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μ SR Study of Superconductivity Above H_{c2} : A Filamentary State in Type-II Superconductors

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The standard interpretation of the phase diagram of type-II superconductors was developed in the 1960s and has since been considered a well-established part of classical superconductivity. In particular, according to the standard picture, in a sample of type-II materials of a planar geometry in a parallel (in-plane) field, superconductivity nucleates at H_{c3} approximately twice as big as the upper critical field H_{c2} . Between these critical fields the superconducting phase exists in a form of a thin surface sheath. Contrarily, in the same sample but in the perpendicular (out-of-plane) field superconductivity nucleates in the bulk at H_{c2} and there is no superconductivity above this field. However, upon closer examination a number of fundamental issues arises that leads one to question this standard picture. To address these issues, we studied equilibrium properties of niobium samples near and above the critical field H_{c2} in parallel and perpendicular magnetic fields. The samples investigated were very high-quality films and single-crystal disks with the Ginzburg-Landau parameters in the range from 0.8 to 1.3. A set of complementary measurements has been performed, which include bulk μ SR, dc magnetometry, electrical transport and scanning Hall-probe microscopy. Contrary to the standard scenario, we observed that a superconducting phase is present in the sample bulk above H_{c2} and the field H_{c3} is the same in both parallel and perpendicular fields. It will be shown that above H_{c2} the superconducting phase forms filaments parallel to the field regardless of the field orientation. Near H_{c2} the filaments preserve the hexagonal structure of the preceding vortex lattice of the mixed state, and the filament density continuously falls to zero at H_{c3} .

References:

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