Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SEM032-01 Room: Exibition hall 7 subroom 2 Time: May 25 09:00-09:15

Magnetization data of single small particle obtained by magnetic ejection and rotation observed in microgravity

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Necessity of clarifying magnetic properties of a single particle is increasing with the growing interest on nano-sized materials, in the field of both natural and industrial research. As it is well known, reliable data of magnetic susceptibility and its anisotropy are required to characterize magnetic property of a material However, in conventional methods, performed in normal gravity condition, measurements of these values are difficult on a small particle due to the following 2 factors, the existence of a sample holder, and the necessity of mass measurement. In a measurement of diamagnetic magnetization using a conventional apparatus, interference of background signal emitted from the sample holder became serious when the sample size was smaller than 1 mm in diameter. Mass measurement of sample became difficult when mass was below 10 micro grams.
Dynamic motions induced by static magnetic field, produced by a Ne-Fe-Co permanent magnet, have been reported recently on mm-sized crystals isolated in a diffused gas medium with negligible velocity(1); here the crystals were released in microgravity produced by a drop capsule (3) (duration of microgravity 4.5 s). An isolated diamagnetic crystal was translated by field gradient force along a direction in which field decreased monotonously. Whereas, a paramagnetic crystal translated in a direction which field intensity increased. In a given field distribution, velocity of the crystal uniquely depended on intrinsic susceptibility of material; the velocity is independent to mass of particle. Rotational oscillation of magnetically stable axis of crystal was observed for various dia- and para-magnetic crystals. In a given field intensity, period of oscillation was determined uniquely by intrinsic magnetic- anisotropy of crystal and diameter of sample; the period was independent to mass of sample. Field-induced translational and rotational motion of ordinary solids that do not contain spontaneous moment cannot be found in previous literatures. The motions are recognized only for materials that contain spontaneous magnetic moments. In a long duration of microgravity, the two motions are observable for solids substance in general at low field intensity.
Attempt to reconstruct magnetization curve is reported in the present work. M-B relationships are obtained for sub-millimeter sized sample of forsterite that had different Fe concentration. The curve was obtained as well for single crystal of magnetite and nickel. The method performed in microgravity is free of both sample holder and mass measurement. The methods are based on motional equations composed only of an inertia term and a magnetic term with no interference of viscous term or a sample holder (4). Accordingly magnetization curve is measured for limitlessly small sample, in condition that the motion can be observed. Lower limit of measurable sample size depends on spatial resolution of the HV video camera which is presently about 20 micron, which can be reduced to several microns by introducing an optical microscope. The mass independent property of field-induced translation is examined by varying crystal sizes. The detection of diamagnetic susceptibility will be realized for a single diamagnetic grain that has a size below 0.1 cm in diameter. Precise data of individual particle may provide information on the distortion of crystal structure that is expected to occur on small particles; the degree of distortion is considered 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.

Keywords: magnetic ejection, magnetic rotation, magnetization, nano-sized material, microgravity, single small particle