Coupling of Spin, Charge and Orbital Ordering in Selected Transition-Metal Oxides

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The coupled order of electronic and magnetic degrees of freedom is a frequently appearing phenomenon in transition-metal oxides that is associated with exotic phenomena such as high-temperature superconductivity and colossal magnetoresistivity. By a precise measurement of the – usually very weak – crystal-structure distortions, direct insight in the nature of the electronic order is obtained. In addition the analysis of the dispersion of magnetic excitations allows one to decide between different models of charge and orbital order.

We will discuss in detail the ordering in layered manganites, $La_{1-x}Sr_{1+x}MnO_4$. For the half-doped material we may unambiguously identify the Goodenough model of electronic order as the appropriate one [1]. Very recent studies on a half-doped perovskite manganate reach at the same conclusion. Overdoping the layered manganate ($x>0.5$) leads to an incommensurate stripe-like coupling of four different order parameters: charges, orbitals and Mn^{3+} and Mn^{4+} spins [2]. Stripe-like phases of charge and magnetic order are also found in layered cobaltates in close similarity with those observed in the nickelates and cuprates [3].

Well-defined charge ordering is also found in the $Y_{1-x}Ca_xTiO_3$ and $RE_{1-x}Ca_xTiO_3$ series accompanying the metal-insulator transition. This charge order may explain the large stability of the insulating phase in these compounds with smaller RE's. In titanates and vanadates with low d-electron occupation the charge modulation is found to be in general larger than in the oxides with large 3d occupation.

[1] D. Senff et al., Phys. Rev. Lett. ***96****, 257201 (2006); [2] H. Ulbrich et al., Phys. Rev. Lett.* ***106****, 157201 (2011); [3] M. Cwik et al., Phys. Rev. Lett.* ***102****, 057201 (2009).*