THE COHERENCE CONUNDRUM IN BEDT-TTF SUPERCONDUCTORS; THE PROLONGED DEATH OF INTERLAYER TRANSPORT AS TEMPERATURE RISES

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Introduction

Much recent attention has focused on so-called “bad metals”, systems that appear to be Fermi liquids at low temperatures, but whose conductivity falls below the minimum metallic limit as the temperature rises [1]. Examples of this behavior may be found among the cuprates, the ruthenates and organic superconductors [1,2]. A key question in such systems concerns the coherence of the electron orbitals, and whether, as suggested by Anderson and others, it is destroyed by thermal fluctuations as the temperature \( T \) rises [2]. Upon such suggestions has a wealth of theoretical supposition been based.

Experimental details and results

To address this question, we have studied magnetic-field-orientation-dependent transport in the crystalline organic superconductor \( \kappa-(BEDT-TTF)_2Cu(NCS)_2 \) at \( T_s \)s of up to 45 K [3]. This material was chosen because it possesses a simple low-temperature Fermi surface that has been very well characterized by experiment [2]. Experiments were carried out using two-axis rotator probes from Oxford and LANL in the 33 T Bitter and 45 T hybrid magnets at Tallahassee. We find that the angle-dependent magnetoresistance oscillations (AMROs) (Figure 1) due to orbits on the quasi-one-dimensional and quasi-two-dimensional Fermi-surface sections are suppressed by rising \( T \) with a power-law dependence suggestive of phonon scattering (Figure 1). This result is an interesting contrast with the zero-field resistivity, which follows a \( T^2 \) dependence that has been attributed to electron-electron scattering. The coherence peak in the resistivity seen in exactly in-plane fields, and other signatures of a three-dimensional Fermi surface, remain to values of \( T \) that exceed the proposed Anderson criterion for incoherent interlayer transport by a factor of order 80. This result suggests that some of the work using the Anderson criterion as an underlying justification may be at best questionable. Theoretical studies of this question are in progress.

Figure 1. Left; typical AMRO data for a range of temperatures (see inset key); \( \theta \) is the angle between the field and the normal to the sample quasi-two-dimensional layers. Right: amplitude of a typical AMRO feature (Yamaji oscillation) versus temperature, showing a \( T^5 \) dependence suggestive of phonon scattering.

References