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Gap signatures in the IR and THz properties of the cuprate and iron-based superconductors

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Christopher Homes
Condensed Matter Physics and Materials Sciences Department
Brookhaven National Laboratory

Advances in infrared spectroscopy have allowed the complex optical properties of superconductors to be examined with unprecedented accuracy. These studies have been particularly revealing in the cuprates and the recently discovered iron-based superconductors, both of which have high critical temperatures (Tc's) [1]. The d-wave symmetry of the superconducting energy gap in the hole-doped cuprates results in a rather ambiguous energy gap in the copper-oxygen planes; however, in the electron-doped materials the energy gap appears to be non-monotonic resulting in clear optical gap below Tc. The cuprates are two dimensional and the superconductivity along the poorly-conducting c axis is due to Josephson coupling between the planes, resulting in the formation of a striking Josephson plasma edge in the reflectance below Tc. The iron-based superconductors are more three dimensional, multiband systems, consisting of electron and hole pockets at the Fermi surface. Superconductivity may be found in a number of different structures, and of these BaFe2As2 (122) is one of the most studied, displaying an anisotropic gapping of the Fermi surface below the structural and magnetic transition, as well as a phonon anomaly [2]. Superconductivity may be induced through cobalt substitution, and a clear optical signature of superconductivity is observed with the formation of at least one gap [3]. Superconductivity is also observed in the even simpler iron-chalcogenide FeTe1-xSex (11) materials, which appear to be strongly correlated [4], with evidence of multiple gaps below Tc [5]. In the iron-based superconductors scattering between the electron and hole pockets is thought to be a necessary element of the pairing mechanism. Thus in the purely hole-doped KFe2As2 it is not surprising that the critical temperature is very low (Tc ~ 3 K); however in the electron-doped K0.8Fe2-ySe2 the critical temperature is an order of magnitude higher (Tc ~ 31 K), suggesting that the pairing mechanism may have to be re-evaluated. Interestingly, while no evidence for a Josephson plasma edge has been observed along the c-axis of the iron-bases superconductors, K0.8Fe2-ySe2 appears to be an inhomogeneous material in which the superconductivity is due to Josephson coupling [6].

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Primary author: HOMES, Christopher (Brookhaven National Laboratory)

Presenter: HOMES, Christopher (Brookhaven National Laboratory)

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