Magnetic property of Ag-In-Tb 1/1 approximant and its relation to Zn-Mg-RE quasicrystals

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Quasicrystals are characterized by sharp Bragg reflections with a point symmetry which is forbidden in a periodic lattice, such as the five-fold symmetry. For magnetic quasicrystals, non-trivial spin ordering arranged on a quasiperiodic lattice is expected theoretically. But up to now the long-range order has not been observed in any magnetic quasicrystals. Even Zn-Mg-RE(RE=rare earth) quasicrystals which have well localized and large 4f magnetic moments just indicate spin-glass-like transition or no transition[1]. The absence of the long-range order evokes a new question whether quasiperiodicity is essentially incompatible with the long-range magnetic order or not.

An approximant is a periodic crystal that has a similar or identical atomic cluster in a finite length scale. Therefore, by studying magnetism of the approximants, one may separately elucidate the effect of the long-range quasiperiodicity and that of the short-range clusters. Fortunately, a magnetic approximant to the icosahedral quasicrystal has been found in Ag-In-RE systems. They seem to have well localized moments as is the case in Zn-Mg-RE, and are more suitable for neutron scattering than Cd-RE approximants in terms of the absorption. Our measurement of static magnetization of Ag-In-Tb 1/1 approximant showed that it has a spin-glass-like transition at $T = 3.7$ K, which is similar to that of Zn-Mg-Tb at 5.8 K[1]. To elucidate difference from Zn-Mg-RE quasicrystals in magnetic ordering, we have performed neutron powder diffraction study at 4G-GPTAS and T1-3-HERMES.

The sample was prepared by melting constituent elements and by annealing the resultant as-cast alloy in an appropriate manner. The data shown in Figure 1 are taken with incident energy $E_{\mathrm{i}} = 13.7$ meV in the double-axis mode. They show clear nuclear Bragg reflections, which are independent of temperature; no magnetic Bragg reflection was observed at the lowest temperature. we also confirmed the absence of the magnetic Bragg reflection using T1-3-HERMES. Figure 1 also shows temperature difference of the powder diffraction patterns measured at 3.5 K and 60 K. It clearly shows two broad peaks at 0.6 and 1.9 Å^{-1}, indicating the development of the short-range-spin correlations at low temperatures. This contrasts to the three-peak feature of the magnetic diffuse scattering pattern in Zn-Mg-Tb. The peak at 0.6Å^{-1} develops below 40 K, which is much higher than the freezing temperature of 3.7 K. Further study using a single crystalline sample is desired to elaborate the short-range-spin correlations in the approximant.

[1] T. J. Sato, Acta Cryst. A**61** (2005) 39.

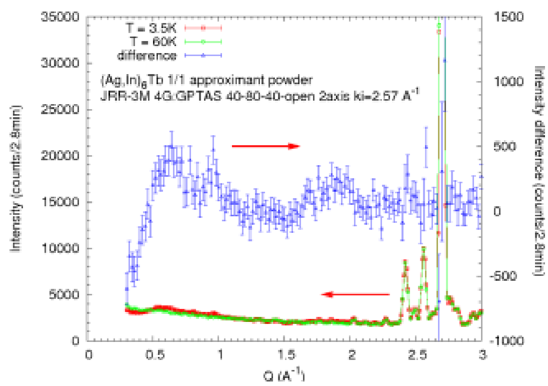

Fig. 1. Neutron powder diffraction patterns at $T =$ 3.5 K(red) and 60 K(green) obtained at 4G-GPTAS. Temperature difference [I(3.5 K) - I(60 K)] as a magnetic scattering contribution is also shown by the blue triangles.