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磁場誘導型自由運動に基づく単一ダストの非破壊分析
Nondestructive analysis of single dust particle based on observation of free magnetic motions in microgravity

植田 千秋 [1*], 久好　圭治 [1]
Chiaki Uyeda[1*], Keiji Hisayoshi[1]

[1] 大阪大学大学院理学研究科宇宙地球科学専攻
[1]Graduate School of Sci. Osaka University

It is expected that the ensemble of dust samples collected by various space missions are generally mixture of various primitive grains which have different origins. For such samples, it is desirable to identify the material of individual grain by a simple and non-destructive method, before performing various refined analysis, such as isotopic, chemical or optical analysis. The situation may be the same for the grain materials that compose the primitive meteorites.

A new principle to identify the material of a single grain is proposed, which is based on magnetic susceptibility data obtained from magnetically induced translation of the grain; when solid grain is released in an area of magnetic field-gradient with negligible initial velocity, a translation caused by field-gradient force is induced on the grain; here the field is located in a micro-gravity condition. In general, every material possesses an intrinsic value of magnetic susceptibility, and the values are compiled in a data book [1]; hence the material of a solid particle is directly identified from the measured susceptibility data.

Previously, the above translation was observed in a large-scaled facility of microgravity for millimeter sized crystal of corundum, diamond, forsterite, MgO and graphite [2][3]. It was deduced from motional equation that acceleration of translation is independent to mass of particles; it uniquely dependent to intrinsic susceptibility assigned to the material, in a given field distribution. Value of susceptibility was obtained from observed acceleration, which agreed well with published values [1]. The measurement was free of a back ground signal of a sample holder; it does not require mass measurement. This means that, in principle, susceptibility is obtained for samples with a limitlessly small size, provided that motion of sample is observable [2]; material identification is also becomes possible for these grains. Specific translation due to magnetic field has not been recognized before for ordinary diamagnetic solid particles; at present, such motions are publically recognized only for materials that contain spontaneous magnetic moment.

Observation of the above translation was extended to micron-sized samples in the present work for the purpose of developing a practical system to identify the above-mentioned primitive grains. The mass independent properties are examined by varying the grain size of the measured materials between 5mm to 0.05mm in diameter.

In general, the conventional facilities of microgravity require long machine time and large running cost. Hence they are not suitable for a routine analysis such as the present measurement of susceptibility. Hence compact microgravity system was newly developed, which can be introduced in an ordinary laboratory. The length of the drop shaft is 1.5m, and the duration of microgravity was 0.62 second. The compact system was realized by designing a small NdFeB magnet circuit. Maximum field intensity of the circuit was 0.7 T at field center. It is noted that this compact apparatus will be the basis to construct a system that can be loaded on a space probe to investigate dust particles. At present, size of system can be reduced to 100 cmˆ3 (2x5x10) in volume, and 1 kg in weight. Specific problems in loading the system in various space missions will be discussed.

[1] K. Hisayoshi et al: J.Phys.: Conf. Ser., in press. [2]C.Uyeda et al: J.Phys.Soc.Jpn. (2010) 79 064709　[3] R. Guputa: Landort Bornstein New Series II (1983) 445.

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