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Spin-lattice coupled anomalies and magneto-crystalline transition in $\text{Pr}_{0.50}\text{Sr}_{0.50}\text{CoO}_3$ investigated by x-ray absorption spectroscopies

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The spin state of Co ions is a key degree of freedom in many $\text{Ln}_{1-x}\text{A}_x\text{CoO}_3$ (Ln : lanthanide, A:alkaline-earth) oxides with remarkable physical properties. In $(\text{Pr}, \text{Ln}_{1-x})\text{Ca}_x\text{CoO}_3$ cobaltites near half-doped ($x \approx 0.5$), Co^{3+} spin-state sharp changes induce a first-order Pr^{3+} to Pr^{4+} valence shift and an exotic MIT. The insulating state is extraordinarily unleashed by electron transfer from Pr to Co sites, producing a volume contraction and stabilizing the diamagnetic Co^{3+} in LS state. $\text{Pr}_{0.50}\text{Sr}_{0.50}\text{CoO}_3$ (PSCO) notably differs from $\text{Pr}_{0.50}\text{Ca}_{0.50}$ (PCCO). In contrast with the absence of long-range magnetic order in PCCO, metallic PSCO is FM below $T_C \approx 230$ K. Here, an unexpected step in magnetization at $T_{S1} \approx 120$ K was ascribed to changes in the magnetocrystalline anisotropy. This step may be positive or negative as a function of the applied field. The crystal symmetry reduction from orthorhombic to tetragonal at T_{S1} , with a significant local deformation of Co-O octahedra could be related to changes in the orbital moment m_l . However, the $\text{Co}_{2,3}$ XMCD-derived m_l shows a monotonous behavior with temperature and no anomaly across T_{S1} . This contrasts with m_s , which presents an upward (downward) step on cooling at 100 (10) mT. This result thus points to a leading role of the spin-lattice coupling in this anomalous transition shown by PSCO. XAS and XES spectra also suggest Co^{3+} ions to be in a mixed spin state coexisting with predominantly low spin Co^{4+} ions, with an average spin state slightly larger than the one recently determined for PCCO.

References

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