Antiferromagnetic order in the Au-Al-Tb quasicrystalline approximant

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The Au-Al-Tb quasicrystalline approximant attracts growing attentions recently because of possible novel magnetic ordering inferred in the macroscopic measurements. This system has magnetic clusters consisting of nearly-icosahedrally arranged Tb magnetic moments, and thus is of considerable interest in its magnetic order. From the susceptibility measurements, a possibility for the antiferromangetic ordering has been proposed, however, no microscopic information on the magnetic ordering was obtained to date. We, hence, undertook the powder neutron diffraction experiment on the Au-Al-Tb approximant crystalline phase. The powder diffractometer ECHIDNA, installed at the OPAL reactor of ANSTO, was used, and the magnetic diffraction patterns in a wide temperature range from RT to 4 K were recorded.

As a result, we have clearly observed magnetic reflections below $T < 11$ K. It may be noteworthy that the appearance of the magnetic peak perfectly coincides with the ordering temperature determined in the macroscopic susceptibility measurement. We found that the magnetic reflection was observed at Q = (1,1,1) position, indicating that the system undergoes antiferromagnetic transition with breaking bcc centering-translational symmetry. The 24 Tb-atom sites in the unit cell are all crystallographically equivalent, and hence we expect that the magnetic representation analysis would work well for the magnetic structure analysis of this kind. By using magnetic representation analysis, we found that the lowest temperature diffractogram is well reproduced by using two basis vectors belonging to one single irreducible representation. In real space, the basis vectors correspond to a noncollinear and noncoplanar spin structure defined on one single icosahedron, as shown in Fig. 1. The spins are found in the mirror plane of the Im-3 space group symmetry of the crystal, indicating that the local crystalline electric field effect plays deterministic role for the magnetic structure stabilization.

Further study on the magnetic symmetry and possible consequence of such nontrivial magnetic structure is in progress.

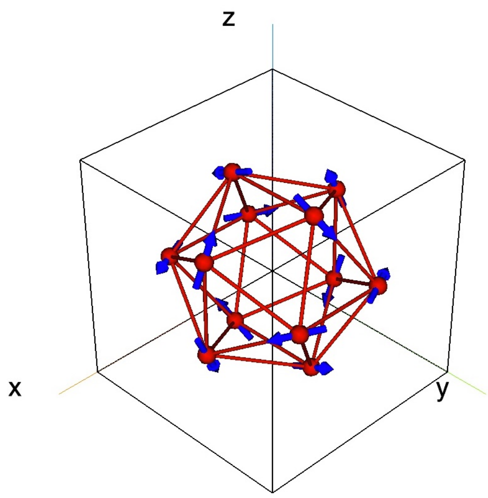

Fig. 1. Magnetic structure in one single Tb icosahedron determined in the present study. Note that the icosahedron on the vertex is depicted; the body-center icosahedron has antiparallel spin configuration.