ON THE ORIGIN OF THE COHERENCE PEAK IN THE INTERPLANE RESISTANCE OF QUASI-TWO DIMENSIONAL ORGANIC METAL: $\beta'-(BEDT-TTF)_2SF_5CHF SO_3$

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We report high field transport measurements on a quasi–two dimensional organic conductor from the family with general chemical formula $\beta'-(BEDT-TTF)_2SF_5R SO_3$, where $R= CHF$. In these all organic salts, the anion layer can be finely tuned, leading to a range of low-temperature properties encompassing superconductivity ($R= CH_2CF_2$), metallic conduction ($R= CHF$) and insulating behaviour ($R= CH_2$) [1].

The interlayer resistances, $R_{zz}$, of single crystals with typical dimensions ~500 x 250 x 400 μm were measured using standard four-wire ac lock-in techniques. 12.5 μm platinum wires were attached to the most conductive planes of the sample using graphite paint. The sample was placed in a probe with a two-axis goniometer allowing the sample to be rotated to any orientation with respect to the magnetic field. The experiments were performed in a resistive Bitter magnet at the NHMFL in Tallahassee, in magnetic fields of up to 33 T and at temperatures down to 500 mK. Complementary experiments were performed in Bristol and Los Alamos.

Figure 1(a) shows the magnetoresistance for a range of temperatures between $T=0.5$ K and 4.2 K and with the magnetic field directed perpendicular to the most conductive plane of the sample. At the lowest temperature studied and at low magnetic fields, one single quantum oscillation frequency (of 180 T) is observed superimposed on a positive background magnetoresistance. This frequency is close to the $198T$ observed in the related superconducting compound, $\beta'-(BEDT-TTF)_2CH_2CF_2SO_3$. The effective mass estimated using the 2D Lifshitz-Kosevich formalism is $1.07 \pm 0.02 m_e$, smaller than that observed for the superconducting compound ($1.96 \pm 0.05 m_e$), suggesting that, as in the case of oxalates ($\beta' (BEDT-TTF)_4[(H_3O)Ga(C_2O_4)_3]Y)$, an enhanced effective mass and superconductivity are closely related [2]. Figure 1(b) shows the angle dependent magnetoresistance of $\beta'-(BEDT-TTF)_2SF_5CHF SO_3$ for different azimutal angles, $\phi$. We observe a strongly anisotropic behaviour suggestive of very elongated elliptical pocket as seen in the superconducting analogue [3] and a peak in magnetoresistance when the field is parallel with the conducting planes. This “coherence peak” is unlikely to be a signature of a 3D Fermi surface due to the relatively large disorder (scattering time almost 50 times shorter than in superconducting material) but perhaps a sign of weak localization, as seen in oxalates [4].

Figure 1:

(a) Field dependence of the interplane magnetoresistance, $R_{zz}$, of $\beta'-(BEDT-TTF)_2SF_5CHF SO_3$ for temperatures between 0.5 K and 4.2 K when the magnetic field is perpendicular to the conducting plane.

(b) Angle dependence of the interplane magnetoresistance, $R_{zz}$, in 32T and at 0.5 K.