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Spin and Orbital Ordering in Vanadates

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Vanadate compounds provide ideal systems to study the interactions between spin, lattice and orbital degrees of freedom. This talk will discuss the physics of two vanadates, CaV_2O_4 and MgV_2O_4. In both materials the Vanadium ion is in the 3+ valence state resulting in two electrons in the 3d-shell and a spin of S=1. In CaV_2O_4 the V^{3+} ions form quasi-one-dimensional zig-zag chains with frustrated first and second neighbor exchange interactions, while in MgV_2O_4 they lie on a frustrated pyroclore lattice. The electronic configuration of the V^{3+} ions consists of two electrons in the three t_{2g} levels giving rise to orbital degrees of freedom in these compounds. The orbital and magnetic degrees of freedom are strongly coupled because the magnetic interactions occur via direct overlap of the t_{2g} orbitals and as a result orbital ordering has a strong impact on the exchange pathways and magnetic behaviour. Both compounds undergo structural phase transitions which either partially or fully lift both the orbital degeneracy and magnetic frustration, long-range antiferromagnetic order then occurs at a lower temperature. Heat capacity, DC susceptibility and neutron and x-ray scattering data will be presented. The results reveal that at high temperatures CaV_2O_4 behaves as a Haldane chain, but at low temperatures, it is a spin-1 ladder, while in MgV_2O_4 three-dimensional magnetism is replaced by one-dimensional behaviour at low temperatures. The results are discussed in term of orbital ordering.