range of $10^{10-11}cm^{-3}$, which is higher than that in conversional dust plasma experiments. (The example of critical parameters around $n_e = 10^{10-11}cm^{-3}$: degree of defilade ξ=5, a particle diameter $r_p = 1\mu m$, electron density $T_e \sim 3eV$, ion density $T_i \sim 300K$) We developed to obtained the electron density of less than $10^{10}cm^{-3}$ with hollow density profile, which is needed to confine three-dimensional dust particles, by using surface energetic confinement system, (SURMAC) [5]

2. Experimental set-up

The SURMAC plasma system is shown in Fig.1. The chamber of inner diameter $R_0 = 94mm$ and height $h = 218mm$ is surrounded by 12 around of samarium cobalt permanent magnets. Permanent magnets column are arranged with alternative pole to have mirror field near the wall of the chamber. Magnetic field strength profile in the horizontal cross section of the chamber is shown in Fig.1 (b). The magnetic field strength at the inner chamber surface is $15kG$ and $10G$ of $r = 20mm$. RF antenna consists of 6 rods along the axis of the chamber and are placed at $r = 38mm$. RF current is fed by the power supply of 13.56*MHz*, 1kW to produce inductively coupled discharge. The dust particles are fed from the top of the chamber and the radial density profile is measured by Langmuir probe confined by the concave shaped electrode where DC voltage can be applied.

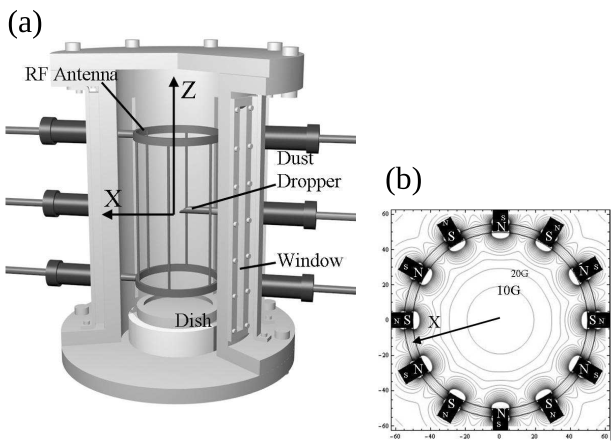

Fig.1 (a) Schematic of RF discharge device.

(b) Arrangement of permanent magnets and magnetic field strength contours in the horizontal cross section Z=0.

3. Preliminary experiment on RF discharge

Plasma is produced by the RF inductive electric fields near the antenna and confined by the strong surface magnetic field near the chamber wall. Examples of the radial electron density profile for Ar gas pressure of 1mTorr, RF power of $1kW$ and 350W frequency of 13.8*MHz* are shown in Fig.2. The hollow density profile obtained have us due to the plasma loss than the top and bottom plate of the chamber where no permanent magnets are placed. The hollow density profile is designed to have three-dimensional dust structures.

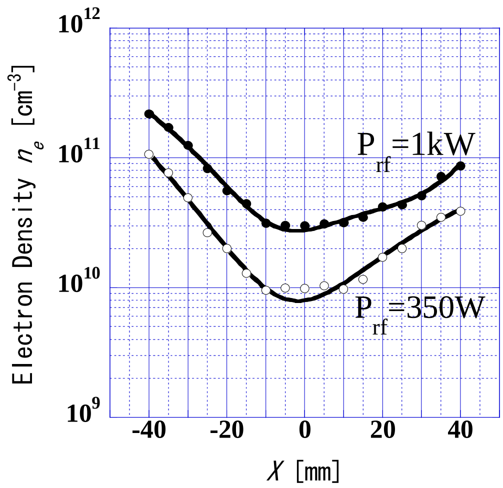

Fig.2 Radial electron density profiles. $f = 13.8MHz$, Ar gas ($1mTorr$).

References

[1] H. Totsuji: Plasma Res., Vol.3, 046 (2008) .

[2] H. Totsuji: Phys. Plasma, **15**, 072111 (2008)

[3] Y. Hayashi: J. Vac. Sci. Technol., A **18** (2000) 938.

[4] Lin. I: J. Vac. Sci. Technol., A **19** (2001) 2373.

[5] Y. Wong, Y. Nakamura, B. H. Quon, J. M. Dawson: Phys. Rev. Lett., Vol.**35**, 17 (1975)