Electronic Transport in a Quasicrystalline Icosahedral Al-Cu-Ru Sample

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Introduction

Quasicrystalline (QC) icosahedral (I) samples display unusual electronic transport properties, including very high room temperature resistivities and in certain cases even metal-insulator transitions (MIT). Most of these materials are ternary alloys, annealed at high temperatures in order to form the icosahedral structure and then very rapidly quenched to room temperature. Measurements have been made previously on the I Al-Cu-Ru system: Lalla *et al*. [1] observed only metallic behavior. Jaiswal *et al*. [2] claimed insulating behavior. We now try to clarify the question of a MIT transition in Al-Cu-Ru.

Experimental

QC samples of Al-Cu-Ru were prepared using the rf induction method [3]. Magnetoconductivity (MC) and zero field conductivity measurements were made using the He^3 SCM2 station at the NHMFL.

Results and Discussion

We summarize the results on a 'barely metallic" sample having a resistance ratio $r = R(4\text{ K})/R(300\text{ K}) = 3.26$. The MC data and fits using the combined weak localization (WL) and the electron-electron interaction (EEI) conductivity expressions are shown in Fig. 1. From the fits, the following values for the inelastic, spin orbit and magnetic spin scattering times were extracted: $\tau_{in}(T) = 5*10^{-11}/T$ in s, $\tau_{so} = 6.6*10^{-12}$ in s and $\tau_s = 1.3*10^{-10}$ in s. The MC data at $T = 0.3$ K is anomalously large. The high temperature conductivity behaves well, nicely following a linear temperature; this $\sigma \propto T^1$ dependence was predicted by Janot [4]. But around 2 K, the σ behavior is anomalous as seen in Fig. 2, displaying a maximum followed by a decrease at lower temperatures. This behavior has never been observed before. Interestingly, the WL expression for the zero field conductivity predicts such a maximum using the above scattering times extracted from the MC data and a scaled WL prefactor, shown by the solid line in Fig. 2. Clearly this sample exhibits metallic behavior. Six other samples also were metallic. None of the Jűlich samples exhibited insulating properties.

References

[1] Lalla N.P., *et al*. *J. of Phys.: Condens. Matter* **7** 2409-2420 (1995).
[2] Jaiswal A., *et al*., *J. Non Crystalline Solids* **351** 239-250 (2005).
[3] Mi. S. and Grushko B, *Intermetallics* **12** 425-435 (2004).
[4] Janot C., *Phys. Rev. B* **53** 181-191 (1996).

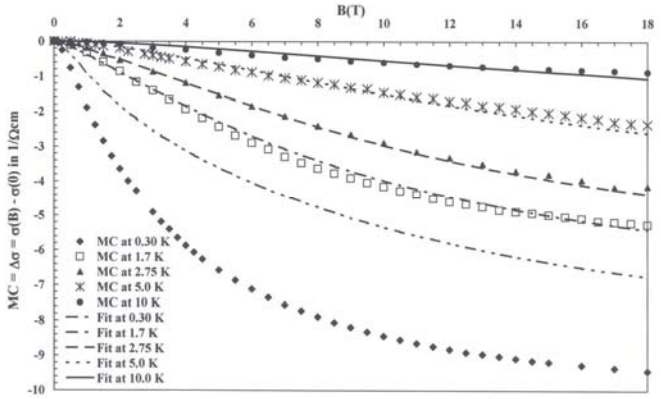

Fig. 1 MC data and combined WL and EEI fits.

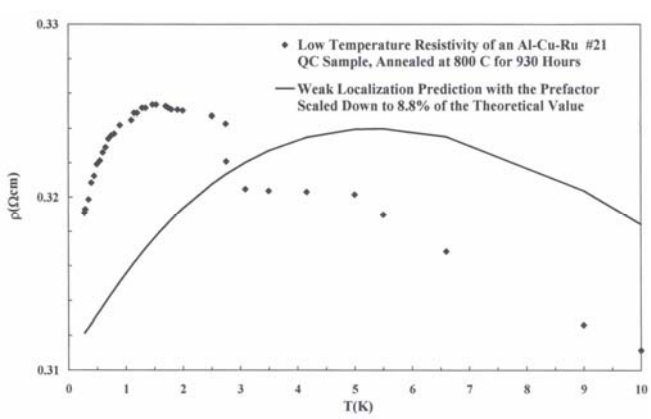

Fig. 2 Anomalous conductivity behavior.