Inhomogeneity and filamentary superconductivity in oxide and transition metal dichalcogenides heterostructures

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Recent progress in the fabrication of 2D highly ordered thin films and in increasing their electron density both by chemical doping or gating has opened a new field with a wealth of interesting physical effects. These range from superconductivity in monolayers, sizable spin-orbit coupling, competition with spatially ordered phases like CDW. We analyze transport properties in terms of a phenomenological model of an exactly solvable random impedance network, representing an inhomogeneous system where superconducting regions are embedded in a normal metal matrix. We find that $LaAlO_3/SrTiO_3$ heterostructures, TMD systems like $TiSe_2$, MoS_2, or ZrNCl are electronically inhomogeneous [1-3], with filamentary superconducting condensate whose macroscopic coherence still needs to be fully investigated and understood. We show how the dissipative (reactive) response of the system non-trivially depends on both the macroscopic and microscopic characteristics of the metallic (superconducting) fraction. We compare our calculations with resonant-microwave transport measurements performed on $LaAlO_3/SrTiO_3$ heterostructures over an extended range of temperatures and carrier densities finding that the filamentary character of superconductivity accounts for unusual peculiar features of the experimental data.

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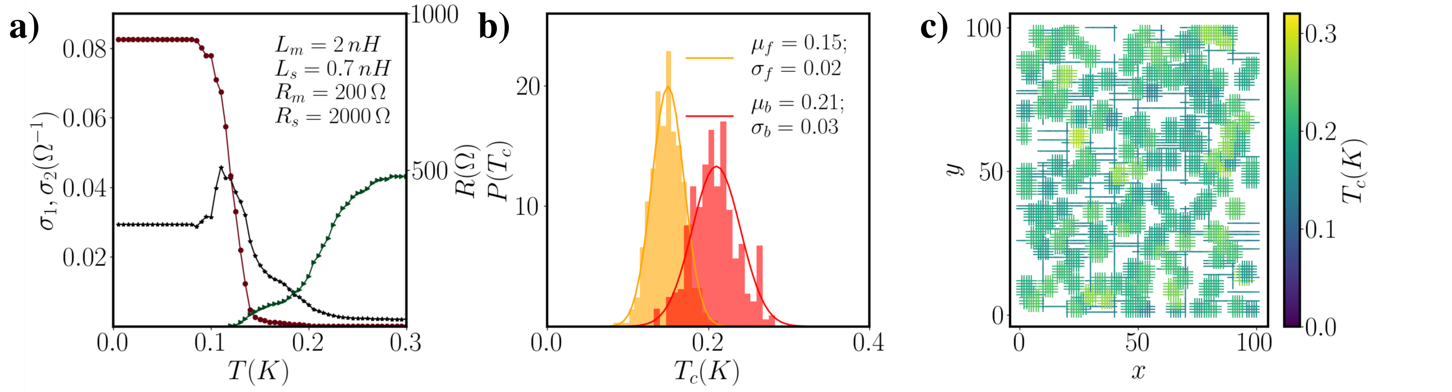

Figure: Temperature dependence of complex conductivity and DC resistivity (a) calculated with the Random Impedance Network model (b,c) to describe the overdoped regime of $LaAlO_3/SrTiO_3$