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Fluctuoscopy of Superconductors[1]

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The study of superconducting fluctuations (SF) is a subject of fundamental and practical importance. Since the moment of discovery SF became a noticeable part of research in the field of superconductivity (SC) and a variety of fluctuation effects have been detected. The interest to SF in SC was regenerated by the discovery of HTS, where, due to extremely short coherence length and low effective dimensionality of the electron system, SF manifest themselves in a wide range of temperatures. The characteristic feature of SF is their strong dependence on temperature and magnetic field. This allows to separate SFs from other contributions and to use them as a tool for characterization of SC systems ("fluctuoscopy") for example to extract the values of T_c, $H_{c2}(T)$ and phase-breaking time from experimental data. We present the complete results for fluctuation magneto-conductivity (FMC) and Nernst signal (FNS) of impure 2D superconductor in the whole phase diagram above the transition line $H_{c2}(T)$, including the domain of quantum fluctuations. Along some line $H_0(T)$, in agreement with experimental findings, FMC becomes zero and beyond it remains small and negative. The corresponding surface in coordinates (T, H) becomes in particular non-trivial at low temperatures and close to $H_{c2}(0)$, where it is trough-shaped. The observation of large FNS in HTS and conventional SC above $T_c(H)$, has attracted much attention recently. The idea to attribute it to the entropy transport by analogy to vortices was proposed. On the other hand this giant effect, close to $T_c(0)$, was explained in terms of SF. Our general results allow to successfully fit the available experimental data in a wide range of magnetic fields and temperatures, to extract the value of the "ghost" field and other parameters of SC. We offer also a qualitative consideration, which gives a natural explanation for the giant value of FNS attributing it to a strong dependence of the fluctuation Cooper pair (FCP) chemical potential on temperature. Close to zero temperature, when the magnetic field approaches $H_{c2}(0)$, a peculiar dynamic state consisting of clusters of coherently rotating FCP forms. We estimate the characteristic size and lifetime of such clusters and present the scenario of fluctuation nucleation of Abrikosov's lattice.

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