Search for the magnetic structure of $CeRh_2Si_2$ under uniaxial pressure by means of neutron diffraction

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In the past few years, several theories that uniformly categorizes the ordered states based on the “augmented multipole” have attracted much interest.[1] Here, “augmented multipole” denotes the multipoles extended to including electron’s spin and charge clusters or locally hybridized electronic states. According this theory, antiferromagnetic (AF) order can be accompanied with magnetoelectric (ME) effect even on the metallic system. Actually, we experimentally found the current-induced magnetization perpendicular to the applied electric current which accompanies the AF order on metallic UNi_4B, $CeRh_2Si_2$[2] and $CeRu_2Al_{10}$.

$CeRh_2Si_2$ exhibits two successive AF orders. We name the high-temperature phase the AF1 phase, and the other the AF2 phase. The AF1 phase is characterized by a propagation vector q_1 = (0.5, 0.5, 0). It is expected that the AF1 phase forms a multidomain state by q_1 and equivalent q_1’ = (0.5, -0.5, 0). The AF2 phase is a multiple-q order formed by q = (0.5, ±0.5, 0) and (0.5, ±0.5, 0.5). The magnetization M induced by applied electric current was found only in the AF1 phase. It indicates that the ME effect is connected with the AF order and its q vector. However, the relation between the ME effect and q vector is hindered by the presence of a multidomain state. Therefore, the measurement of M on a de-twined sample is strongly desired. We recently found that the in-plane uniaxial stress σ suppresses M and resistivity ρ in the AF1 phase.[3] It suggests that σ might resolve the multidomain state. In order to reveal the relation between the q vector and the suppression of M and ρ, we conducted neutron diffraction measurement on single-crystalline $CeRh_2Si_2$ under σ.

The measurement was performed at PONTA (5G). The sample was mounted so as to have (H, H, L) scattering plane and σ || [1-10]. A cramp-type cell was used for the application of σ. Figure 1 shows the Temperature dependence of the integrated intensity of Q = (0.5, 0.5, 0) [q_1], (0.5, 0.5, 0.5), and (0.5, 0.5, 1)[q_1’ + (0, 1, 1)] at σ = 0, and 25 MPa. In ambient pressure, the temperature dependence of each reflection was consistent with a previous paper.[4] By the application of σ = 25 MPa, we found that (0.5, 0.5, 0) reflection is enhanced while (0.5, 0.5, 1) reflection is completely suppressed in the AF1 phase. It means that a multidomain state in the AF1 phase was de-twinned by the application of σ. It is worth noting that q perpendicular to σ ($q_{\perp\sigma}$) is favored. By comparing this result with M and ρ, we also found that the suppression of M and ρ is caused by the anisotropy of q. M perpendicular to q is smaller than M parallel to q ($M_{\perp q} < M_{\parallel q}$), and the same is the case with ρ ($\rho_{\perp q} < \rho_{\parallel q}$). These results will be a great help when we will measure the anisotropy of ME effect.

[1] for instance, S. Hayami H. Kusunose, and Y. motome, Kotaibuturi **50**, 217 (2015).
[2] H. Saito *et al.*, 73rd JPS annual meeting, 22aK504-10 (2018).
[3] H. Saito *et al.*, 76th JPS annual meeting, 14aC1-14 (2021).
[4] S. Kawarazaki *et al.*, Phys. Rev. B **61**, 4167 (2000).

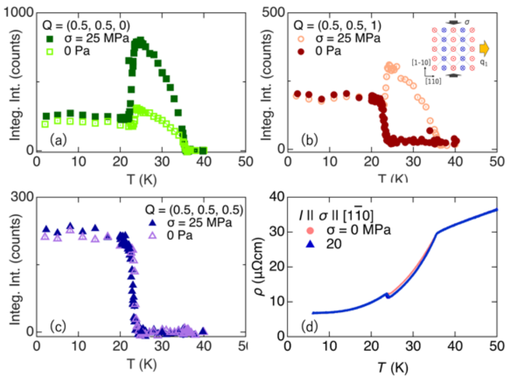

Fig. 1. Temperature dependence of the intensity of Q = (a) (0.5, 0.5, 0), (b) (0.5, 0.5, 1), and (c) (0.5, 0.5, 0.5) reflections and (d) ρ under the application of σ along [1-10]. A schematic of the de-twinned state is shown in inset.