Observation of the angular momentum compensation by using the Barnett effect

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Angular momentum compensation is a crucial characteristic in the field of spintronics, where significant attention is focused on the high-speed magnetic response at the angular momentum compensation temperature. In some ferrimagnets, known as N-type, a magnetic compensation temperature (T_M) exists, at which magnetization vanishes even in the ferrimagnetically ordered state. Furthermore, when g-factors of magnetic moments belonging to different sublattices are different, ferrimagnetic materials exhibit another compensation point called the angular momentum compensation temperature (T_A), where the net angular momentum $\langle J_{net} \rangle$ in the material also disappears even in the magnetically ordered state. Determining T_M is relatively straightforward, as it can be obtained through magnetization measurements. However, conventional magnetization measurements using a magnetic field are inadequate to determine T_A. Here, we show that T_A can be measured by using the Barnett effect, wherein magnetization is induced by mechanical rotation [1, 2]. Figure 1 shows the experimental results of the Barnett effect on the rare earth iron garnet ($Ho_3Fe_5O_{12}$) at low temperatures. Magnetization induced by the Barnett effect vanishes at T_M=135 and T_A=240K. We also demonstrate that T_A can be manipulated by partially substituting Dy for Ho [3]. At the composition of $Ho_{1.5}Dy_{1.5}Fe_5O_{12}$, T_A coincides with room temperature, which is critical for operating magnetic devices.

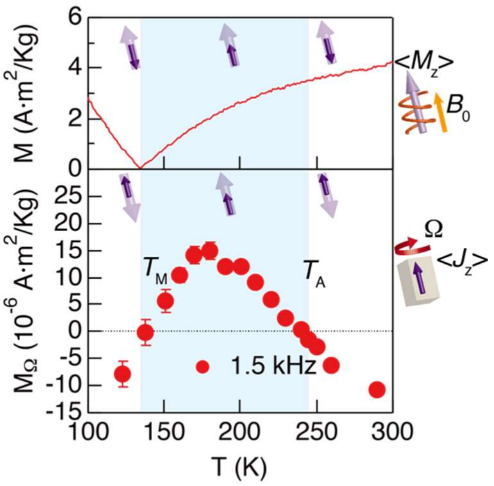

Fig.1: The upper panel shows the temperature dependence of magnetization of $Ho_3Fe_5O_{12}$ in a magnetic field of 1000 Oe. The lower panel shows the temperature dependence of magnetization of $Ho_3Fe_5O_{12}$ due to mechanical rotation at a rotational frequency of 1.5 kHz (red solid circle).

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[2] S. J. Barnett, Phys. Rev. **6**(4), 239 (1915).

[3] M. Imai, H. Chudo, et al., APL **114** 162402 (2019).