Superconductivity in $KTaO_3$ Oxide 2DES

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Transition-metal-oxide two-dimensional electron systems (2DES) offer a versatile route to engineer electronic phases arising from the interplay of symmetry breaking, orbital reconstruction and spin–orbit coupling. A paradigmatic example is the $LaAlO_3/SrTiO_3$ (LAO/STO) interface, where superconductivity and Rashba spin–orbit coupling coexist and can be controlled by electric field effect making this 2DES a model systems for investigating interfacial superconductivity and possible unconventional pairing mechanisms. A variety of field effect mesoscopic devices, including Josephson Junctions, SQUIDs, quantum dots and quantum point contact devices have also been realized in the latest years, showing the ability to control the 2DEG at the relevant scales including the superconducting coherence length or the Fermi wavelength. However, superconductivity in LAO/STO occurs at relatively small energy scales, with critical temperatures typically below 250mK and superconducting gaps of only a few tens of microelectronvolts. In this context, $KTaO_3$-based two-dimensional electron gases have recently emerged as particularly promising systems. Superconductivity at $KTaO_3$ interfaces, in the (111) crystallographic orientation, exhibits critical temperatures up to 2.2 K and the larger atomic spin–orbit coupling associated with Ta-5d orbitals leads to substantially enhanced spin–orbit energy scales.
In this presentation, we discuss recent experiments on superconducting $KTaO_3$-based two-dimensional electron gases, with particular emphasis on the role of magnetotransport as a probe of superconducting fluctuations and spin–orbit coupling. We then focus on the device architectures that can be envisioned in this material platform, including electrostatically defined mesoscopic structures, with the aim of investigating unconventional superconducting regimes and their dependence on crystal orientation, confinement, and electric-field control.

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