A Study on Paramagnetic Anisotropy of Amorphous Silicate Particle Orientated to Solve the Mechanism of Dust Alignment in the Dense Regions

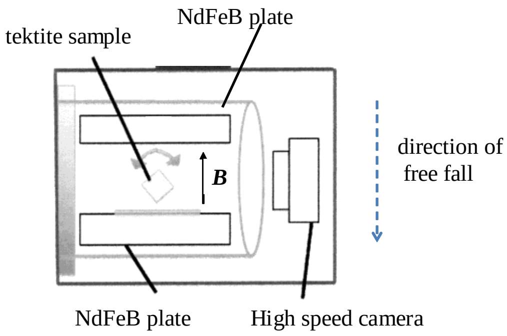
C. UYEDA, M.YOKOI and K. HISAYOSHI

Institute of Earth and Space Science, Graduate School of Science, Osaka University

According to the observed results of infra-red emission, the majority of dust particles in the dense regions are composed of non-crystalline silicates along with various types of rock forming crystals. The cause of dust alignment is not clear as yet in the dense region, since the conventional Davis-Greenstein theory is not effective in a condition where dust and the gas are in a thermal equilibrium state. An model was proposed to solve the mechanism of alignment in this region, which was based on a simple balance between rotational Brownian energy $½k_BT$ and magnetic anisotropy energy $½m\Delta\chi B^2$; m and $\Delta\chi$ describes the mass and anisotropy of susceptibility per unit mass of dust particle, respectively [1]. Previously the above model was considered only for the crystalline dust particles, because amorphous material was generally considered to bear an isotropic magnetization. In the present study, anisotropy of paramagnetic susceptibility $\Delta\chi_{PARA}$ is detected on a sub-millimeter sized tektite (Moldavite, Czech Republic), which is a typical amorphous silicate produced in nature. The tektite samples were formed into rectangular plates (0.5 x2.0 x 2.0 mm); with the plate being parallel to the surface of the bulk tektite sample. An uni-axial anisotropy of $\Delta\chi_{PARA}$ = (7±3)x10^{-7}emu/g was obtained for the tektite plates; the surface plane of the bulk sample was identified as the easy plane. In order to examine the origin of the observed magnetic anisotropy, electron spin resonance (ESR) was carried out on the same tektite plate used in the $\Delta\chi$ measurement. A clear variation of g-value with respect to applied field direction was observed, which was consistent with the properties of $\Delta\chi_{PARA}$. It was confirmed that $\Delta\chi_{PARA}$ derive from the anisotropy of the molecular field of a Fe. ion. Based the obtained $\Delta\chi_{PARA}$ value, the practicability of the above-mentioned model is quantitatively examined for all the types of dusts identified in the dense region. The cause of $\Delta\chi_{PARA}$ observed for an amorphous material is not clear as yet. Due to the large temperature gradient along a normal vector of tektite during its cooling process, the principle axes of the molecular field of individual Fe ion may be preferentially aligned along the normal vector.

[1] T. Takeuchi et al: EPS. 65 193-197, 2013

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



The $\Delta\chi_{PARA}$ value is obtained from a period of rotational-oscillation observed for a direction of magnetically stable axis with respect to field [2]; sample was released in an μg area produced by a short drop shaft.