Far-infrared studies of charge ordering and superconductivity in layered organic conductors $\alpha$-(BEDT-TTF)$_2X$

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A comparative study of the low-energy optical properties of the metallic $\alpha$-(BEDT-TTF)$_2$KHg(SCN)$_4$ and the superconducting $\alpha$-(BEDT-TTF)$_2$NH$_4$Hg(SCN)$_4$ was performed by polarized reflection measurements at temperatures $5 \, \text{K} \leq T \leq 300 \, \text{K}$. The optical conductivity of $\alpha$-(BEDT-TTF)$_2$NH$_4$Hg(SCN)$_4$ steadily increases with decreasing frequency as expected for a metal. However, for the non-superconducting K-analog we find in both orientations of the highly conducting plane the gradual development of a pseudogap in the optical conductivity around $200 \, \text{cm}^{-1}$ as the temperature is reduced below 200 K; a narrow Drude-like contribution remains. We assign the observed behavior to the proximity of a correlation induced metal-insulator transition.$^1$

The far-infrared in-plane reflectivity of superconducting $\alpha$-(BEDT-TTF)$_2$I$_3$ was measured down to very low frequencies ($10 \, \text{cm}^{-1}$). We determined an energy gap of $25 \, \text{cm}^{-1}$ which opens below $T_c = 8 \, \text{K}$; $2\Delta/k_B T_c = 4.4$ is in good agreement with moderate coupled BCS superconductor. A considerable low-frequency absorption remains in the superconducting state. From our analysis we estimated a London penetration depth $\lambda_L \approx 6 \, \mu\text{m}$.$^2$

Additionally, we present data on the optical properties of the organic metal (BEDT-TTF)$_4$Ni(dto)$_2$ which strongly indicate that a correlation gap opens at low temperatures.$^3$