LOW T_c SUPERCONDUCTIVITY AND POSSIBLE CHARGE DENSITY WAVE INSTABILITY IN $Li_{0.9}Mo_6O_{17}$

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Abstract

Magnetoresistance and Hall effect studies, performed on $Li_{0.9}Mo_6O_{17}$ single crystals, are consistent with a decrease of carrier concentration and an increase of the mobility below $T_M \approx 25$ K. This supports a mechanism of CDW gap opening at T_M.

Introduction

The lithium purple bronze $Li_{0.9}Mo_6O_{17}$ is one of the metallic low dimensional molybdenum bronzes $A_xMo_yO_z$ (A = Li, Na, K, Rb, Tl) which show electronic instabilities [1]. Other members of the family, such as $K_{0.9}Mo_6O_{17}$ show charge density wave (CDW) instabilities induced by the quasi-twodimensional crystal structure. $Li_{0.9}Mo_6O_{17}$ is the only member which shows a superconducting transition at Tc $\approx$ 2 K [2]. It also shows an anomalous increase of the electrical resistivity below $T_M \approx$ 25 K [3]. This increase has been attributed to two possible mechanisms, either a weak localization process, related to disorder induced by Li vacancies [4] or to a charge density wave instability [5]. Crystal structure studies show that $Li_{0.9}Mo_6O_{17}$ is a quasi one-dimensional conductor, with infinite zigzag chains of Mo^{5+}-O_6 octahedra along the monoclinic b-axis [5]. This is corroborated by optical reflectivity studies [6]. Low temperature structural data, which could corroborate the existence of CDW satellites, are presently not available. One should note that band structure calculations predict a nesting of the Fermi surface consistent with a CDW instability.

We now report magnetoresistance and Hall effect studies at low temperatures (> T_c), which support the existence of such an instability.

2 - Experiment

The single crystals of $Li_{0.9}Mo_6O_{178}$ are grown by the electrocrystallization technique, as described elsewhere [9] · They are in shape of platelets elongated along the monoclinic b-axis and parallel to the b-c plane. Fig. 1 shows magnetoresistance curves obtained below 40 K for current parallel to b and magnetic field perpendicular to the b-c plane, up to 6 Teslas. Magnetoresistance is found positive, and large below T_M ($\Delta\rho/\rho_0 \approx$ 25 % at 4.2 K, for B $\approx$ 6 Teslas). Fig. 2 shows the Hall constant as a

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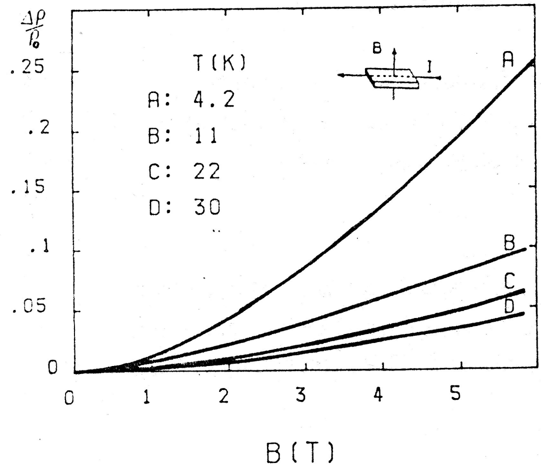


Figure 1
Magnetoresistance vs magnetic field. I // b, B⊥ b,c plane

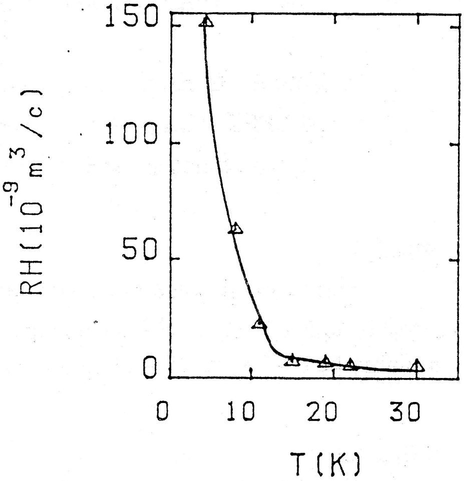
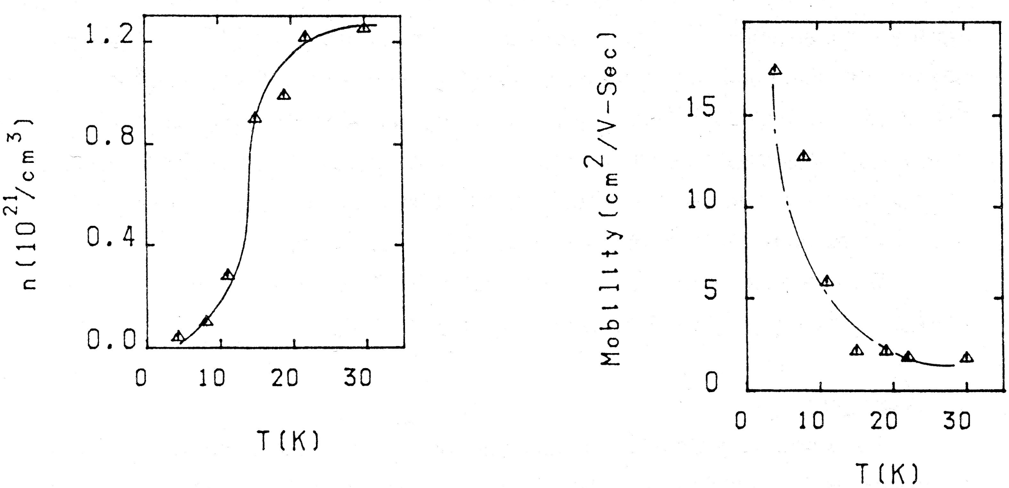


Figure 2
Hall constant vs temperature. I // b, B⊥ b, c plane



(a) (b)

Figure 3
(a) Carrier concentration vs temperature, as obtained from R_H with a one-band model
(b) Mobility vs temperature, obtained from combined data of R_H and electrical conductivity.

function of temperature, measured in low fields ($B < 0.5$ Tesla). It shows a steep increase below $\approx$ 20 K. The carrier concentration evaluated in a simple one-band model, is shown as a function of temperature on Fig. 3a. Fig. 3b shows the thermal dependence of the mobility as obtained from the combined data of Hall effect and electrical conductivity. One then obtains below T_M a steep decrease of the carrier concentration together with an increase of the mobility.

3 - Discussion

The magnetoresistance and Hall effect data are inconsistent with a localization process taking place below 25 K. Such a process should lead to a negative magnetoresistance [12], while our samples show a positive one. Although a one-band model is questionable, Hall effect is rather consistent with a decrease of the carrier concentration below T_M, as expected if there is a CDW gap opening. The increase of mobility at low temperature is also inconsistent with a localization process. It rather suggests that the CDW instability induces on the Fermi surface small pockets with large mobility. One should note that magnetic susceptibility data did not support a CDW model, as no measurable anomaly was found at T_M [2]. However, the expected decrease of the susceptibility can well be masked by a Curie tail due to paramagnetic defects.

We have previously reported pressure studies up to 20 kbar which show a decrease of T_M associated to an increase of T_c under pressure [11]. These results are also consistent with the existence of a CDW gap, closing progressively under pressure. The superconducting instability therefore takes place on the Fermi surface left after CDW gap opening. Low temperature structural studies would now be necessary to corroborate the presence of a CDW instability below T_M in $Li_{0.9}Mo_6O_{17}$.

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12 - See for exemple H. Fukuyama and K. Yosida, J. Phys. Soc. Japan, 46, 102 (1979).