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Collective charge response in the weak ferromagnetic phase of κ-$(BEDT\text{-}TTF)_2Cu[N(CN)_2]Cl$

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Abstract

We summarize the main features of the low frequency dielectric relaxation observed below 30K in the weak ferromagnetic state of κ-$(BEDT\text{-}TTF)_2Cu[N(CN)_2]Cl$. The observed width of the relaxation process is somewhat broader than for a Debye process and has a moderate strength of about $3\cdot10^3$. The mean relaxation time, which is much larger than expected for single particle excitations, is thermally activated in a manner similar to the dc conductivity and saturates below the antiferromagnetic phase transition. A charged domain wall in a random ferromagnetic domain structure is proposed as the relaxation entity.

Keywords: Organic superconductors, Transport measurements, Magnetic phase transitions

κ-$(BEDT\text{-}TTF)_2Cu[N(CN)_2]Cl$ belongs to the κ-$(ET)_2X$ (X= polymerized anion) class of ET systems in which orthogonally aligned ET dimers form 2D conducting layers sandwiched between the polymerized anion layers. While the nature and properties of spin density waves found in the Bechgaard salts are well understood, not much is known about the origin and features of the magnetic state in κ phase BEDT-TTF compounds [1,2]. In order to get more information about the low-temperature state in this material we have performed measurements of the magnetic anisotropy and the low-frequency dielectric response. The complete account of the work will be given elsewhere [3].

The main dielectric relaxation process takes place below 32 K. The width is larger than for the Debye process and does not change with temperature below 28 K. The relaxation strength is of the order of 1000 and decreases on lowering the temperature. The mean relaxation time is too long to be attributed to free carriers. τ_0 is thermally activated with an activation energy close the free-carriers one in the narrow temperature range 32 K-25 K, and saturates below T_N=22 K. We propose a charged domain wall in the ferromagnetic domain structure as the relaxation entity. The broad distribution of relaxation times ($1-\alpha$ ~0.7) might be reasonably assumed to be due to a distribution of activation energies. Then, the dielectric response is due to the activation between different metastable states over energy barriers. These metastable states correspond to local changes of the spin configuration. The length scale over which such processes occur defines the thickness of the wall. The fact that the energy scale for the barrier heights is close to the free-carrier activation energy only above T_N=22 K indicates that the free-carrier screening influences the relaxation only in the fluctuating pretransitional regime. At 22 K the relaxation time levels off. This change might indicate that the resistive dissipation is not the dominant dissipation mechanism in the weak ferromagnetic state. Namely, one could expect that the free-carrier screening becomes negligible once the electron density becomes smaller than the one electron per the domain wall length L_{WF}. If we assume that this condition is satisfied at T<20K and take into account the resistance increase of about 5 orders of magnitude between RT and 20 K, we get for L_{WF} ~ 100 μm.

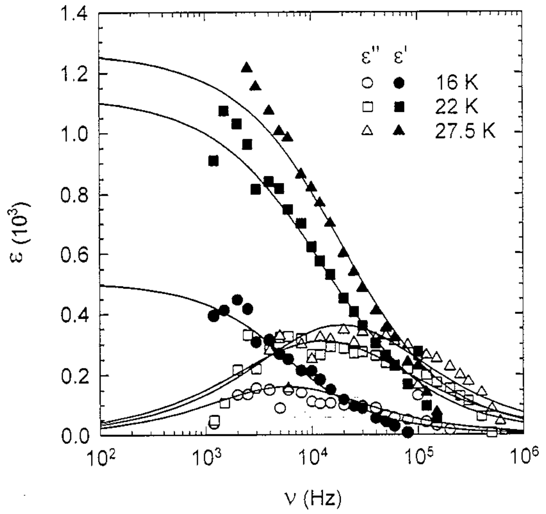

Fig.1.Frequency dependence of the real and imaginary parts of the dielectric function for three representative temperatures. Full lines are from fits to the Havriliak-Negami form.

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