Magnetic structure of Weyl semimetal candidate NdGaSi

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Dirac and Weyl fermions have attracted great attention in condensed matter physics. In two dimensional graphene, massless Dirac fermions are realized, and the unique behaviour in the physical properties such as quantum Hall effect is observed. In three dimensional topological system, Weyl semimetal with an inversion symmetry-breaking is recently discovered for several semimetals. Weyl fermions induce the unique transport properties, such as the magneto-resistance induced by the chiral anomaly and the anomalous Hall effect. Then, the study of Weyl semimetal is very important for both foundation and application. On the other hand, the many reported Weyl semimetals with the polar structure have no magnetism. Although the relationship between the magnetism and the Weyl semimetal phase is discussed for several materials, such as Nd2Ir2O7, GdPtBi, and YbMnBi2, it is not clear.

We focus on the Weyl semimetal candidate having the magnetism, RGaSi (R=Pr, Nd, Gd, and Sm) [1]. In RGaSi, the crystal structure is classified by order/disorder of Ga/Si sites. The crystal structure with the order of Ga/Si sites belongs to the polar space group I41md same as the famous polar Weyl semimetal TaAs. Indeed, the realization of Weyl semimetal state has recently been suggested in the isostructural compound with the first principle calculation. Although many Weyl semimetals have the polar crystal structures, the relationship between the Weyl semimetal phase and the polar structure in RGaSi is not clear. Furthermore, RGaSi has the magnetism originated from the magnetic moment of R-ions, and the antiferromagnetic or ferrimagnetic transitions are observed at around 15 K. In the coexistence of the properties of the Weyl semimetal and the magnetism, the novel physical properties are expected. However, the magnetic structure of RGaSi is not clear. Then, we need to examine the magnetic ordering at low temperature. In order to clarify the relationship between the magnetic ordering and the physical property of Weyl semimetal, we carried out the magnetic structure analysis in Weyl semimetal NdGaSi.

We have carried out the neutron diffraction measurement in the single crystal NdGaSi by using HB-3A (Four Circle Diffractometer).

Figure 1 shows the temperature dependence of the integrated intensity at Q=(1,0,1). A small intensity at the Q=(1,0,1) exists above TN=12 K, which is originated from the nuclear reflection. With decreasing T, a large-intensity component due to magnetic ordering appears below TN. The magnetic diffraction measurements on the NdGaSi single crystal were carried out in order to clarify the magnetic structure. At 20 and 5 K, the neutron intensities were measured at many Q-points. The magnetic intensities were obtained by subtracting the integrated intensity at 20 K from that at 5 K. As a result, we observed the magnetic reflections at the fundamental Q-points. At this moment, we try to analyze the magnetic structure.

[1] G. Darone, et al., JSSC. 201, 191 (2013).