# Charge order and anomalous magnetism in the Na cobaltates

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In 2003 superconductivity at 4.5K has been discovered in $Na_{0.35}CoO_2$,$1.3H_2O$, a hydrated cobaltate. These layered Na cobaltates have some analogies with the cuprates as 2D conductivity occurs in the $CoO_2$ planes, where the Co are arranged on a triangular lattice, and doping can be modified by changing the Na content. Also ordered magnetic phases have been evidenced, but unexpectedly for large values of $x$ for which one would expect a hole doping of the band insulator $NaCoO_2$. Indeed, in the high crystal field on the Co sites in these compounds, an ionic picture for the Co states would correspond to low spin configurations $Co^{3+}$, S=0 or $Co^{4+}$, S=1/2.

After a brief general introduction on these materials, we shall present SQUID, $^{23}$Na and $^{59}$Co NMR[(1)] and $\mu$SR data[(2)] taken on samples synthesized and characterized by X ray cristallography in LLB, Saclay. We evidence that the Co charge is uniform for $x$=0.35 as in the hydrated superconducting phase. For high Na contents the samples are found to display ordered Na structures or mixtures of those, with different $x$ values. In pure phases isolated for specific $x$ values, we evidence a charge disproportionation into non magnetic $Co^{3+}$ and more magnetic Co sites with an average charge of about $Co^{3.5+}$, except for $x$=0.5[(3)]. This hole delocalization and charge order occur both for paramagnetic and AF phases[(4)]. NMR investigations of the dynamic susceptibilities allow us to characterize the nature of the in plane electronic correlations in most parts of the phase diagram.

Contrary to the case of most cuprates for which dopant disorder is quite influential, the hole doping achieved in cobaltate samples is associated with the insertion of well ordered Na planar structures. They have to be taken into account to explain theoretically the metallicity, the magnetic properties and their evolution with doping.

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[3] *J. Bobroff, G. Lang, H. Alloul, N. Blanchard and G. Collin, Phys. Rev. Lett.* ***96****, 107201 (2006).*
[4] *H. Alloul, I. Mukhamedchine, G. Collin et N. Blanchard, Europhysics Lett.* ***82****, 17002 (2008).*