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Mott criticality and multiferroicity in organic κ -(BEDT-TTF)$_2$X salts[1]

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Layered organic charge-transfer (CT) salts of the κ-(BEDT-TTF)$_2$X family show a wealth of electronic phases resulting from the interplay of strong electron-electron correlations, reduced dimensions and magnetic frustration. Of particular interest has been the bandwidth-controlled Mott transition, separating an antiferromagnetic (afm) insulating state from a correlated metallic and superconducting state. Whereas the hydrogenated X = Cu[N(CN)$_2$]Br salt is located on the metallic side, the deuterated variant, denoted κ-D8, is situated in splitting distance to the Mott transition, enabling the s-shaped transition line $T_{\rm MI}$ to be crossed via temperature sweeps. The talk will address the following aspects: 1) Thermal expansion measurements on single crystalline κ-D8 reveal discontinuous changes of the lattice parameters on crossing the Mott transition line and a huge anomaly close to the second-order critical end point of $T_{\rm MI}$ [1]. By elaborating on a scaling theory [2], we found that (i) the latter effect is a consequence of an almost divergence of the Grüneisen parameter Γ at the finite-T critical end point, and (ii) that the expansivity data of [1] are in excellent agreement with the Mott criticality lying within the 2D Ising universality class [2], at variance with results from conductivity measurements [3]. Thermal expansion measurements under Helium-gas pressure are underway for providing thermodynamic information at variable pressure. 2) Surprisingly, for the isostructural X = Cu[N(CN)$_2$]Cl salt, located close to the Mott transition on the insulating side, we found that besides the well-established afm order at $T_{\rm N} \sim 27$ K, the system also reveals a ferroelectric transition at $T_{\rm FE}$, making this material the first multiferroic CT salt [4]. Most remarkably, the measurements reveal $T_{\rm FE} \approx T_{\rm N}$, suggesting a close interrelation between both types of ferroic order.

The work was performed in collaboration with M. de Souza, L. Bartosch, P. Lunkenheimer, J. Müller, S. Krohns, A. Loidl, B. Hartmann, J. A. Schlueter

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