Magnetism of Tsai-type approximants

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Tsai-type approximants, which are composed of rare-earth(*R*) icosahedra, are of particular interest in view of their magnetism since they provide unique localized spin systems, i.e., a periodic array of interacting *R* spin icosahedra. Since the first observation of long-range magnetic order in a Tsai-type approximant [1], i.e., Cd_6Tb, much attention has been paid to the magnetism of Tsai-type approximants and a number of binary and ternary Tsai-type approximants have been synthesized and investigated to date. Although the existence of various magnetic orders such as antiferromagnetic(AF), ferromagnetic(FM) and spin-glass (SG) states has been well demonstrated so far, AF states in ternary systems were found only recently, i.e., in the Au-Al-(Gd.Tb) systems [2]. The $Au_{73}Al_{13}Gd_{14}$ and $Au_{72}Al_{14}Tb_{14}$ approximants exhibit a sharp cusp at T_N=9.4 and 11.8 K, respectively, in the χ-T curves without bifurcation of ZFC and FC curves, suggesting an occurrence of AF transitions. Below T_N, a spin-flop phenomenon was clearly noticed in the *M*-*T* curve for both compounds. One characteristic feature here is the observation of spin-flop for $Au_{73}Al_{13}Gd_{14}$ that has isotropic Gd spins.

The Au-Al-(Gd,Tb) systems have a large single phase region, elongated over wide Au/Al ratios with the constant *R* composition of 14 at%. The magnetic ground state systematically changes with a variation in the Au/Al ratio. The AF states were found at a small region where the Weiss temperatures Θ_p is weakly positive, implying that both FM and AF interactions coexist stabilizing the AF order. In the presentation, we will first discuss the condition for the formation of the AF state in Tsai-type approximants in general based on the observation in a variety of alloy systems, and then discuss the possible origin of the AF order in terms of the nearest and second-nearest interactions.

[1] R. Tamura, Y. Muro, T. Hiroto, K. Nishimoto, and T. Takabatake, Phys. Rev. B **82** (2010) 220201(R).
[2] A. Ishikawa, T. Fujii, T. Takeuchi, T. Yamada, Y. Matsushita, and R. Tamura, Phys. Rev. B **98** (2018) 220403(R).