Slow Dynamics due to Electronic Ferroelectricity in Strongly-Correlated Molecular Conductors

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Thanks to the powerful toolkit of organic chemistry, quasi-two-dimensional molecular metals κ-$(ET)_2X$ and related compounds are highly tunable and constitute a playground for studying rich phase diagrams with novel quantum phases and interesting ground states of strongly interacting electrons residing in a relatively soft lattice.

Electronic ferroelectricity, where electrons play the role of the ions in conventional displacive ferroelectrics, has recently become an active area of research, where it has been suggested that in certain dimerized systems the electric dipoles originate from charge order, i.e., a charge disproportionation within the $(ET)_2$ dimers, indicating a breakdown of the dimer-Mott model [1,2,3]. In such a scenario, one expects characteristic and large changes of the low-frequency dynamics of the charge carriers coupled to the electronic, magnetic and lattice degrees of freedom. In this talk we will discuss such dynamical measurements employing fluctuation (noise) spectroscopy in the mHz – kHz regime [4]. The method is complementary to dielectric spectroscopy and allows to extract spectroscopic information in conductive systems from electronic transport measurements, i.e. without injecting additional charge carriers.

In this talk we aim to give an overview of the systematics of charge fluctuations in the dimer-Mott and charge-ordered states of various different materials. We discuss and compare the spin-liquid candidate and Mott insulator X = $Cu_2(CN)_3$, the multiferroic Mott insulator X = $Cu[N(CN)_2]Cl$ [2], the ferroelectric charge-ordered insulators X = $Hg(SCN)_2Cl$ [5] and α-$(ET)_2I_3$ [6], the square lattice dimer-Mott system β'-$(ET)_2ICl_2$ [7] and the recently synthesized system κ-$(BETS)_2Mn[N(CN)_2]_3$. Among these different compounds, we will discuss remarkable similarities as, e.g., the formation of nano-scale polarized clusters and strong out-of-equilibrium kinetic processes upon approaching and inside the ordered phase, respectively, as well as electric-field tuning of the charge dynamics.

Finally, we will comment on the controversial relationship of structural and electronic glassiness in the non-dimerized compounds θ-$(ET)_2MM'(SCN)_4$, where a charge-ordered state can be kinetically avoided in favor of a novel charge-glass state [8,9].

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