Fluctuation Spectroscopy of Quasi-2D Organic Superconductors κ-(BEDT-TTF)$_2$X – A New Approach to Study the Intrinsic Electron Dynamics

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The family of quasi-2D organic conductors κ-(BEDT-TTF)$_2$ with X = Cu[N(CN)$_2$]Cl, Cu[N(CN)$_2$]Br and Cu(NCS)$_2$ are model systems for low-dimensional metals, where the interplay of charge, spin, and lattice degrees of freedom lead to a rich temperature-pressure or temperature-X phase diagram. Particularly interesting is the region in the vicinity of the first-order Mott metal-to-insulator transition (MIT), where localized magnetic insulating, superconducting, and unusual normal-metallic states meet.

We have employed low-frequency noise spectroscopy [1,2] for the first time in this class of materials, aiming to study the intrinsic dynamics of correlated π-carriers in the vicinity of the Mott transition and in order to delineate the nature of low-energy excitations in the unusual metallic state.

By applying a phenomenological random fluctuation model we are able to extract the density of states D(E) of fluctuations giving rise to the observed 1/f-type noise. A pronounced peak in D(E) in the range of 230 meV is assigned to the rotational degrees of freedom of the ET molecules' ethylene endgroups, which in turn are related to a certain degree of intrinsic disorder affecting also the ground-state properties near the MIT. A second peak at about 100 meV is related to the so-called T* anomalies observed in the normal-metallic state and being discussed in terms of a "pseudogap behavior".

In addition, the electronic noise is a sensitive probe to study the percolation-type superconductivity in the inhomogeneous coexistence region of superconducting and antiferromagnetic insulating phases at low temperatures close to the MIT [1].

We will present a comparative discussion of the dynamical properties of the π-carriers as inferred from the resistance fluctuations for materials with different chemical compositions and at different pressure conditions. We will debate the consequences for the understanding of the phase diagram of these materials.

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