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4. Spin Structure of Two Dimensional Antiferromagnet on the Triangular Lattice; $LuFeCoO_4$

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ABSTRACT

Recently, many interesting experimental and theoretical investigations have been reported on the phase transition or the magnetic ordering in two dimensional antiferromagnets of triangular lattice structure (2D-AFT). The $RFe^{3+}M^{2+}O_4$ family (R; Lu, Yb, Tm, Er or Y. M; Fe, Co, Mn, etc..) is one kind of 2D-AFT. Oxides belonging to this family have a stacked hexagonal layer structure. Equal numbers of Fe^{3+} and M^{2+} ions occupy crystallographically equivalent sites. Neutron diffraction experiment was performed on some oxides of this family, and the magnetic Bragg line (1/3,1/3,1) was observed. This fact shows that the magnetic structure of this family is of two dimensional character. Thus, spins in these oxides are thought to be frustrated. (In the case where M^{2+} is non-magnetic, the magnetic scattering was not found in the neutron diffraction). Here, the difficulties in grasping magnetic properties of this family are as follows: 1) Random distribution of Fe^{3+} and M^{2+} within one layer. 2) Frustration effect on spin system.

In this study, the distribution in spin orientation of Fe^{3+} in $LuFeCoO_4$ is examined mainly. So far, about $YbFeMnO_4$, where magmetic ions Fe^{2+} are substituted with M^{2+}, a previous Mössbauer study has performed in detail only on powder sample, and a model of isotropic distribution of spin orientation for $YbFeMnO_4$ has been proposed: the same model has been supposed to be applicable to $LuFeCoO_4$ based on the feature of its low temperature spectra. In order to obtain more determination, a study on single crystals both of these oxides has been desired.

In the present study, Mössbauer study on single crystal $LuFeCoO_4$ is performed at room temperature and 4.2K. Magnitude of external field is 0, 35 or 60kOe at 4.2K, and 0 or 60kOe at room temperature. If the above-mentioned presupposition, that spins in $LuFeCoO_4$ could also have an orientational distribution, is correct,

a distribution in each Mössbauer parameters is naturally expected even in the case of single crystal, and Mössbauer parameters for quadrupole interaction cannot be determined from spectra at low temperatures. In such a case, an experiment in a magnetic field is effective to determine the sign of electric field gradient Vzz and to obtain the spin orientational distribution.

From the spectrum obtained at room temperature without magnetic field, the average of quadrupole splitting and the intensity ratio of the doublet are determined. From the spectrum obtained at room temperature in an external field of 60kOe, the sign of Vzz is determined as Vzz>0, and a more probable single set of parameters related to the quadrupole splitting is also determined.

As the purpose of this study is to examine the magnetic structure, experiments at low temperature are important. Obtained spectra, especially those in external fields, show that it is impossible to explain the experimental result without taking some distribution in spin orientation into account.

On analysis of the present data, a probable distribution in quadrupole interaction parameters are negrected and the above-obtained single set of parameters is used. The orientational distribution of spins is determined by the Hesse-Ruobartsch method for each of Mössbauer spectra corresponding to H=0, 35 and 60kOe. Resultant distributions are very different from the one expected from "spheroid-like distribution of spin direction ", and the orientations of spins spread widely around about 50° to the c-axis, which is the easy axis of magnetization, but at 90°.

In addition to the above-mentioned Mössbauer study on single crystal, another Mössbauer study with a powder sample of the same oxide is performed at temperatures between 4.2K and 300K. And the σ-T curve, the σ-H curve and neutron diffraction are also measured on the same single crystal by Dr.J Iida who made the single crystal. All these data indicate that this oxide has the characteristics of magnetic properties of 2D-AFT.