Unusual electronic and magnetic properties in cobaltites with low dimensionality

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The cobaltites properties depend on the cobalt oxidation- and spin-states. Combined to the low dimensionality and geometrical frustration, this gives rise to complex physical properties. In the case of the 1D $Ca_3Co_2O_6$ compound, the "Co-O" chains are made of alternating face-sharing octahedra (*oct.*) and trigonal biprisms (*bip.*). The ferromagnetic (F) chains separated by the calcium are set on a triangular lattice and, due to the interchain antiferromagnetic (AF) coupling, $Ca_3Co_2O_6$ can be viewed as a triangular Ising AF system. In the chains, low-spin (*LS*) and high-spin (*HS*) Co^{3+} cations alternate in the *oct.* and *bip.*, respectively. This 1D system exhibits remarkable magnetization (M) plateaus, at low T, with one plateau corresponding to the ferrimagnetic (FI) configuration of the chains on the triangle. Interestingly, the *oct*. coordinated *LS* cations can be totally or partially substituted by either magnetic (Ir^{4+}, Rh^{4+}, S = 1/2) or diamagnetic (Sc^{3+}: $3d^0$) cations. For both $Ca_3Co_2O_6$ and Ca_3CoRhO_6, a 'partially disordered AF' state is realized, but, for Ca_3CoIrO_6 the M plateau at $M_{saturation}/3$ (FI) is suppressed. The properties of these materials (M, ρ, Seebeck) will be compared to those of Sr_3NiIrO_6. In the latter, the intrachain coupling between $Ni^{2+}_{bip.}$ (S=1) and $Ir^{4+}_{oct.}$ (S = ½) is AF contrasting with the F ones in Ca_3CoMO_6 (M = Co, Ir, Rh). The low-T magnetic properties of the Sr_3NiIrO_6 compound show a spin disordered state similar to that of the Ca_3CoMO_6 compounds (left fig.).

The 'misfit' cobaltites possess 2D structures with two aperiodic substructures built of rocksalt-type separating layers sandwiching CdI_2-type CoO_2 layers. The latter is made of edge-shared CoO_6 octahedra leading to an unusual coexistence of LS Co^{3+}/Co^{4+} cations. In this hexagonal layer, the cobalt form a triangular plane and due to the rhombohedral crystalline-field, the t_{2g} orbitals are believed to be splitted in two subbands with heavy and light holes responsible for metallicity and large thermoelectric power (TEP), respectively. The structural features of new misfit cobaltites will be shown and discussed in connection to their magnetoresistance and magneto-TEP properties (right fig., from *A.Maignan,S. Hébert, M.Hervieu, C. Michel, D. Pelloquin and D. Khomskii, J. Phys.: Condens. Matter, 15 (2003) 2711*).