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Electronic correlations and superconducting response in the optical properties of FeTe$_{0.55}$Se$_{0.45}$

C.C. HOMES, A. AKRAP, J.S. WEN, Z.J. XU, Z.W. LIN, Q. LI, G.D. GU, Condensed Matter Physics and Materials Science Dept., Brookhaven National Laboratory, Upton, New York — The in-plane complex optical properties of the iron-chalcogenide superconductor FeTe$_{0.55}$Se$_{0.45}$ have been determined above and below $T_c = 14$ K. At room temperature the conductivity is described by a weakly-interacting Fermi liquid with $\omega_{p,D} \simeq 7200$ cm$^{-1}$ and $1/\tau_D \simeq 414$ cm$^{-1}$. Below 100 K the conductivity is no longer described by the Drude model. Adopting the generalized Drude model reveals that $1/\tau(\omega) \propto \omega$ in the terahertz region just above $T_c$, signaling the increasingly correlated nature of this material. For $T \ll T_c$ the superconducting plasma frequency $\omega_{p,S} \simeq 3000$ cm$^{-1}$ ($\lambda_{\text{eff}} \simeq 5300$ Å); $\omega_{p,S}^2/\omega_{p,D}^2 \ll 1$ indicating that this material is not in the clean limit. Allowing $\sigma_{dc} \equiv \sigma_1(\omega \rightarrow 0)$, then $\sigma_{dc}(T \simeq T_c) \simeq 3500 \pm 400$ Ω$^{-1}$cm$^{-1}$ and the superfluid density $\rho_{s0} \equiv \omega_{p,S}^2 \simeq 9 \pm 1 \times 10^6$ cm$^{-2}$ places material close to the scaling line $\rho_{s0}/8 \simeq 8.1 \sigma_{dc} T_c$ for a BCS dirty-limit superconductor. Below $T_c$ the optical conductivity reveals two energy scales for the superconductivity at $\Delta_1(0) \simeq 2.5$ meV and $\Delta_2(0) \simeq 5.1$ meV, consistent with the $s^\pm$ model.

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