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Characterization of single grain sample realized by magnetic ejection and rotation observed in microgravity

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Abstract
Development of a simple and nondestructive method to characterize single grain particles is desired in various field of material science, including earth science. We propose a new method of characterization that is based on magnetization measurement of a single small particle. For this purpose, field-induced translation and rotation of submillimeter-sized quartz, calcite and forsterite was observed for the first time in microgravity condition that was produced in a drop capsule. Preliminary experiment on free translational motion due to repulsive field-gradient force was recently observed for corundum in micro-gravity (1). In a given field gradient B(dB/dx), acceleration of translation was uniquely determined by magnetic susceptibility of corundum (2).
A permanent magnetic circuit (NEOMAX X- 1466) was used as a field generator, which produced homogeneous field in an area of 1.5cm in diameter at the center of pole pieces. The samples prepared for rotational oscillation was set inside the homogeneous area, while initial sample position of the translation experiment was set just out side this area. Microgravity experiments was performed at MGLAB (Micro Gravity Laboratory of Japan, Toki, Gifu, Japan)(3). The dynamical motion of sample was recorded by a high-vision video camera.
The measured results are analyzed in terms of simple motional equations. It was expected that, in a given field distribution, velocity of sample at an arbitrary position was uniquely determined by intrinsic susceptibility of sample and field intensity of the sample position. Therefore, velocity and B were measured at several sample positions in a single observation. Linear correlations were obtained between the two parameters for the measured samples, and values of susceptibilities that were determined from the gradient of the linear relationship agreed with published data(2). Accordingly, efficiency of measuring susceptibility by this method was confirmed. To the best of out knowledge, field-induced translational and rotational motion of ordinary solid material, free of spontaneous moment, does not appear in previous literatures. At present, dynamic motions of solid induced by a magnetic field are publically recognized only for materials that contain spontaneous magnetic moments; the effect is familiar by magnetic separation of magnetite grains.
From the values of susceptibility and anisotropy obtained from the above two motions, characterization of a small grain can be carried out. This is because each material posses different intrinsic susceptibility and anisotropy, as is seen in a data book that compiles the published data (2). The susceptibility observed in the present work ranged between 2x10E-7 and 5x10E-6 emu/g ; almost all the published values of organic and inorganic distribute within this range (2). Hence identification is possible for natural material in general. It is deduced from the motional equations that measurement can be realized on limitlessly small sample in principle without consuming the sample, since the method are free of sample holder and mass measurement; these factors are inevitable in conventional methods performed in terrestrial gravity. Magnetization data of individual fine particle is expected to provide useful information on the distortion of crystal structure that is considered to occur on fine particles; the degree of distortion is expected to increase with reduction of particle size
References (1) K. Hisayoshi, S. Kanou and C. Uyeda: J. Phys. : Conf. Ser., in press. (2) R. Guputa:

Landort Bornstein New Series (1983) 445. (3) T.Iwakami and M.Nokura: J.Jpn.Soc.Microgravity Appl. 23 (2006) 186. (4) C.Uyeda submitted.

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