Highlights

Activity C - Innovative materials with strong interplay of spin, orbital, charge and topological degrees of freedom - 2021

Magnetic-Field Tunable Intertwined Checkerboard Charge Order and Nematicity in the Surface Layer of Sr_2RuO_4

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In strongly correlated electron materials, the electronic, spin, and charge degrees of freedom are closely intertwined. This often leads to the stabilization of emergent orders that are highly sensitive to external physical stimuli promising opportunities for technological applications. In perovskite ruthenates, this sensitivity manifests in dramatic changes of the physical properties with subtle structural details of the RuO_6 octahedra, stabilizing enigmatic correlated ground states, from a hotly debated superconducting state via electronic nematicity and metamagnetic quantum criticality to ferromagnetism. Here, it is demonstrated that the rotation of the RuO_6 octahedra in the surface layer of Sr_2RuO_4 generates new emergent orders not observed in the bulk material. Through atomic-scale spectroscopic characterization of the low-energy electronic states, four van Hove singularities are identified in the vicinity of the Fermi energy. The singularities can be directly linked to intertwined nematic and checkerboard charge order. Tuning of one of these van Hove singularities by magnetic field is demonstrated, suggesting that the surface layer undergoes a Lifshitz transition at a magnetic field of ≈32T.

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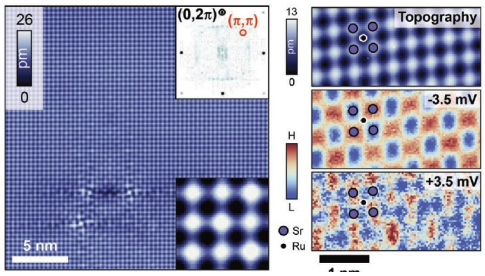

Fig. 1: Left: Topography showing the Sr square lattice. Lower inset: enlarged topography. Upper inset: Fourier transformation with Bragg peaks at (0, 2π) and (2π, 0). Peaks at (π, π) and (−π, π) coincide with the periodicity of the surface reconstruction. Right, top: Topography with a model indicating the positions of the Sr atoms. Bottom: Real-space g(r,V) maps at V=−3.5mV and +3.5mV recorded simultaneously with the topography. A strong checkerboard charge order is observed.

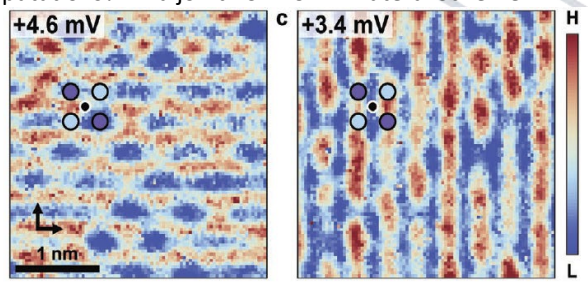

Fig. 2: Nematicity and the equivalence of checkerboard charge order with C4 symmetry breaking. The charge order on the Sr lattice combined with the octahedral rotations leads to a broken C4 symmetry, due to which oxygen atoms along the [10] and [01] directions are in an inequivalent environment. The measurements reported above show nematicity in the atomic scale charge modulations (T = 1.8 K).