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## Optical effects in multiband conductors and superconductors[1]

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Multiband materials display a wide variety of interesting transport phenomena, often with striking optical effects. Two examples are the colossal magnetoresistance in the semimetal $WTe_2$, and the emergence of superconductivity in the iron-based material $FeTe_{0.55}Se_{0.45}$ with a critical temperature ($T_c$) of $\simeq$ 14 K. The complex optical properties are determined from a Kramers-Kronig analysis of the reflectance, which is measured in the transition metal-chalcogenide ($a$-$b$) planes over a wide energy range. A poor metal at room temperature, $WTe_2$ undergoes a Lifschitz transition to become a perfectly-compensated semimetal at low temperature, leading to the formation of a striking plasma edge in the far-infrared reflectance. By considering Drude components for the electron and hole pockets, and by examining both the real and imaginary parts of the optical conductivity, it can be demonstrated that one of the scattering rates collapses at low temperature.[2] Dirac and Weyl semimetals display very small scattering rates, and $WTe_2$ is thought to be a type-II Weyl semimetal. $FeTe_{0.55}Se_{0.45}$ is also a poor metal at room temperature, with a flat and almost frequency-independent optical conductivity. Just above $T_c$, a narrow Drude response emerges, superimposed on a broad, temperature-independent Drude component. Below $T_c$, dramatic changes in the in-plane reflectance signal the formation of multiple superconducting energy gaps which may be determined from the real part of the optical conductivity to be $2\Delta_1 = 5.6$ and $2\Delta_2 = 11.2$ meV on the broad and narrow bands, respectively. Interestingly, this material is simultaneously in both the clean and dirty limit.[3]

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[2]C. C. Homes, M. N. Ali, and R. J. Cava, Phys. Rev. B **92**, 161109(R) (2015).
[3]C. C. Homes, Y. M. Dai, J. S. Wen, Z. J. Xu, and G. D. Gu, Phys. Rev. B **91**, 144503 (2015).