Observation of angular momentum compensation by using Barnett effect

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Using mechanical rotation, we are trying to exploit new research field of spintoronics. The coupling between spin and mechanical rotation was experimented over 100 years ago by Barnett, Einstein, and de Haas[1, 2]. Barnett discovered a phenomena that a rotating matter is magnetized, so-called Barnett effect. In recent years it has become possible to observe the Barnett effect in paramagnetic materials without spontaneous magnetization[3, 4]. The origin of the Barnett effect is spin-rotation coupling $H_{\Omega} = -\hbar J \cdot \Omega$, where J and Ω are electronic total (spin) angular momentum and angular velocity. Accordingly, we can detect net angular momentum of electrons in magnetic materials by using the Barnett effect.

Using the temperature tunable apparatus, we measured the Barnett effect in ferrimagnet $Ho_3Fe_5O_{12}$[5]. Ferrimagnets contain some kinds of magnetic ions, the magnetic moments of which are antiferromagnetically coupled to each other. In some ferrimagnets, the size of the sublattice magnetic moments is balanced at a temperature called the magnetization compensation temperature T_{M}, resulting that net magnetization becomes zero. In addition, when the gyromagnetic ratio is different for each ion, the net angular momentum becomes zero at a temperature called the angular momentum compensation temperature T_{A}, which is a key characteristic in the field of spintronics in a viewpoint of high-speed magnetic response. We succeeded in observing the temperature dependent net angular momentum of $Ho_3Fe_5O_{12}$, and determined its $T_{\mathrm{A}} = 245$ K [5]. In addition, we demonstrate that T_{A} of $Ho_3Fe_5O_{12}$ can be controlled by partially Dy substitution for Ho[6]. The magnetization compensation temperature T_{M} and T_{A} increase linearly with increasing x. We clarified the angular momentum compensation coincides with room temperature at $x = 1.5$.

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