Max Planck Research Department for Structural Dynamics

SEMINAR

October 11th, 2011 - 11:00 am

Seminar Room 108, DESY Bldg. 49

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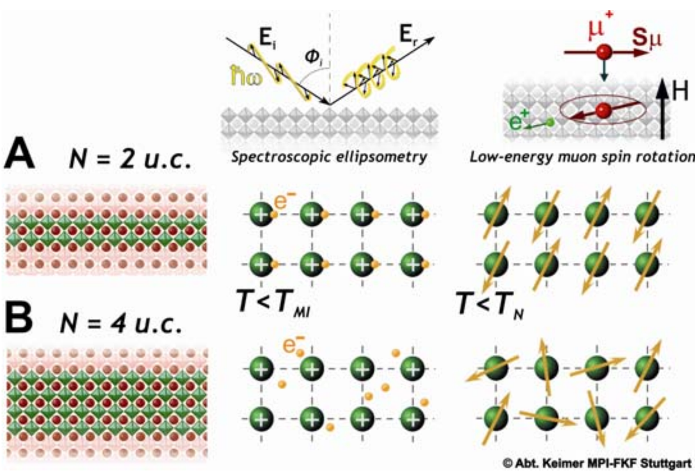
Control of electron flow and magnetism in atomically thin transition metal oxides

Recent advances in the synthesis of transition metal oxides (TMO) heterostructures with atomically sharp interfaces open new functionalities by tuning the interfacial properties of correlated electron materials, in the same manner as for semiconductor heterostructures. Motivated by the desire to realize the potential of TMO heterostructures in controlling collective quantum phases, we have built devices out of atomically thin layers of two different TMOs - LaNiO3 and $LaAlO_3$ - which are metallic and insulating in bulk form, respectively. To explore the behavior of electrons in the atomically thin layers, we have used a suite of advanced experimental probes such as synchrotron-based infrared ellipsometry (at the IR1 beamline of ANKA, Karlsruhe) and low-energy muon spin rotation (at the LEM beamline of PSI, Villigen). When the layers are more than three atomic monolayers thick, the electrons were found to behave in a manner closely similar to the one in the bulk. In heterostructures where the conduction electrons are confined to two atomic monolayers separated by insulating layers, their behavior changes completely, exhibiting a sequence of two collective phase transitions upon cooling. We have provided strong evidence that these transitions correspond to the onset of charge and antiferromagnetic spin order. We have thus demonstrated that the collective electronic phases in these TMO devices can be accurately controlled by adding a single atomic monolayer.



Schematic representation of the main experimental results: Dielectric response and transverse field muon spin rotation measurements show that A superlattices with $LaNiO_3$ as thin as two unit cells undergo a sequence of collective metal-insulator and antiferromagnetic transitions upon cooling, whereas B superlattices with thicker $LaNiO_3$ layers remain metallic and paramagnetic at all temperatures.

Reference: A. V. Boris et al., Science 332, 937 (2011).

Host: Andrea Cavalleri, Condensed Matter Division, MPSD, CFEL