Lasting interests in oxide hetero-interfaces

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In the last two decades, different heterointerfaces have shown emergent properties very different from their constituents. Two insulating oxides $SrTiO_3$ and $LaAlO_3$, joined together to form a heterostructure, produced a highly conductive two-dimensional electron liquid (2DEL) at the interface. This 2DEL exhibits exciting new phenomena such as finite-momentum triplet superconductivity coexisting with inhomogeneous ferromagnetism. For reasonably strong disorder, the system breaks up into mutually excluded regions of superconductivity and ferromagnetism, with a clustering of vacancies at low temperatures, ruling out an FFLO state [1]. A phase-transition to topological superconductivity is driven by perpendicular magnetic fields and gapless topological excitations [2] at the core of a vortex, such as Majorana fermions, may be realised. Possible scenarios for anomalous Hall effect and spin Hall effect with changing Fermi surface topology (a Lifshitz transition) are outlined [3]. The observation of transient superconductivity above nominal Tc implying a 'hidden' superconducting order [4,5] is understood. The electronic properties [6] of a polar-polar $LaVO_3/KTaO_3$ (LVO/KTO, 001) hetero-interfaces of up to six and five layers of KTO and LVO, respectively, suggest the presence of multiple Lifshitz transitions (LT). While the spin-orbit coupling is found to be negligible, coming only from the Ta 5d xy-derived bands, intriguing magnetic properties are observed. The magnetic states are highly sensitive to the number of layers of LVO & KTO: even-even and odd-odd layers show AFM order for more than two LVO layers. The spin-polarized density of states reveals that all the interfaces with ferromagnetic (FM) ground states are half-metallic. Remarkably, the critical thickness of four LVO layers for metallic interface, observed in experiments, appears only when the system is magnetic. The small energy differences between AFM and FM configurations indicate a possible coexistence of competing AFM and FM ground states in these interfaces.

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