Anisotropy of the Upper Critical Field Under Pressure in the Heavy Fermion Superconductor UTe_2

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We studied the anisotropy of the superconducting upper critical field H_{c2} under pressure in UTe_2 in the spin-triplet state. The superconductivity collapsed at 1.5 GPa, and a magnetically ordered state appeared. The H_{c2} curve for the field along the a-axis showed an abrupt enhancement at the high-field and low-temperature regions, implying different order parameters. The H_{c2} curve for the *b*-axis showed the cutoff of superconducting phases above the metamagnetic transition field H_m~35 T at ambient pressure with the field-reentrant behavior, which was immediately suppressed with pressure. Our results demonstrate the novel interplay between spin-triplet superconductivity and magnetism.

The recent discovery of superconductivity in the heavy fermion paramagnet UTe_2 has attracted much attention because of its novel phenomena. The superconducting state below T_c = 1.6 K is proposed to be a spin-triplet state, as it is established in ferromagnetic superconductors, such as URhGe and UCoGe. In UTe_2, a field-robust superconductivity, which significantly exceeds the Pauli limit, was observed at the verge of the ferromagnetic order. Thus, the spin-triplet state is most likely to be realized.

We measured the magnetoresistance under pressure for the field along the *a*-, *b*-, and *c*-axes in the orthorhombic structure of UTe_2 [1]. The measurements were performed in Oarai, Sendai, and Grenoble within the framework of an international collaboration project between IMR and UGA/CEA-Grenoble. Figure 1 shows the *H*-*T* phase diagram of H_{c2} at different pressures for $H \parallel a$ and *b*-axes. For the $H \parallel a$-axis corresponding to the easy-magnetization axis, an unusual enhancement was detected at low temperature and in the high-field region at 0.5 and 0.86 GPa. At a higher pressure (1.4 GPa), the initial slope of H_{c2} was almost vertical or even positive, indicating that superconductivity was stabilized by the magnetic field. For the $H \parallel b$-axis, the field-reentrant superconductivity was suppressed owing to the suppression of the metamagnetic transition field H_m. At 1.32 GPa, the H_{c2} curve showed a strong convex curvature, and $H_{c2}(0)$ was reduced to 9 T, which is approximately equal to H_m.

These typical H_{c2} curves under pressure for the *a* and *b*-axes were attributed to the multiple superconducting phases originating from the spin degree-of-freedom for the spin-triplet state. The multiple superconducting phases were experimentally detected as a thermodynamic response [2], indicating different order parameters. Another important factor is the interplay with magnetism, which developed above 1.5 GPa in a long-range order. The Fermi surface reconstruction induced by a magnetic field and pressure, such as the Lifshitz transition [3], will play an important role in spectacular superconducting phases.

This work was done in collaboration with G. Knebel, K. Motoi, M. Valiska, F. Honda, D.X. Li, D. Braithwaite, G. Lapertot, W. Knafo, A. Pourret, Y. J. Sato, Y. Shimizu, T. Kihara, J. P. Brison, and J. Flouquet.

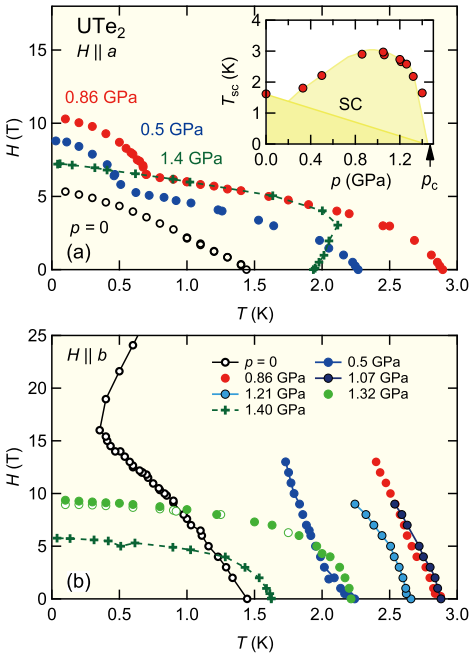

Fig.1: Upper critical field H_{c2} for the field along *a* and *b*-axes at different pressure in UTe_2 [1]. The inset of panel (a) show the T-P phase diagram at zero field.

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Keywords: superconducting, heavy fermion, actinide
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