ANGLE-DEPENDENT-MAGNETO-RESISTANCE-OSCILLATIONS (AMRO) IN κ–(BEDT-TTF)$_2$Cu(NCS)$_2$ UNDER HIGH HYDROSTATIC PRESSURE

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The nature of the interlayer transport in the quasi-2D organic conductors, and in particular whether it is coherent, incoherent or "weakly" incoherent, has attracted significant interest recently, both experimentally [1,2] and theoretically [2,3]. Previous ambient pressure studies of angle dependent magnetoresistance oscillations (AMRO) and magnetic quantum oscillations in the superconducting κ - phase BEDT-TTF salts have yielded estimates of the inter- and intra-layer quasiparticle dispersion. A peak in the magnetoresistance occurring when the magnetic field is directed close to parallel to the layers is indicative of coherent interlayer transport; a quantitative estimate of the magnitude of the transfer integral in the interlayer direction can be obtained from the angular width of the peak [1,2]. In addition, the effect of pressure on the superconductivity has been studied [4], demonstrating a strong correlation between the size of the superconducting energy gap and the quasi-particle density of states at the Fermi energy. Here, we have combined these methodologies to investigate how pressure affects the effective mass (quasi-particle density of states), the inter- and intra-layer transfer integrals. Measurements of these parameters will reveal how the coherence of the interlayer transport evolves with pressure, and will allow a comparison with theories of unconventional superconductivity invoking Fermi-surface nesting and spin fluctuations (see, for example, [5]).

We have performed AMRO under hydrostatic pressures using a miniature diamond anvil cell (DAC) on κ – (BEDT-TTF)$_2$ Cu (NCS)$_2$. Samples of dimensions ~150 x 100 x 50 μm, were mounted in a DAC using pressed gold wire attached to the sample using graphite paint. The DAC was mounted on a two-axis goniometer that was placed in a 32 mm bore resistive magnet at the NHMFL in Tallahassee; we were able to perform angle-dependent measurements in temperatures down to 500 mK in fields of up to 33 T, using standard 4-wire AC lock-in techniques at hydrostatic pressures of 9.8 and 17.2 kbar.
In Figure 1, the magnetoresistance as a function of temperature is shown for one sample at two different pressures. At these pressures superconductivity is completely suppressed, in agreement with previous studies [2]. With increasing field two Shubnikov de-Haas oscillations are observed superimposed on a positive background magnetoresistance. The higher (β) frequency oscillation is associated with a quasiparticle orbit that encloses an area equal to the whole Brillouin zone, allowing us to extract its area, A_{BZ}; the values obtained are very similar to previously reported experimental values [4], with A_{BZ} = 3.84 x 10 $^{+19}$ m^{-2} and 3.89 x10^{+19} m^{-2} at 9.8 kbar and 17.2 kbar respectively. The left-hand graph in Figure 2 shows polar angle AMRO sweeps taken at 9.8 kbar, for a range of azimuthal orientations (indicated to the right). The right-hand graph in Figure 2, shows a close-up of the AMRO with the field directed almost parallel to the layers, showing the peak associated with coherent interlayer transport. Using these data, the evolution of the intra- and inter-layer Fermi surface parameters can be obtained as a function of pressure; these results will be discussed in detail elsewhere [6].

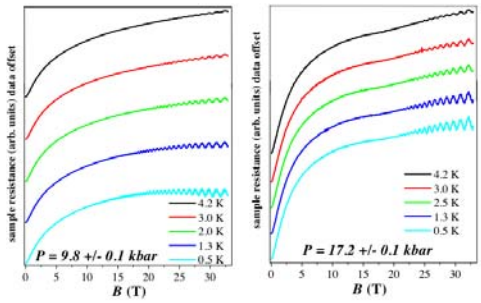

Figure 1: Magnetoresistance at different temperatures for samples at two different hydrostatic pressures, on the left 9.8 kbar and on the right 17.3 kbar.

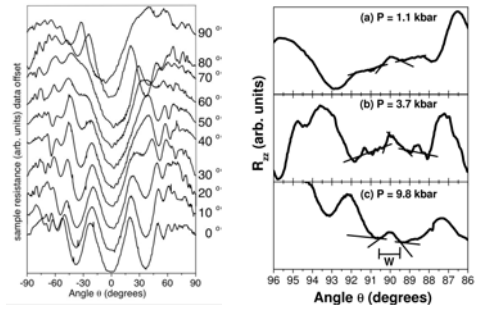

Figure 2: Left: AMRO taken with B = 30 T, T = 0.5 K and P = 9.8 kbar. Right: close-up showing the coherence peak at three different pressures.

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[1] J. Singleton *et al.*, Phys. Rev. Lett., 88, 037001 (2002).
[2] Goddard *et al.*, Phys. Rev. B 69, 174509 (2004).
[3] R.H. McKenzie and XX Moses, Phys. Rev. Lett., 81, 4492 (1998).
[4] J Caulfield *et al*, J. Phys.: Condens. Matter, 6, 2911 (1994).
[5] J. Schmalian, Phys. Rev. Lett., 81, 4232 (1998).
[6] A.F. Bangura *et al*, *in preparation*.