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Saturated Magnetization of Single Grain Obtained from Field-Induced-Translation in a Chamber Type Micro-G System

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A new technique to obtain precise value of saturated magnetization Ms of a single small particle is required in various field of magnetic science. For example, the magnetic structure of pre-solar magnetite, recently indentified form the IDP samples, are expected to provide information on the magnetic field structure at the time of super-nova explosion. Magnetization data of individual micron-sized Fe-Ni grain embedded in the primitive meteorites may preserve information of the field intensity at the stage of their formation.

A method to detect Ms of small grain is newly proposed and experimentally examined; the method is based on field-induced translation of the grain which was released in diffused (about 100 Pa) microgravity space. The released samples translated in the direction of monotonously increasing field by field-gradient force.The sum of kinetic and magnetic energy is conserved between any two different positions, denoted as position-i and ?j. The above-mentioned conservation is described as $(1/2)mv_i^2$-$mMsH_i$=$(1/2)mv_j^2$-$mMsH_j$. Here v_j, and H_j denote sample velocity and field intensity at position-j, respectively; m and Ms denote mass and saturated magnetization per unit mass of the grain, respectively. The Ms value was obtained from the gradient of a linear correlation between many sets of (v_i^2-v_j^2, H_i-H_j) data obtained between two different sample positions -i and -j. The MS values obtained by the above manner agreed fairly well with the published values for millimeter sized grains of Fe and Ni metal. It was also confirmed from the observation that amount of various energy losses caused, for example, by viscous drag from the gas medium was negligibly small compared to kinetic and magnetic energies.

In previous reports we have observed field-translation of various diamagnetic and paramagnetic grains, confirmed that their kinetic energy and magnetic energy were preserved as well during the translation [1]. Accordingly the present result on ferromagnetic materials indicated that the energy conservation rule is confirmed throughout the major 3 types of magnetic materials. It is noted that the above translations are all independent to mass m of particle, because the translations are driven by a magnetic volume force originating from individual atoms(or molecules) that compose a material. If the translation of particle is observable, its magnetization is obtainable irrespective of sample size. Using a conventional apparatus, detection of magnetization becomes difficult for a single small sample, because of the difficulty of mass measurement and because of interference of sample holder (noise signal etc).

Conventional micro-G facilities are not suitable for a routine analyzing process because they require a long machine time and high running feet for a single turn of experiment. In the present work, a chamber type drop shaft was introduced to apply a short duration of micro-G ($t < 0.5$s). Accordingly, the above-mentioned translation was observable in an ordinary laboratory chamber. In order to realize the compact system, the size of the measuring system was reduced to ~25cm in diameter (30kg in weight) by introducing a coupleof NdFeB magnetic plate as a field generator. Because of its simplicity, the compact drop shaft was recently adopted in an educational program at a senior high school; here residual-G was diminished by introducing a 2 fold capsule[2].

[1] C.Uyeda et al: Jpn. Phys. Soc. Jpn. 79, 064709 (2010)

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