Magnetic ordering and excitations in the Zn-Fe-Sc-RE (RE: rare-earth) icosahedral quasicrystals

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Quasicrystals are characterized by sharp Bragg reflections with a point symmetry that is forbidden in a periodic lattice, such as the five-fold symmetry. For magnetic quasicrystals, non-trivial ordering of spins arranged on a quasiperiodic lattice may be expected in theory. Nevertheless the long-range order has not been observed yet in any magnetic quasicrystals, despite continuous efforts to find the magnetic long-range order made to date. The recently discovered Zn-Fe-Sc-*RE* (*RE*: rare-earth) quasicrystals has been expected to have the highest possibility to show magnetic long-range order, since it has highest magnetic ion concentration among magnetic quasicrystals reported to date. In addition, the combination of the $3d$ and $4f$ moments may provide longer inter-spin interactions, resulting in the likely situation for the long-range order. Here, we report first neutron scattering study on the new magnetic quasicrystals Zn-Fe-Sc-*RE* (*RE* =Ho and Tm). Experiments have been performed at the triple-axis spectrometer 4G-GPTAS with incident energy $E_{\mathrm{i}} = 13.7$ meV. Data shown here were taken with a double-axis mode. A powder sample of Zn-Fe-Sc-*RE* was prepared by melting constituent elements and heat-treated in an appropriate manner.

Shown in Fig. 1 are powder diffraction patterns taken at the two temperatures $T = 3.8$ and 30 K. The difference between the two-temperature data sets is also shown by the blue triangles. As the nuclear Bragg reflections are clearly seen in the figure at both the temperatures, the temperature dependence shows very flat behavior, excluding possibility for appearance of the magnetic Bragg reflections at the lowest temperature. We also checked existence of the magnetic Bragg reflections in several samples with *RE* = Ho and Tm, with a few different *RE* concentration, however, all of them gives negative results. Further exploratory study on the magnetic quasicrystal with higher magnetic ion concentrations is in progress; neutron diffraction study on those materials is obviously necessary to detect definite long-range signal.

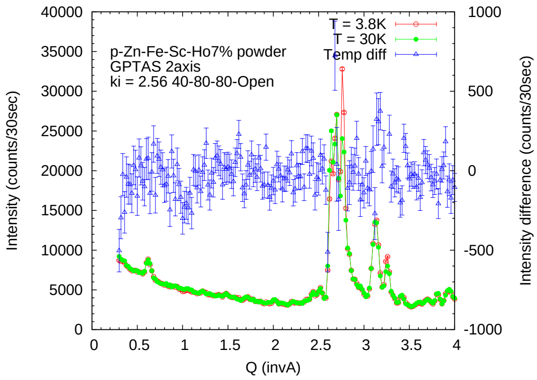

Fig. 1. Neutron powder diffraction patterns at $T = 3.8$ (red) and 30 K (green) obtained at ISSP-GPTAS. Temperature difference [$I(3.8\ \mathrm{K}) - I(30\ \mathrm{K})$], as a magnetic scattering contribution, is also shown by the blue triangles.