Field-induced magnetic correlations in chiral lattice semimetals $Ce_3Co_4Sn_{13}$ and $Ce_3Rh_4Sn_{13}$

K. Iwasa[1], Y. Otomo[2], K. Suyama[2], A. Goukasov[3], B. Gillon[3], J.-M. Mignot[3]
Frontier Research Center for Applied Atomic Sciences, Ibaraki University, Japan[1]
Department of Physics, Tohoku University, Japan[2]
Laboratoire Léon Brillouin, CEA-CNRS, CEA/Saclay, France[3]

Electronic correlation phenomena have been central topics of solid-state physics. In the case of f-electron systems, the c–f hybridization effect has been a key issue. In addition, topological natures of electrons have recently been attractive recently: the electronic state of topological insulators of surface states and graphen are expressed as massless Dirac or Weyl fermions. A theoretical study have proposed a way to find three-dimensional (3D) bulk Weyl fermions in chiral symmetry lattices (J. L. Manñs, Phys. Rev. B **85**, 155118 (2012)). It is an attractive subject to find such chiral fermion systems and electronic correlations between the chiral fermions and the f electrons.

$Ce_3Co_4Sn_{13}$ has been reported to undergo a structural phase transition at 160 K (C. S. Lue et al., Phys. Rev. B 85, 205120 (2012)), and similar phenomena are also suggested for $Ce_3Rh_4Sn_{13}$ (A. Ślebarski et al., Phys. Rev. B **86**, 155122 (2012)). We evidenced low-temperature crystal structure categorized in the chiral space group $I2_13$ below the structural phase transitions at 160 and 352 K in $Ce_3Co_4Sn_{13}$ and $Ce_3Rh_4Sn_{13}$, respectively (Y. Otomo et al., Phys. Rev. B **94**, 075109 (2016)). The electrical resistivity data of $Ce_3Co_4Sn_{13}$ and $Ce_3Rh_4Sn_{13}$ are almost independent of temperature, in contrast to metallic behaviors of the La-based reference materials. These structural finding and transport property are expected to be signatures for the formation of Weyl semimetal state. The electronic Sommerfeld coefficients of these compounds reach approximately 4 J/(mol-Ce K^2) at 1 K (A. L. Cornelius et al., Physica B **378–380**, 113 (2006), A. Ślebarski et al., Phys. Rev. B **86**, 205113 (2012), E. L. Thomas et al., J. Solid State Chem. **179**, 1642 (2006)). This fact was understood as HF systems. However, our recent inelastic neutron scattering experiment revealed the emergence of spin excitations in the range up to 1 meV below 20 K (K. Iwasa et al., Phys. Rev. B **95**, 195156 (2017)), which originates from the crystal-electric-field (CEF) doublet ground state. Therefore, coherent spin dynamics emerge in the semimetal chiral phase. On the other hand, $Ce_3Co_4Sn_{13}$ and $Ce_3Rh_4Sn_{13}$ do not exhibit any magnetic ordering down to 0.5 K (K. Iwasa et al., in preparation), and previous study on $Ce_3Co_4Sn_{13}$ reported the field-induced antiferromagnetic correlations at 4.2 K (A. D. Christianson et al., Physica B **403**, 909 (2008)). Based on the $I2_13$ structure, the two inequivalent Wyckoff sites for the Ce ions take different CEF schemes (K. Iwasa et al., Phys. Rev. B **95**, 195156 (2017)). Thus, the magnetic-field-induced antiferromagnetic correlation can be understood different magnetic moments at the two Ce-ion sites. In order to examine such scenario for the Ce $4f$-electron state, we performed polarized neutron diffraction measurements under the magnetic fields up to 6 T below 20 K, by using the hot-neutron diffractometer 5C1 installed in the Orphée reactor of Laboratoire Léon Brillouin.

Figure 1 shows measured intensity maps within the [1 0 0]-[0 1 0] reciprocal plane perpendicular to the applied magnetic fields of 6 T at measurement temperature of 2 K for $Ce_3Co_4Sn_{13}$. The measured results for the up (upper panel) and down (lower panel) spin polarizations of the incident neutron are not identical with each

other, in particular for the reciprocal-lattice region with h and $k < 10$. Similar polarization dependence was also observed for $Ce_3Rh_4Sn_{13}$. Such results indicate characteristic magnetic-moment distribution, the magnetic-scattering neutron wave from which interferes with the nuclear-scattering wave. Preliminary analysis for the flipping-ratio data shown in Fig. 1 based on the Cambridge crystallography subroutines give the magnetic moments of 1.5 and $0.9\mu_B$ at the two inequivalent Ce-ion sites. This result is consistent with the aforementioned structural and magnetic properties in the chiral phase.

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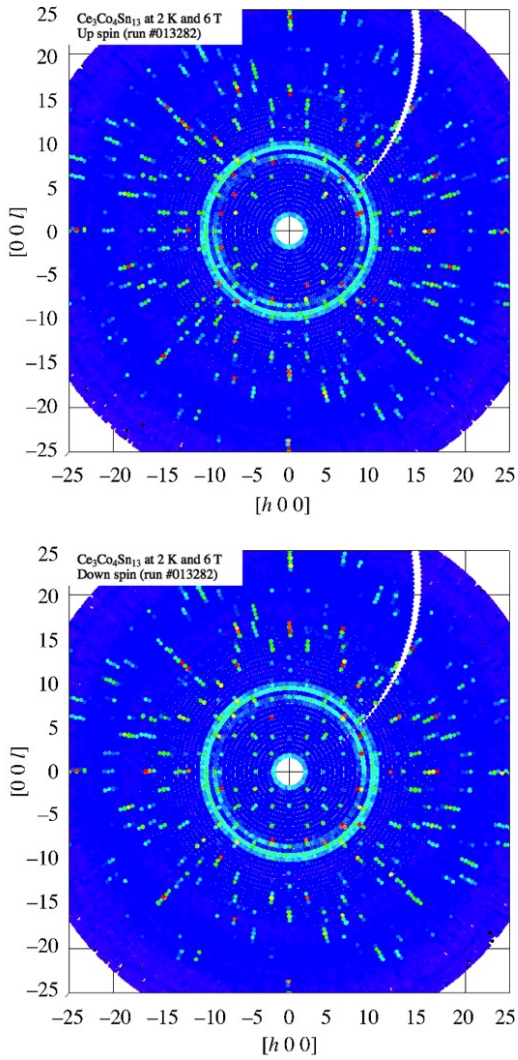

Fig. 1. Diffraction-intensity maps within the [100]-[010] reciprocal plane perpendicular to the applied magnetic fields of 6 T at measurement temperature of 2 K.