Effect of a Magnetic Field on the Temperature Dependence of the Pseudogap in $YBa_2Cu_3O_{7-\delta}$ Films

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It is believed that magnetic correlations are the most likely additional pairing mechanism for the high-T_c superconductors (HTSCs), but this issue is still a subject of active debate [1]. To clarify the issue, the influence of a magnetic field with B up to 9 T directed along the c axis ($B \parallel c$) on the resistivity $\rho(T)$, fluctuation conductivity and pseudogap (PG), $\Delta^*(T)$, in thin $YBa_2Cu_3O_{7-\delta}$ film with a critical temperature T_c = 88.8 K was studied. It is shown that near T_c the magnetic field sharply increases $\rho(T)$ and decreases T_c. Also, a sharp increase in the coherence length along the c-axis $\xi_c(0)$ from 1.33 Å to 4.14 Å was found for B <1 T. But, for $B > 1$ T, $\xi_c(0)$ retains a constant value of ≈ 4.14 Å up to $B = 9$ T.

The PG analysis shows that the most interesting behavior is observed in the range of SC fluctuations $T_{01} > T > T_G$, where $T_G > T_c$ is a Ginzburg temperature [2]. This is well illustrated by the field dependence of $\Delta^*(T_G)/k_B$, which rapidly decreases linearly at $0 < B < 1$ T, but changes its slope at $B > 1$ T. This is confirmed by the field dependence of the Ginzburg number $Gi = (T_G - T_c^{mf})/T_c^{mf}$, which linearly increases by 8.4 times at $B = 9$ T, but changes slope at $B \approx 1$ T.

Thus, it was shown for the first time that all three parameters, namely $\xi_c(T)$, $\Delta^*(T_G)/k_B$ and Gi, change their behavior exactly at $B \approx 1$ T, indicating a change in the interaction of the magnetic field with the HTSC. It is believed that at $B < 1$ T the magnetic field destroys the LPs by breaking pairs. At $B > 1$ T, the field penetrates into the HTSC in the form of a two-dimensional lattice of Abrikosov vortices, the interaction mechanism with which is significantly different, leading to a change in the indicated parameters at $B > 1$ T. To ensure the observed increase in Gi, the coherence length along the conducting planes, $\xi_{ab}(0)$, must decrease by approximately three times. This leads to a very interesting but unexpected result, namely $\xi_{ab}(9\text{T}) \approx \xi_c(9\text{T})$, which indicates the isotropization of both Cooper pairs and Abrikosov vortices in a strong magnetic field.

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References

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