Superconductivity and quantum phase transitions at oxide interfaces

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At the interface between insulating oxides such as SrTiO3/LaAlO3 or LaTiO3/SrTiO3, a superconducting two-dimensional electron gas (2DEG) has been discovered [1, 2, 3], whose carrier density can be tuned by applying a gate voltage. The unique possibility of modulating the superfluid density easily and continuously opens new perspectives to tackle fundamental issues in condensed matter physics, such as the Superconductor to Insulator Quantum Phase Transition (QPT) in a two-dimensional system. Using two different external parameters, the magnetic field and the electric field, we explored the phase diagram of the 2DEG. As proposed theoretically [4], we point out that the system can be described as a disordered array of coupled superconducting puddles. Depending on the conductance, the observed critical behaviour is single (corresponding to the long-range phase coherence in the whole array) or double (one at intermediate distances belonging to the (2+1)D clean XY universality class related to local phase coherence, the other one to the array of puddles) [5]. Moreover, by retrieving the coherence-length critical exponent ν, we show that the quantum critical behaviour can be clean or dirty according to the Harris criterion, depending on whether the phase-coherence length is smaller or larger than the size of the puddles. Finally, the electric-field driven QPT reveals an anomalous critical behavior. It can be understood if we assume that the dynamics in the Cooper pair channel is dominated by (nearly critical dynamical) density fluctuations in the low doping regime. This shades a new light on unexplained critical exponents found in the literature.

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