Determination of magnetic field in planetary formation region based on alignment of dust composed of major rock forming minerals

Chiaki Uyeda magnetic anisotropy club[1]

[1] -

http://psmac0.ess.sci.osaka-u.ac.jp/uyeda/ueda.html

Circumstellar field around Young Stellar Objects is one of the major factors that control stellar and planetary formation; it is expected that field structure may be determined from polarimetry data obtained with high spatial resolution (e.g. by ALMA). Polarization is caused by dust alignment; however the mechanism of alignment in the dense region is explained by the conventional Davis Greenstein theory in this region, since thermal equilibrium is achieved between dust and gas phases in this region. Efficiency of magnetic alignment at low field intensity has recently become clear for most of the ordinary nonmagnetic solids. Alignment is caused by anisotropy of diamagnetic or paramagnetic susceptibility. Alignment of micro-crystal, dispersed in gas medium at equilibrium condition, is achieved when the magnetic anisotropy energy induced in the crystals are one order of magnitude larger compared to thermal agitation energy. Partial alignment large enough to cause polarization occur at temperatures below T=100K for forsterite and enstatite grains at field intensity of 0.1mT, according to measured results of magnetic anisotropy; this field intensity is comparable to that of the star formation region estimated from paleo-magnetic data of primitive meteorites. Forsterite and enstatite were recently identified as the major dust components in this region by mid-infrared spectroscopic observations. The practicability of the dust alignment in star formation region is deduced based on experimental data in the low temperature region, which serve as a basis to determine field structure from polarimetry data. Magnetic alignments of minerals are believed to occur only for particles which possess spontaneous magnetic moments at present. We report significant rotational oscillation due to anisotropy of paramagnetic susceptibility for large single crystals of forsterite and enstatite at a weak field of 200 G produced by a horseshoe magnet; magnetic oscillations of ordinary oxide minerals without spontaneous moments at this field intensity do not appear in previous literatures. Similar efficiency of magneto-rotation due to paramagnetic anisotropy is expected for most of the rock forming minerals, which usually possess comparable amount of paramagnetic anisotropy caused mainly by the Fe ions. Precise temperature dependence of paramagnetic anisotropy were obtained from the period of oscillation at temperatures between T = 300-100 K. Possibility of new types of magnetic effects on ordinary rock forming minerals in various cosmic and terrestrial conditions may be considered based on the measured paramagnetic anisotropy values.Efficiency of magnetic alignment above T=1000 K is observed for the first time on various solid materials; efficiency of alignment due to the conventional spontaneous magnetic-moments are lost at this temperature. Measurements were performed on diamagnetic SiC, forsterite and graphite for the purpose of estimating magnetic field around the Asymptotic Giant Branch (AGB) Stars; polarimetry deriving from dust alignment was recently reported in this region. The above-mentioned materials are the major components of pre-solar grains contained in primitive meteorites; existences of radiogenic isotopes indicate that these grains were formed in the envelopes of the AGBs. Theoretically deduced field-intensity of this region have the level of B = 0.1-0.3 T. Partial alignment at T = 1000 K is expected at this field intensity for crystal grains of the measured materials; observed values of diamagnetic anisotropy at this temperature was used in the estimation. Up to now, field intensity has not been determined from observation for most of the stars, and the above-mentioned experiment can be the basis of such observations.