Supplemental Materials

Reentrant spin reorientation transition and Griffiths - like phase in antiferromagnetic TbFe$_{0.5}$Cr$_{0.5}$O$_3$

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Neutron powder diffraction (NPD) Analysis

FIG. S1. Rietveld refinement of neutron powder diffraction data at 350 K with Pnma space group. The intensity of nuclear Bragg peak position at (101) is not fully accounted for by the model.
FIG. S2. Neutron powder diffraction pattern of TbFe$_{0.5}$Cr$_{0.5}$O$_3$. The experimental data (red) and calculated pattern (black) with the Rietveld refinement program at 300 K, 215 K, 100 K, 20 K and 7.7 K for all possible irreducible representations confirms that the magnetic structure of TbFe$_{0.5}$Cr$_{0.5}$O$_3$ belongs to $\Gamma_2$ representation at 300 K, at $T_N$ (257 K) it transforms to $\Gamma_4$, and at $T_{SR}$ (190 K) it re-enters $\Gamma_2$ which remains stable down to 7.7 K.

| $T$ (K) | Element       | $m_x$ ($\mu_B$) | $m_y$ ($\mu_B$) | $m_z$ ($\mu_B$) |
|---------|---------------|-----------------|-----------------|-----------------|
| 300     | Fe$^{3+}$/Cr$^{3+}$ | 0.52(4)         | 3.58(1)         | 0.62(1)         |
| 215     | Fe$^{3+}$/Cr$^{3+}$ | 0.48(6)         | 0.59(2)         | 1.74(3)         |
| 100     | Fe$^{3+}$/Cr$^{3+}$ | 0.52(4)         | 3.48(2)         | 1.38(5)         |
| 20      | Fe$^{3+}$/Cr$^{3+}$, Tb$^{3+}$ | 0.11(4) | 3.14(4) | 0.00 | 0.75(2) | 0.84(6) |
| 7.7     | Fe$^{3+}$/Cr$^{3+}$, Tb$^{3+}$ | 0.13(1) | 3.19 (4) | 0.00 | 1.27(1) | 0.00 |

Table. S1. Components of magnetic moment obtained from neutron powder diffraction for TbFe$_{0.5}$Cr$_{0.5}$O$_3$ at different temperatures.
