Ruthenates: Unconventional superconductivity and magnetism

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Ruthenates represent an extraordinary system with a large variety of phases such as unconventional superconductivity, Mott-insulating magnetic order and strong correlation of spin and orbital kind. The electronic properties of these systems are governed by the three 4d-t_{2g}-orbitals, suggesting that a multi-band picture is essential in order to understand many properties. In this talk I will point out several problems where multi-band aspects appear crucial for the spin-triplet superconducting phase of Sr_2RuO_4. This includes thermodynamic properties and the stability of the so-called chiral p-wave state. Multi-orbital physics apparently also plays an essential part in the magnetic properties of the alloy $Ca_{2-x}Sr_xRuO_4$ which shows a structural quantum phase transition separating phases with enhanced ferromagnetic and antiferromagnetic spin correlations, and the Mott-insulating antiferromagnetically ordered phase. I will show that these features have a consistent explanation, if we assume that some of the t_{2g}-orbitals localize, forming a spin-orbital system that can be described by a Kugel-Khomskii-type model. Finally, some comments will be given on the magnetic behaviour of the multi-layer ruthenates.