Neutron powder diffraction study on the Au-Ga-Tb quasicrystal approximant

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Quasicrystal is a substance with long-range quasiperiodic atomic arrangement, nonetheless, with the rotational symmetry that is prohibited in the periodic crystals, such as the five-fold symmetry. The quasicrystal is, therefore, different from periodic crystals and random glasses, and now is regarded as the third form of solids. There is a class of crystals, called " approximants ", in which the high-symmetry (such as icosahedral) atomic clusters, identical to those in the quasicrystals, form periodic array, and thus being approximation of the quasicrystalline structure. Recently, for the first time we have determined magnetic structure of the antiferromagnetic 1/1 Au-Al-Tb approximant using ECHIDNA [1], which turns out to be a very intriguing non-collinear and non-coplanar whirling order. We also have performed single crystal neutron diffraction on the macroscopically ferromagnetic quasicrystal approximant Au-Si-Tb [2]. Together with the crystalline-electric-field anisotropy estimated from inelastic neutron scattering spectra, we also proposed nontrivial noncollinear and noncoplanar magnetic structure quite similar to that observed in the Au-Al-Tb. In this work, to accumulate knowledge on the magnetic ordering in the quasicrystal approximants, powder neutron diffraction was performed on the Au-Ga-Tb 1/1 approximant.

A polycrystalline alloy of the Au-Ga-Tb 1/1 approximant was prepared by arc melting with high purity Au, Ga and Tb elements with proper heat treatment to obtain single phase specimen. The neutron powder diffraction experiment has been performed using the high-resolution powder diffractometer ECHIDNA installed at the OPAL reactor, Australian Nuclear Science and Technology Organisation [3]. For most of the magnetic diffraction measurement, neutrons with $\lambda = 2.4395$ Å was selected using the Ge 311 reflections, whereas for the structure analysis, to obtain reflections in a wide Q-range, we select $\lambda = 1.622$ Å using the Ge 335 reflections. The sample was set in the ϕ6 mm vanadium sample can, and then set to the cold head of the closed cycle ^{4}He refrigerator with the base temperature 3.5 K.

Figure shows the overall diffractograms at the base temperature ($\simeq$ 3.5 K) and the paramagnetic temperature $T = 20$ K. One can clearly see the development of sharp magnetic reflections at the base temperature. They are the clear indication of magnetic long-range order in this 1/1 approximant. The magnetic structure analysis using the representation analysis is now under way.

References: [1] T. J. Sato, A. Ishikawa, A. Sakurai, M. Hattori, M. Avdeev and R. Tamura, Phys. Rev. B 100, 054417 (2019); [2] T. Hiroto, T. J. Sato, H. Cao, T. Hawai, T. Yokoo, S. Itoh, and R. Tamura, J. Phys.: Condens. Matter (in press); [3] M. Avdeev and J. R. Hester, J. Appl. Crystallogr. 51, 1597 (2018).

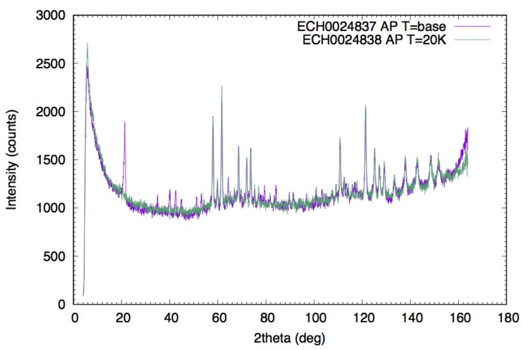

Fig. 1. Neutron diffraction patterns obtained in at the base temperature ($\simeq$ 3.5 K) and the paramagnetic temperature $T = 20$ K at ECHIDNA.