Experimental System Using a Chamber-type μG Drop-shaft Orientated to Reproduce Elemental Dynamical Processes of Solid Particles Expected in Astronomical Condition

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It was recently reported that field-induced rotation and translation is commonly expected to occur on a single millimeter [1] and sub-millimeter [2] sized diamagnetic grain by a static field below B = 1T, in a diffuse μG condition. The motions are independent to mass of grain because the motions are induced by magnetic volume forces that derive from individual atoms that compose the grains. Field-induced motions of ordinary solid, free of spontaneous moment, has not been recognized previously at such low field. The motions were observable by introducing a short μG drop-shaft (μG duration > 0.5 s), which was realized by adopting a pair of small Nd-Fe-B plates (3 x 1 x 0.5 cm) as a field generator.

By using the above-mentioned apparatus, the reproduction of various elemental (rotational and translational) processes of dust particles that are expected in space and planetary science becomes possible in an ordinary laboratory. Inter- and circum-stellar magnetic fields are usually determined from the starlight polarization in the visible and infrared region; the polarization is caused by magnetic alignment of the dust particles with geometrical anisotropy [3]. The origin of dust alignment has been explained by various models based on different elemental processes, such as the "paramagnetic relaxation-", a "pinwheel-" ,a "Langevin process-" or a "radiative torque-" model. Existence of super-paramagnetic or ferromagnetic inclusions was proposed as positive factor to increase the efficiency of the above-mentioned processes. In order to examine the efficiency of the model based on the Langevin process, oscillation of magnetically stable axis with respect to the magnetic field direction is newly observed for sub-millimeter-sized crystals of apatite, calcite and α-quartz in the present report. The observed period of oscillations were consistent with those expected from applied field intensity, diameter of crystal and anisotropy of diamagnetic susceptibility, $\Delta\chi_{DIA}$. The present technique established for sub-mm sized crystal is a step to detect the movement of μm-sized grains. The observations are desired as well on the elemental processes assumed in other models on dust alignment.

The result of above-mentioned field-induced translation is applicable in identifying the micron-sized grains or regolith collected at the surface of asteroids, planets and satellites. In such missions, a simple and non-distractive method to identify the material of a particle (without consuming sample) is desired at the first stage of studying the collected grain ensemble. Such method has not been established as yet. The technique is useful in the search of new types of pre-solar grains as well. The process of translation may play a supplemental role in the movement of solid particles in galactic space, since both diamagnetic grains and magnetic field are omnipresent in various inter- and circum-stellar regions.

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[3] Spizer "Physical Properties in the Interstellar Medium"1978. [4] Uyeda, C. et al, *EPS*, 62, 99, 2010.