Unconventional exchange-bias effect in single crystals of $RFeO_3$ (R =Er, Nd, Sm) and $GdCrO_3$ compensated ferrimagnets

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Rare-earth orthoferrites $RFeO_3$, where R is a rare-earth ion, are narrow-gap multiferroics and are of considerable interest in the creation of multifunctional devices with magnetoelectric coupling. These compounds meet such requirements as the natural abundance of the constituent chemical elements and the relative cheapness of their synthesis. A fairly large amount of research on the physical properties of orthoferrites in recent years is due to the presence of the phenomena of magnetic moments terahertz frequency dynamics, negative magnetization, exchange bias (EB), spin switching, and magnetocaloric effect induced by magnetic and thermal treatment.

Ferrimagnetic orthochromite $GdCrO_3$ has currently also attracted large interest because of its possible applications, such as fast spin switching, a phenomenon of negative magnetization, ferroelectricity, magnetoelectric effect, and giant magnetocaloric effect. The antisymmetric exchange Dzyaloshinskii-Moriya (DM) interaction between Cr^{3+} spins and antiferromagnetic (AFM) interaction between Gd^{3+} and Cr^{3+} spins are believed to be mainly responsible for these effects.

In compensated ferrimagnets, e.g. $RFeO_3$ (R = Er, Nd, Sm) or $GdCrO_3$, an unconventional phenomenon of EB is observed. The conventional EB is related to the interaction at the interface between, for example, a ferromagnet and an antiferromagnet. In ferrimagnets with compensation temperature (T_{comp}), the mechanism of exchange coupling between the rare earth sublattices and Fe or Cr is responsible for the EB effect. In $ErFeO_3$ and $NdFeO_3$ single crystals, the EB phenomenon occurs only in the close vicinity of T_{comp} (T_{comp}^{Er} = 45 K, T_{comp}^{Nd} = 9.2 K), the sign of H_{EB} changes to the opposite when T_{comp} is exceeded. $SmFeO_3$ single crystal shows the EB effect not only near T_{comp}^{Sm} = 4.8 K but also at higher temperatures. $GdCrO_3$ has a high T_{comp} = 144 K. The EB is observed near the compensation temperature but only for $T > T_{comp}$, below T_{comp} the EB disappears [2]. Probably the different behavior (compared to $RFeO_3$) observed in $GdCrO_3$ is due to the properties of the magnetic moment of Gd, which has only a spin component. The influence of hydrostatic pressure on the magnetic properties of this compound [3] will also be discussed.

[1] I. Fita, A. Wisniewski, R. Puzniak, E. E. Zubov, V. Markovich, G. Gorodetsky, Phys. Rev. B **98**, 094421 (2018).

[2] I. Fita, R. Puzniak, A. Wisniewski, and V. Markovich, Phys. Rev. B **100**, 144426 (2019).

[3] I. Fita, R. Puzniak, and A. Wisniewski, Phys. Rev. B **103**, 054423 (2021).