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Directly probing the effect of strain on magnetic exchange interactions

KATHRIN DORR, Institute for Physics, MLU Halle-Wittenberg

Thin films of transition metal oxides of the perovskite type ABO_3 (B = 3d or 4d metal) have revealed abundant examples for strain-driven changes of magnetic ordering. One most popular is the strain-induced ferromagnetic ferroelectric state of otherwise antiferromagnetic paraelectric $EuTiO_3$. Another promising example is the strain control of orbital occupation and magnetic coupling at oxide interfaces of $SrRuO_3$ with manganites. In spite of strong efforts, the theoretical treatment of magnetic exchange in complex oxides has remained a challenge, and experiments continue to show unpredicted / unexplained large effects of the epitaxial strains in films. In order to provide meaningful experimental data on strain dependences, epitaxial thin films should be grown in various coherent strain states on different substrates without changing anything but the strain. This is inherently difficult: possible problems may arise from a strain-dependent oxidation level or microstructure. As a complementary approach, the in-plane strain of epitaxial oxide films can be controlled reversibly using a piezoelectric substrate, even though the accessible reversible strain of 0.1 – 0.2% is an order of magnitude smaller. In my talk, I will address reversible-strain studies on $La_{0.7}Sr_{0.3}MnO_3$, $La_{1-x}Sr_xCoO_3$ (x = 0, 0.2, 0.3) und $SrRuO_3$ films, showing the strain response of the magnetic Curie temperature, the magnetization and the electrical resistance and discussing the current understanding of the strain effects on magnetic ordering. In $La_{0.8}Sr_{0.2}CoO_3$, a strain-driven phase transition between ferromagnetic and spin-glass-like could be established by combining the piezoelectric substrate with a tuned buffer system providing varied as-grown strain states. In $SrRuO_3$, a tetragonal tensile strain state shows a suppression of the ordered magnetic moment. Lattice parameters and symmetries of the films were determined by x-ray diffraction. It is noted that the atomic displacements (bond lengths and angles) under strain in these compounds are yet essentially unknown and subject to present research.