Interplay of Charge Order and Superconductivity in Two-Dimensional Organic Metals

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Some of the two-dimensional quarter-filled BEDT-TTF salts are superconductors, while some of them remain metallic down to low temperatures; others undergo a sharp metal to insulator transition. Why do these materials behave electronically so differently although they are similar in structure? Optical spectroscopy reveals that these compounds are subject to charge order to a different degree. The interplay of charge order and superconductivity suggest superconductivity mediated by charge order fluctuations.

We present optical investigations on two-dimensional organic metals with a quarter-filled conduction band, in particular the 5 K superconductor β″-(BEDT-TTF)$_2$SF$_5$CH$_2$CF$_2$SO$_3$. Raman and infrared measurements indicate a charge disproportionation of 0.2*e*. The optical conductivity evidences interaction of the charge carriers with charge-order fluctuations: Strong localization due to nearest neighbor Coulomb interaction significantly reduces the spectral weight of the Drude response and an intense charge-fluctuation band forms around 300 cm^{-1}. An interaction of charge carriers with charge fluctuations becomes evident by the linear dependent spectral weight of the Drude component as well as a collective charge-order excitation at 30 cm^{-1} intensity, which is linked to the intensity of Drude response. Below T_c = 5 K we observe a superconducting gap (2Δ = 12 cm^{-1}). The overall results suggest that superconductivity in this compound is mediated by charge-order fluctuations.

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