Magnetic properties of new copper polychalcogenides

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Presented report is devoted to study of a family of copper polychalcogenides (i. e. compounds based on copper, chalkogen and alkali metal), which is as yet not very well explored in respect of their physical properties. These systems are closely related to the cuprates – high temperature superconductors (HTSC) and they exhibit many similar physical properties. We would like to pay attention to magnetic investigation of two compounds: $K_3Cu_8Se_6$ and $K_3Cu_8Te_6$.

$K_3Cu_8Se_6$ exhibits CDW transition at temperature $T_C = 181$ K [1, 2] and magnetic investigations confirm existing phase transition at that temperature. We can observe the change of the magnetic susceptibility character from diamagnetic to paramagnetic (see Fig. 1).

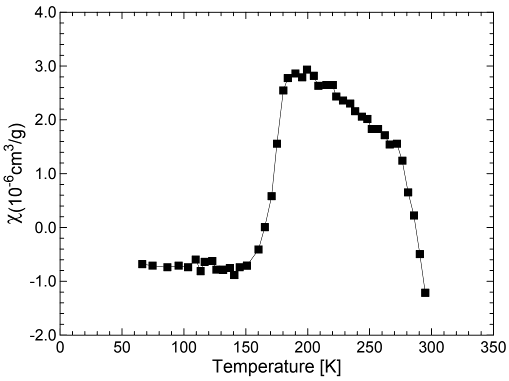

Fig. 1. Magnetic susceptibility χ of $K_3Cu_8Se_6$. Maximum at T = 180 K and transition to diamagnetic state below T = 165 K.

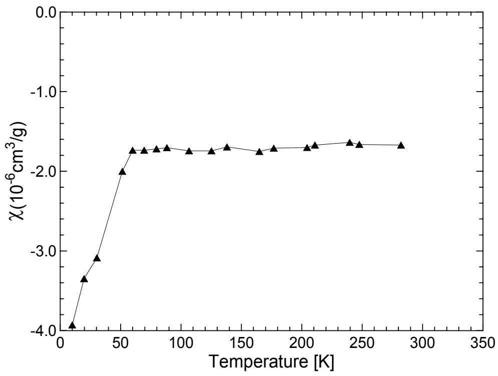

Fig. 2. Magnetic susceptibility χ for $K_3Cu_8Te_6$, at T = 60 K magnetic susceptibility achieves stable value: $\chi \approx -1{,}7\times10^{-6}$ cm^3/g.

Contrary to $K_3Cu_8Se_6$ the transport properties of $K_3Cu_8Te_6$ [1, 2] do not show any changes which can be attributed to the CDW transition. $K_3Cu_8Te_6$ exhibits unusual linear in T behaviour of metallic resistivity down to $T \ll \Theta_D$ (although χ vs. T dependence for $K_3Cu_8Te_6$ exhibits an anomalous behaviour below T = 50 K, see Fig. 2, which is not yet explained).

The results of the investigations of the temperature dependencies of magnetic susceptibility and resistivity are presented in Table 1.

In conclusion we have studied properties of some recently synthesized copper chalcogenides A–Cu–X (where A = alkali metal or alkaline earth metal and X = S, Se, Te). In this report we have focused on the magnetic properties of these compounds. Very interesting features such as: phase transitions connected with CDW formation in $K_3Cu_8Se_6$, and the changes in behaviour of magnetic susceptibility for $K_3Cu_8Te_6$ in contrast to unusual linear in T behaviour of metallic resistivity down to $T \ll \Theta_D$ have been observed.

Table 1. Details of physical properties (resistivity and magnetic susceptibility) of new copper polychalcogenides.

Compound [references]	Resistivity	Magnetic susceptibility
$K_3Cu_8Se_6$ $K^+_3Cu^+_8(Se^{2-})_5Se^-$ [1-3]	p-type metal $\rho_{290K}=44\times10^{-6}$ [Ωcm] $d\rho/dT_{(200\div250\ K)} = 0{,}155\times 10^{-6}$[$\Omega$cmK^{-1}] $\rho_{300\ K}/\rho_{10\ K} \approx 10{,}6$ CDW phase transition in 180 K, (1-st type)	diamagnetic or weak paramagnetic with phase transition at 180 K, changes in χ(T) are correlated with changes in ρ(T)
$K_3Cu_8Te_6$ $K^+_3Cu^+_8(Te^{2-})_5Te^{-1}$ [1-3]	p-type metal $\rho_{300K}=19{,}5\times10^{-6}$ [Ωcm] $d\rho/dT_{(10\div340\ K)} = 0{,}057\times 10^{-6}$[$\Omega$cmK^{-1}] $\rho_{300\ K}/\rho_{10\ K} = 5{,}6$	diamagnetic $\chi_{280K} = -1.6\times10^{-6}cm^3g^{-1}$ In $T_c \sim 60$ K – change of the χ(T) character. It can suggest a phase transition
$Na_3Cu_8S_6$ $Na^+_3Cu^+_8(S^{2-})_5S^-$ [4]	p-type metal $\rho_{300K}=352\times10^{-6}$ [Ωcm] $d\rho/dT_{(10\div340\ K)} = 0{,}937\times 10^{-6}$[$\Omega$cmK^{-1}] $\rho_{300\ K}/\rho_{10\ K} = 3{,}5$	diamagnetic $\chi_{280K} = -1.6\times10^{-7}cm^3g^{-1}$
KCu_3Se_2 $K^+Cu^+_3(Se^{2-})_2$ [1, 2]	metal – nonmetal phase transitions at T = 165 K $\rho_{300K}=56\times10^{-6}$ [Ωcm] $\rho_{165K}=168\times10^{-6}$ [Ωcm] $d\rho/dT_{(70\div100\ K)} = 0{,}566\times 10^{-6}$[$\Omega$cmK^{-1}] $\rho_{165\ K}/\rho_{10\ K} = 1{,}5$	diamagnetic $\chi_{280K} = -3{,}1\times10^{-6}cm^3g^{-1}$
$BaCuS_{3-x}$ $Ba^{2+}Cu^{1+}(S^{1-})_3$ [1, 4, 5]	metal – nonmetal phase transition at T = 270 K $\rho_{300\ K} = 356\times10^{-3}$[$\Omega$cm] $\rho_{300K}=368\times10^{-3}$ [Ωcm] $\rho_{270K}=393\times10^{-6}$ [Ωcm] $d\rho/dT_{(30\div100\ K)} = 1{,}85\times 10^{-3}$[$\Omega$cmK^{-1}] $d\rho/dT_{(120\div250\ K)} = 0{,}348\times 10^{-3}$[$\Omega$cmK^{-1}] $\rho_{270\ K}/\rho_{10\ K} = 2{,}35$	diamagnetic $\chi_{280K} = -2.3\times10^{-7}cm^3g^{-1}$
$CuTe_{3-x}$ $Cu^{1+}(Te_{3-x})^{1+}$ [3]	metal-semiconductor phase transition at T = 300 K $\rho_{300K}=76{,}3\times10^{-6}$ [Ωcm] $d\rho/dT_{(10\div340\ K)} = 0{,}306\times 10^{-6}$[$\Omega$cmK^{-1}] $\rho_{300\ K}/\rho_{10\ K} \approx 100$	diamagnetic $\chi_{280K} = -2.3\times10^{-7}cm^3g^{-1}$

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