Amit Ghosal Talk

Title: Superconductivity in a disordered vortex lattice

Abstract: Orbital magnetic field and strong disorder weaken superconducting correlations acting individually on a type-II s-wave superconductor. The Abrikosov vortex lattice, resulting from the applied magnetic field, melts with an increase of the strength of the field, turning the system into a metal. Similarly, the presence of disorder causes a superconductor to insulator transition beyond a critical strength of disorder. Here we show that the interplay of these two perturbations, when present simultaneously in a two-dimensional superconductor, causes its intriguing evolution. In particular, we show that the local superconductivity can actually strengthen due to interesting spatial reorganization or order parameters in the presence of strong disorder.

While at weak disorder strengths the critical magnetic field for the suppression of superconducting energy gap matches with the critical field at which superfluid density vanishes, the two 'critical' fields diverge from each other with the increase of the disorder strengths. Our results have important consequences for the strong magnetoresistance peak observed in disordered superconducting thin films. We illustrate this by calculating the dynamical conductivity and analyzing its low-frequency behavior. Our results, which emphasize the role of spatial fluctuations in the pairing amplitude, capture the non-monotonic evolution of the magnetoresistance, consistent with experiments. We will also demonstrate that the presence of even weak disorder causes the Caroli-deGennes-Matricon zero-bias peak in vortex-core density of states to disappear. The origin and consequences of such dramatic behaviors will be discussed along with their experimental relevance.

Work done in collaboration with Anushree Datta (IISER Kolkata), Anurag Banerjee (IISER Kolkata) and Nandini Trivedi (OSU).