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Fluctuation-related diamagnetism in superconductor

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In a superconductor, thermal fluctuation lead to the presence of superconducting regions with finite lifetime also above the superconducting transition temperature(T_c) to which is connected a non zero magnetization (M_{dia}).
The experimental study of the magnetic field dependence of M_{dia} is of speculative interest and can give information about the physical properties of the system
Our researches presently deal with following systems:
-Lead Nanopartcles
-Irradiated Magnesium Diboride(MgB_2) and Aluminium doped MgB_2
In lead nanoparticles the reduced dimensionality enhance M_{dia} and simplify the theoretical descprition, allowing a comparison of experimental data with exact theoretical results. In our case, we have found a good agreement between data and theory.
In Irradiated Magnesium Diboride(MgB_2) and Aluminium doped MgB_2, the experimental study of M_{dia} gived us informations on the effect induced by the disorder on the samples. In fact it is proved that the origin of M_{dia} is quite different in neutron irradiated and in Al-doped MgB_2: in the latter the magnetization curves reflect the precursor diamagnetism typical of heterogeneous system; at variance, neutron irradiated MgB_2 displays novel properties: the transition temperature, although fluence-dependent, is practically site-independent and the superconducting fluctuations and the related diamagnetism basically retaining the features of the pure (unirradiated) MgB_2.
The fluctuation-related diamagnetism above the superconducting transition temperature T_c in neutron irradiated and in Al-doped MgB_2 is studied by means of SQUID high resolution isothermal measurements of the diamagnetic contribution to the magnetization, $M_{dia} = M_{dia}(H, T=const)$.

In both the neutron irradiated and the Al-doped compounds, T_c decreases on increasing the fluence and the Al amount, respectively. The field dependence of M_{dia} is apparently similar in both types of compounds: for evanescent field - M_{dia} goes as H^n, (with n in between ½ and 1) and by increasing the field above a given value H_{up} an upturn in the field dependence occurs and $|M_{dia}|$ decreases. However, from the comparison of the temperature behaviours of H_{up} it is proved that the origin of the precursor diamagnetism is quite different in neutron irradiated and in Al-doped MgB_2. In fact, in the latter the magnetization curves reflect the precursor diamagnetism typical of heterogeneous system and unrelated to superconducting fluctuations, being due to site dependence of the transition temperature. At variance, neutron irradiated MgB_2 displays different and novel properties. The transition temperature, although fluence-dependent, is practically site-independent, the superconducting fluctuations and the related diamagnetism basically retaining the features of the pure (unirradiated) MgB_2. The anisotropy parameter γ involved in the fluctuations spectrum appears to decrease upon irradiation with respect to the value $\gamma \approx 7$ in pure MgB_2. The upturn field H_{up} is also found to decrease, consistently with an almost isotropic effective coherence length.

The implications of these experimental findings on the character of the disorders induced by heterovalent substitutions and by neutron irradiation in MgB_2 are discussed.

References

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