Search of new unconventionnal superconductors: the case of Cr based compounds

Pierre Toulemonde[1,2], *Justin* Jeanneau[1,2], *Manuel* Nunez-Regueiro[1,2]
[1]*Univ Grenoble Alpes, Inst. NEEL, F-38000 Grenoble, France*
[2]*CNRS, Inst NEEL, F-38000 Grenoble, France*

After 30 years of research on the superconducting cuprates, the discovery of high T_c superconductivity in related iron based pnictides in 2008 has stimulated the search of new superconductors. In particular, antiferromagnetic (AFM) systems with 3d transition elements, with high Néel temperature (T_N), moderate magnetic moments and with crystallographic 2D layers could be adequate parent phases for new unconventional superconductors. Among 3d elements, Chromium has recently focused attention with the discovery of superconductivity in CrAs at T_c~2K under a moderate pressure of ~0.8GPa and in a family of Cr-based 1D compounds $A_2Cr_3As_3$ (A=K,Rb,Cs) with T_c values in the 2.2-6.1K range at ambient pressure.

During these last few years we have investigated several Cr-based systems like $CrSb_2$ and the layered Cr-based oxides, i.e. the Sr-based Ruddlesden-Popper (RP) series $Sr_{n+1}Cr_nO_{3n+1}$ obtained under high-pressure and high temperature (HP-HT) conditions. We have used high pressure in order to tune and weaken the AFM order, to possibly induce a superconducting state.

For $CrSb_2$ we have followed the decrease of T_N under pressure and found a simultaneous structural and electronic transition, i.e. a transition from a semiconducting state towards a metallic state, above 10 GPa. For the RP series, up to 20GPa no superconductivity was found in n=1 (Sr_2CrO_4), n=2 $Sr_3Cr_2O_7$ and n=∞ ($SrCrO_3$) members and the chromates remain insulating. Nevertheless we have evidenced several interesting properties at ambient pressure in n=2 and 3 members. The antiferromagnetic ordering of $Sr_3Cr_2O_7$ at T_N=210K, clearly visible in the magnetization and specific heat measurements, yields a huge transition entropy, Rln(6). By neutron powder diffraction (NPD) as a function of temperature we have determined the AFM structure, that coincides with the one obtained from DFT calculations. It is accompanied by anomalous asymmetric distortions of the CrO_6 octahedra. Strong coupling and Lanczos calculations on a derived Kugel-Khomskii Hamiltonian yield a simultaneous orbital and moment ordering. Our results favor an exotic ordered phase of orbital singlets not originated by frustration in this CrO_2-bilayer system. Moreover in the case of Sr_2CrO_4, our NPD study reveals that their CrO_6 octahedra show an anomalous apparently inverse Jahn-Teller effect, i.e. a smaller distortion at low temperature, i.e. below its T_N=110K and T_S=140K. DFT calculations support this scenario.