Role of electronic and atomic properties in an XY-like spin-glass system $Ni_{0.4}Mn_{0.6}TiO_3$

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Abstract

Recent discovery of XY-like spin-glass on single crystal $Ni_{0.4}Mn_{0.6}TiO_3$ (NMTO) introduces linear magnetoelectric coupling and toroidal moment. Generally, combination of the competing exchange interactions and either site or bond disorder can give rise to a spin glass state. We have used synchrotron techniques like x-ray absorption near-edge structure (XANES), extended x-ray absorption fine structure (EXAFS) and resonant inelastic x-ray scattering (RIXS) to investigate the roles of electronic and atomic properties in the XY-like spin-glass system. Magnetization measurements reveal the signatures of spin-glass behavior in the NMTO with a freezing temperature of $T_{SG}\approx$ 9.1 K. RIXS experiments provide the evidence of *d-d* excitations at Ni and Mn L_3-edge. These excitations at Ni L_3-edge are strongly dependent on the excitation energies; however they are almost independent for Mn L_3-edge. Further, these inelastic features show stronger intensities than elastic peaks at Ni L_3-edge, which indicate high probability of *d-d* excitations at Ni 3*d* orbitals. Using temperature dependent XANES, x-ray linear dichroism (XLD) and EXAFS studies along with RIXS, it has been shown that the preferential occupation of orbitals from out-of-plane states ($3d_{3z^2-y^2}$) to in-plane ($3d_{x^2-y^2}$) the due to local disorder of Ni-O bond lengths. We therefore believe that XY-like spin glass state of NMTO is associated with the unoccupied in-plane ($3d_{x^2-y^2}$) states.