Magnetic structures of quasicrystal approximants

Taku J Sato#
Institute of Multidisciplinary Research for Advanced Materials,
Tohoku University, 2-1-1 Katahira, Sendai 980-8577, Japan

#Corresponding author: taku@tohoku.ac.jp

Magnetic clusters with icosahedral point symmetry have been of continuous interest because of their nontrivial ground and/or excited states originating from frustrated geometry. Recently, it has been recognized that a number of crystalline phases exist nearby the quasicrystalline phase in phase diagram that have icosahedral symmetry clusters arranging periodically, and are called "quasicrystal approximants". The approximants offer a new playground to study the magnetic behavior of interacting icosahedral clusters in a periodic lattice.

Recently, we have investigated microscopic magnetic order in the two magnetic approximants, *i.e.*, ferromagnetic Au-Si-Tb and antiferromagnetic Au-Al-Tb systems using neutron diffraction [1,2]. The magnetic structure of the former Au-Si-Tb approximant was solved by single-crystal neutron diffraction using the HB-3A four-circle diffractometer installed at HFIR, ORNL, USA, whereas that of the latter Au-Al-Tb approximant has been obtained by powder neutron diffraction using the high-resolution powder diffractometer ECHIDNA installed at OPAL reactor, ANSTO, Australia.

From those experiments, it becomes clear that both the approximants have intriguing non-collinear magnetic structures, despite relatively simple magnetic behavior observed in the bulk magnetic measurements. The ordered spin directions are mostly in the local mirror plane at the Tb^{3+} sites and are nearly tangential to the icosahedral cluster surface. The only difference between two systems may be the spin arrangement at the opposite vertices in a single icosahedral cluster; in Au-Si-Tb the spins at the opposite vertices align parallel, and hence the total magnetic moment of a cluster becomes finite, whereas for Au-Al-Tb, the cluster moment vanishes as the spins at opposite vertices are antiparallel, compensating each other. The similarity strongly suggests that the spin direction is fixed by the local anisotropy due to the crystalline electric field, and the drastic change of macroscopic behavior is attributable to the subtle difference of the spin-spin interaction possibly due to the change of the Fermi level [3].

Acknowledgments: This work has been done in collaboration with T. Hiroto, H. Cao, A. Ishikawa, A. Sakurai, M. Hattori, M. Avdeev and R. Tamura, for whom the author wish to thank.

[1] T. Hiroto, T. J. Sato, H. Cao and R. Tamura (unpublished).
[2] T. J. Sato, A. Ishikawa, A. Sakurai, M. Hattori, M. Avdeev and R. Tamura (submitted, arxiv: 1904.13008.)
[3] A. Ishikawa, T. Fujii, T. Takeuchi, T. Yamada, Y. Matsushita, and R. Tamura, Phys. Rev. B 98, 220403(R) (2018).