Dimensionality-Controlled Collective Charge and Spin Order in Nickel-Oxide Superlattices

Y. Matiks[a], B. Boris[a], E. Benckiser[a], A. Frano[a], T. Prokscha[b], E. Morenzoni[b], G. Cristiani[a], H.-U. Habermeier[a], and B. Keimer[a]

[a]Max Planck Institute for Solid State Research, Stuttgart, Germany
[b]Paul Scherrer Institute, Villigen, Switzerland

The competition between collective quantum phases in transition metal oxides depends very sensitively on the dimensionality, because the low-dimensional correlated electron systems are known to be more susceptible to collective ordering phenomena. Such high susceptibility indicates an alternative route towards dimensionality control by means of the deposition sequence of electronically active and inactive TMO layers. Motivated by the desire to realize the potential of TMO heterostructures in controlling collective quantum phases, we have fabricated superlattices of the paramagnetic metal $LaNiO_3$ and the wide-gap insulator $LaAlO_3$ with atomically precise layer sequences. Using optical ellipsometry and low-energy muon spin rotation, superlattices with $LaNiO_3$ as thin as two unit cells are shown to undergo a sequence of two sharp, collective electronic phase transitions upon cooling. We have provided strong evidence that the two transitions correspond to the onset of charge and antiferromagnetic spin order. By showing that samples with thicker LaNiO3 layers remain uniformly metallic and paramagnetic at all temperatures, we have demonstrated full dimensionality control of these collective instabilities [1].
[1] A. V. Boris, Y. Matiks, E. Benckiser *et al.*, Science, in press