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Dynamic change at the superconducting transition in a gate-controlled electronic system

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The realization of two-dimensional electronic gases (2DEGs) in $SrTiO_3$-based heterostructures has led to important discoveries about superconductivity [1] in low dimensions. This system exhibits a superconducting dome [2] in the phase diagram. Some other interesting aspects are the observation of pairing interactions without superconductivity [3] and density-of-states features resembling the pseudogap in cuprates [4].

The physics of $SrTiO_3$ has interested researchers over a long time. Bulk crystals of $SrTiO_3$ are superconducting with a non-monotonic variation of critical temperature as a function of doping [5]. This material exhibits different types of ferroic ordering. Some recent reports indicate that ferroelastic ordering may significantly impact the development of the superconducting state. It has been suggested that the occurrence of superconductivity is mediated by polar modes [6]. A conducting 2DEG on the surface of $SrTiO_3$ is an excellent platform to investigate the impact of different types of structural ordering on superconductivity.

We have explored the phenomenon of superconductivity in the electronic system at an $AlO_x/SrTiO_3$ interface. Near the onset of the phase transition, the system undergoes dynamic change lasting tens of seconds upon sweeping the gate voltage. This can be interpreted as the result of a strong impact of structural defects and distortions of the substrate on the superconducting state. The timescale of several seconds is extremely large to be explained by a purely electronic mechanism. It matches well with known timescales for relaxation processes related to the motion of oxygen vacancies and polar domains. These measurements, therefore, hint at a prominent role played by structural properties of $SrTiO_3$ in determining the onset of the superconducting transition.

References:
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