μSR-studies on the Heavy-Fermion-Superconductor $CeCoIn_5$ at high magnetic fields

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The Heavy-Fermion (HF) compound $CeCoIn_5$ becomes superconducting at a remarkably high transition temperature of $T_C = 2.3$ K. Due to its layered crystal structure a strong anisotropy of the upper critical magnetic field H_{c2} is found (5 T and 11.8 T for $\hat{c} \parallel H$ and $\hat{a} \parallel H$ respectively). In the vicinity of H_{c2} the normal to superconducting transition changes from second to first order [1,2], so far evidenced in measurements of specific heat and thermal conductivity. It is suggested that at high fields and very low temperatures a specifically modulated superconducting state is formed, the FFLO state, theoretically predicted by Fulde, Ferrell, Larkov and Ovchinikov in the early 1960s [3,4].

We have carried out transverse field μSR-measurements between 2 T and 5 T ($\hat{c}$-axis parallel H) on single-crystalline $CeCoIn_5$ in a temperature range between 25 mK and 7 K. In addition to the standard modulation perpendicular to the applied field due to the flux line lattice (orbital currents), a longitudinal modulation is expected. In that case an additional broadening of a local probe spectrum due to hyperfine fields (spin magnetization) should occur. Theoretically that broadening is explicitly shown by calculations based on the quasiclassical Eilenberger theory [5]. Our data clearly evidence the fielddriven change from second to first order transition at an external field of 4.8 T. On the other hand no additional line broadening is observed at very low temperatures below T_C in this orientation ($\hat{c} \parallel H$), which disagrees with the assumptions of the FFLO state. Instead of broadening or saturation of the relaxation rate our analysis shows a peaklike structure at T_C and a significant decrease of the relaxation rate below T_C with decreasing temperature, which is unique so far among HF systems.

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