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Phase transition and anomalous electronic behavior in the layered superconductor CuS probed by NQR

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Abstract

Nuclear quadrupole resonance (NQR) on copper nuclei has been applied for studies of the electronic properties of quasi-two-dimensional (2D) low-temperature superconductor CuS (covellite) in the temperature range of 1.47-290 K. Two NQR signals corresponding to two structural nonequivalent sites of copper, Cu(1) and Cu(2), have been found. The temperature dependences of copper quadrupole frequencies, linewidths, and spin-lattice relaxation rates altogether demonstrate the structural phase transition near 55 K, which is accompanied by transformations of the electronic spectrum not typical for simple metals. The analysis of NQR results and their comparison with literature data show that the valence of copper ions at both sites is intermediate between monovalent and divalent states with the dominance of the former. It has been found that there is a strong hybridization of the Cu(1) and Cu(2) conduction bands at low temperatures, indicating that the charge delocalization between these ions takes place even in 2D regime. On the basis of our data, the occurrence of an energy gap, charge fluctuations, and charge-density waves, as well as the nature of the phase transition in CuS, are discussed. It is concluded that some physical properties of CuS are similar to those of high-temperature superconductors in the normal state. © 2009 The American Physical Society.

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