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Fluctuoscopy of Superconductors

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Abstract:

We develop the general approach for description of fluctuation phenomena in the whole phase diagram of a dirty superconductor above the upper critical field line $H_{c2}(T)$. First of all we derive the exact expression for the fluctuation conductivity in two dimensional superconductors as a function of temperature and magnetic field in the whole domain of the normal phase. Focusing on the vicinity of the quantum phase transition near zero temperature we arrive to the conclusion that as the magnetic field approaches the critical field $H_{c2}(0)$ from above, a peculiar dynamic state consisting of the
clusters of coherently rotating fluctuation Cooper-pairs forms, which we identify as the precursor of Abrikosov lattice. We estimate the characteristic size $\xi_{QF}(H)$ and lifetime $\tau_{QF}(H)$ of such clusters and indicate in the corresponding domain of the phase diagram, where such phenomenon can be observed. The derived values $\xi_{QF}(H)$ and $\tau_{QF}(H)$ allow us to reproduce qualitatively the available results for the quantum fluctuation contributions to the in-plane conductivity, magnetization, and the Nernst coefficient.
The developed approach gives possibility to study in details also other important manifestations of the fluctuation phenomena, attracted attention of superconductive community in last decade: the giant Nernst signal, specifics of the NMR relaxation above the Abrikosov's vortex state, and opening of pseudo-gap above the transition temperature. Careful

study of the role of fluctuations in the latter phenomenon allows us to predict the new type of zero-bias anomaly in tunneling conductivity of superconducting films. All theoretical results are provided by the computer programs allowing to fit experimental data and extract the necessary information concerning microscopic parameters of the studied superconducting systems.