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Unconventional magneto-transport in novel layered cobalt oxides

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Among strongly correlated transition-metal oxides, cobalt oxides are known to have unique features arising from the spin-state degree of freedom tightly coupled with Co valence. The Co^{4+} ion in the low spin-state is responsible for anomalous metallic states such as large thermopower in Na_xCoO_2 and unconventional superconductivity in hydrated Na_xCoO_2. The Co^{2+} ion favors the high-spin state, which makes magnetic insulators. The Co^{3+} ion is most interesting in the sense that the low-, intermediate- and high-spin states are nearly degenerate, where a spin-state crossover/transition occurs with temperature or pressure. Recently we have discovered two complex layered cobalt oxides, which exhibit unprecedented transport originated from interplay between charge, orbital and spin-states. The first one is $SrCo_6O_{11}$, in which the Co-O Kagome lattice and two-types of Co-O pillars are stacked along the c axis [1]. The conduction electrons in the Kagome lattice interact with Ising spins in the pillars, and shows two-step plateau in the magnetoresistance along the c axis. The second one is $Sr_3YCo_4O_{10.5}$, which exhibits a ferromagnetic insulating state below 340 K. Various substitutions of Sr, Y and Co sites dramatically suppress this ferromagnetic state, and concomitantly modify the magneto- and thermoelectric transport. We will discuss the structure-property relationship based on structure analyses. The main part of this work was done in collaboration with S. Ishiwata, W. Kobayashi, and M. Takano.

[1] S. Ishiwata et al., Chem. Mater. 17, 2789 (2005) ; Phys. Rev. Lett. 98, 217201 (2007)
[2] W. Kobayashi et al. Phys. Rev. B 72, 104408 (2005) ; S. Ishiwata et al. Phys. Rev. B75, 220406(R) (2002)