Superconductivity in a disordered vortex lattice

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Orbital magnetic field, as well as strong disorder, weaken superconducting correlations of a type-II superconducting film when acting individually. The Abrikosov vortex lattice, resulting from an externally applied orbital magnetic field, melts with the increase of the magnetic field strength turning the superconductor into a metal. On the other hand, increasing of disorder causes it to undergo a transition to an insulator beyond the critical strength of disorder. Here we show that the simultaneous presence of these two perturbations, leads to an interesting evolution of superconductivity. In particular, we demonstrate that the local superconductivity strengthen in the presence of disorder, due to a self-consistent spatial reorganization of order parameters. At weak disorder strengths, the same critical field collapses of superconducting energy gap, and is responsible for the vanishing of the superfluid density. However, the two critical fields diverge from one another at large disorder strengths. In addition, disorder is found to distort the Caroli-de Gennes-Matricon vortex state, which in the clean system features a strong zero-bias peak in the local density of states (LDOS) at the vortex-core. This peak disappears and the LDOS at the vortex core features a dip instead, even for weak disorders. On the other hand, LDOS promotes a hard gap acriss the system at large disorder strengths. The origin and consequences of such contrasting behavior will be discussed along with possible experimental signatures.

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