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Magnetic transition at ~150 K in nanoscale BiFeO$_3$

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From the high resolution powder neutron diffraction data, we obtain an evidence of spin-reorientation type transition around ~150 K in nanoscale BiFeO$_3$. The magnetic phase forms at ~150 K, as a result of canting of the spins away from c- to a-axis by ~6$^\circ$, has been modeled by considering two antiferromagnetic phases of propagation vectors $k = (0, 0, 0)$ and $(0, 1/4, 1/4)$ and moments aligned along c- and a-axes. Direct magnetic measurement too, under both 0 and 50 kOe field, offers evidence for such a transition. While the experiment on a single crystal does not offer any evidence of magnetic transition at ~150 K [M. Ramazanoglu et al. Phys. Rev. B 83 (2011), art. 174434(1-6)], clear observation of the transition in nanoscale BiFeO$_3$ implies crucial role of the antiferrodistortive rotation of FeO$_6$ octahedra, associated with large magnetization and enhanced canting angle, in inducing the transition. The transition is found to have a significant influence on the crystallographic parameters too, including the structural noncentrosymmetry which show distinct anomaly around 150 K.

Keywords: Spin reorientation transition, size and strain effect, nanoscale BiFeO$_3$

Introduction

The magnetic structure in multiferroic BiFeO$_3$ is known to be complicated ever since its solution way back in 1982 when the time of flight experiment of neutron diffraction showed that the canted G-type antiferromagnetic structure undergoes a cycloidal modulation over a length scale of ~62 nm [1]. The magnetic transition point ($T_N$) was determined to be ~653 K in bulk sample. Surprisingly, the neutron diffraction patterns recorded across a wide temperature range 5-700 K did not exhibit signature of any further magnetic transition within 5 K to $T_N$ [2]. In recent times, however, different experiments, including direct magnetic measurements, present
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