Generation of dusty plasma with polarized dust particles under ultra violet irradiation

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It has been investigated that surfaces of artificial satellite in space become positively or negatively by space plasma and the strong ultraviolet light from the sun. For the active photoelectron emission under the irradiation environment of the strong ultra-violet ray from the sun, irradiated surface of object would be possible to be charged positively. Then, it is considered that the surface charge distribution and spatial potential around the object should depend on the electrical characteristics of the object, such as conductor or insulator. In the case of insulated object, irradiated surface of object can take a positive charge by the photoemission, as the result, the polarity of the charge and spatial potential around the object is reversed in the irradiated side and non-irradiated side of the object. It should be possible to produce the dusty plasma composed of polarized charged dust particles by UV light irradiation to the insulator dust particles in the laboratory plasma. It is considered that polarization of dust particles affect on the Coulomb interaction, dust structure and the interaction between dust particles and ion flow, which are derive generally from the assumption that dust particle is point charge. In this work, we tried generation of the dusty plasma to be an aggregate of electric dipole by irradiation of ultra violet light and observation of the dynamics of polarized dust particles.

One-turn and two-turn RF internal copper antenna (d = 18 cm and 16cm) is located the center of the stainless chamber. RF power supply at 13.56 MHz is applied to the antenna with the matching network. When the RF power is 40W and Ar gas is 5 - 8 Pa, typical plasma parameter were Ne = 10^7 - 10^8 cm^-3, Te = 3 - 5 eV and plasma potential Vs = 5 - 10 V. Negative biased electrodes composed of the disk electrode and ring electrode (90 mm in diameter, 10 mm in distance between electrodes.) were located below the height of 13 cm from the RF antenna for levitation control. The negative voltage is applied to the disk and ring electrode independently (Vdisk= -60 - 0V, Vring = -90 - 0 V). Ultraviolet light emitted by the deuterium DC discharge lamp (30W, 150W) and ultra-violet LED (UV-LED). The light of deuterium lamp is converged by the fused quartz lens which was installed in the vacuum, and is irradiated from the horizontal direction of levitated dust particles. And UV-LED was located in the disk electrode below the height of several mm from trapped dust particles. The observation of dust particles was carried out using the charge coupled device (CCD) camera with the microscopic lens, imaging the scattered light from the dust particles by He-Ne and semiconductor laser which was expanded vertically. Dust particles (10 micrometer in diameter, acrylic resin) were provided from a dust feeder located at 30 mm up from the RF antenna, and levitate in the RF ion sheath around the negatively biased electrode.

In case of the experiment using the two-turn antenna, the filamentary structure of dust particles was found in the levitating dust cloud. The vertical arrangement of the fine particle was observed in the upper part, and in the bottom part, the dust particles have irregularly lined up. Inter-particle distance is 0.7 - 1.0 mm in vertical direction, and 1.0 - 1.5 mm in horizontal direction, and length of dust particles column is about 10 mm. Particles in vertical neighborhood move with the correlation, and it is indicated that dust particles are strongly coupled to vertical direction. The change of the dust particles by the incidence of the ultraviolet light using deuterium lamp (30W) and UV-LED was not observed, It seems that the strength of irradiated UV light is insufficient to polarize the dust particles. Experiments using the stronger ultraviolet radiation and the more precise observation are necessary in order to clarify the effect of the ultraviolet light.