

FFLO phase diagram of layered organic superconductor κ -(BEDT-TTF)₂Cu(NCS)₂ with nonmagnetic disorder

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Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) superconductivity [1] has been attracted much interest because of the exotic superconductivity beyond the framework of the BCS theory. The FFLO superconducting phase can be stabilized even above the Pauli limit, where the Zeeman effect breaks superconducting Cooper pairs. Because of a periodic nodal structure of the superconducting order parameter, characteristic vortex dynamics are reported in the FFLO phases [2]. There are two necessary conditions of the FFLO superconductivity: the quenched orbital effect and clean limit superconductivity. The former condition is satisfied in magnetic fields parallel to the conducting planes, which has been discussed in various organic superconductors. The later condition, suggesting that the FFLO superconductivity is unstable to the disorder of the electronic system, has not been systematically studied so far. The main reason is that it is difficult to introduce disorder in crystals qualitatively and artificially.

In this study, we have performed the resistance and magnetic torque measurements to reveal the disorder effects on the FFLO phase of a highly two dimensional organic superconductor κ -(BEDT-TTF)₂Cu(NCS)₂ (κ -NCS) [3]. κ -NCS with a high critical temperature $T_c \approx 9$ K is one of the best candidates for the FFLO phase studies. X-ray irradiation is known to be an effective method of introducing disorder in crystals [4]; molecular defects in the anion molecules by the X-ray irradiation cause local modulation of the charge transfer. We have precisely measured the magnetic field dependence of the electrical resistance and magnetic torque in κ -NCS crystals irradiated with X-ray for various times. When the magnetic field orientation is aligned within $\pm 0.2^\circ$ from the in-plane direction, T_c decreases with increasing the X-ray irradiation time. In magnetic torque curves, the irreversibility field, which gives the lower limit of the critical field, is shifted to a lower field with increasing the irradiation time. From these results, the detailed high-field superconducting phase diagram of the disorder introduced κ -NCS is determined.

References

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