Observation of large anomalous Nernst effect and quantum-critical scaling in the Weyl ferromagnet Co_2MnGa thin films

°Ryota Uesugi[1], Tomoya Higo[1, 2, 3], Susumu Minami[2], Daisuke Nishio-Hamane[1], Zheng Zhu[1], Mihiro Asakura[2], Akito Sakai[1, 2, 3], Yoshichika Otani[1, 3, 4], Ryotaro Arita[3, 4, 5], and Satoru Nakatsuji[1, 2, 3, 6, 7]

1. ISSP, Univ. of Tokyo, 2. Dep. of Phys., Univ. of Tokyo, 3. JST CREST, 4. RIKEN CEMS, 5. RCAST, Univ. of Tokyo, 6. TSQS, Univ. of Tokyo, 7. Johns Hopkins Univ.

E-mail: r_usg@issp.u-tokyo.ac.jp

Thermoelectric generation is expected to be utilized as the built-in energy source for IoT devices, and heat flux sensing for thermal management. The anomalous Nernst effect (ANE)[1-3] is one of the practical thermoelectric phenomena for device fabrication because a three-dimensional structure of π-shape is not required due to the electromotive force orthogonal to the heat flux. On the other hand, its smaller conversion efficiency of ~ 1 μV/K than the Seebeck effect (a few hundred μV/K) constricted the practical use of ANE and required it to enhance its efficiency. As a result of developments in the topological band structure focused on Weyl cones, the large anomalous Hall and Nernst effects were discovered in the antiferromagnet Mn_3Sn at room temperature comparable to ferromagnet[3]. Moreover, in Co_2MnGa[4] and Fe_3Ga[5], the conversion efficiency was enhanced by one order of ~ 6 μV/K at room temperature. Therefore, it opened a new path for developing practical thermoelectric devices using ANE[6-8].

In particular, the Weyl cone in Co_2MnGa makes not only nodal lines but also, a horizontal band dispersion near the Fermi level, called the Lifshitz quantum critical point. In fact, an intrinsic (Berry curvature driven) component of ANE, which shows the characteristic temperature T dependence of $\sim -T\log T$, was observed in single crystal bulk of Co_2MnGa[4], however not yet in thin film samples.

In this study, we fabricated epitaxial Co_2MnGa film and measured temperature dependence of anomalous Hall and Nernst effect. By optimizing the deposition method, not only the large anomalous Nernst effect but also the quantum-critical scaling of $\sim -T\log T$ was observed as in the bulk sample.

[1] Y. Sakuraba, *Scripta Materialia* **111**, 29 (2016).
[2] M. Mizuguchi and S. Nakatsuji, *Sci Technol Adv Mater* **20**, 262 (2019).
[3] S. Nakatsuji and R. Arita, *Annu. Rev. of Cond. Mat. Phys.* **13**, 119 (2022).
[4] A. Sakai, *et al., Nat. Phys.* **14**, 1119 (2018).
[5] A. Sakai, *et al., Nature* **581**, 53 (2020).
[6] W. Zhou and Y. Sakuraba, *Appl. Phys. Express* **13** (2020).
[7] T. Higo, *et al., Adv. Funct. Mater* **31** (2021).
[8] K. Uchida, W. Zhou, and Y. Sakuraba, *Appl. Phys. Lett.* **118** (2021).