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**Gate control of the mobility, carrier density and superconductivity at the $LaAlO_3/SrTiO_3$ interface**[1]

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The conductivity at the $LaAlO_3/SrTiO_3$ interface [1], and in particular its control with a back-gate electrode in the superconducting regime [2], offers a powerful route to explore the 2D superconductor-insulator transition. An essential requirement is to fully understand how the gate voltage changes the various characteristic properties of the system, such as the mobility, carrier density, critical temperature, critical fields and superfluid density. One important point, for example, is that with back-gating the Hall mobility variation is significantly larger than the change in sheet carrier density [3]. These results indicate that the relative disorder strength increases across the superconductor-insulator transition, and that disorder is the primary control parameter associated with back-gating. I will discuss how this 2D superconductor-insulator transition can be understood, in analogy to thickness variations in other more conventional systems, and from studies of symmetrically confined 2D superconductivity in STO [4,5]. The importance of the strong dielectric nonlinearity in STO at low temperatures will be stressed, leading to the result that the gating phase diagram is a nonlinear function of the starting free carrier density. Our collaborative efforts using real space imaging of the superfluid density by scanning SQUID microscopy, offering an extremely powerful complementary tool to transport studies, will also be discussed, as well as the relationship between the superconductivity and the ferromagnetism in this fascinating system [6].

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