Partial order of conduction electrons in Mn$_3$CoSi

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Unconventional phase transitions have been discovered in various materials. One of them is a phase separation at the tri-critical point of quantum phase transition. Partial magnetic order has been observed in a non-centrosymmetric compound of MnSi near the quantum phase transition under pressure. On the search of new unconventional magnetic transition, we discovered the highest-temperature magnetic short-range order (SRO) in a new noncentrosymmetric magnet Mn$_3$RhSi by the complementary use of muon spin relaxation (HiFi and ARGUS at ISIS), neutron, X-ray scattering, electron diffraction, and magnetization measurements. It has a hyperkagome network of magnetic Mn ions. We think that the unconventional magnetic SRO emerges due to the spatially inhomogeneous order parameter, where the Lifshitz condition is violated by the Dzyaloshinskii-Moriya interaction in a noncentrosymmetric magnet. The intriguing point of the SRO is not limited in the highest-temperature record of magnetic SRO, but also in the observed Q-position different from long-range antiferromagnetic (AF) order Q-position. At present, however, the mechanism is still unknown. To reveal the mechanism, we believe that it is necessary to complete the phase diagram (Fig. 2) by measuring the related family compounds such as Mn$_3$CoSi ($a = 6.28$ Å) with a different lattice constant resulting in a different bandwidth from that of Mn$_3$RhSi ($a = 6.47$ Å). The Néel temperature of Mn$_3$CoSi is about 100 K, whereas that of Mn$_3$RhSi is 190 K. However, it was unknown which the SRO transition temperature of Mn$_3$CoSi becomes lower than that of Mn$_3$RhSi.

TF μSR measurement of Mn$_3$CoSi (RB2070006) successfully showed SRO anomaly above Néel temperature in the asymmetry as shown in Fig. 1. The magnetic SRO of Mn$_3$CoSi is found to start at about 250 K. From this result, we may conclude that the SRO temperature increases with increasing the lattice constants as shown in Fig. 2. This result suggests that the present world record of SRO temperature may further increase with increasing the lattice constant.

References