Electronic Raman Spectroscopy of Electron-doped High-Temperature Superconductors

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Inelastic (Raman) scattering of light from electrons in a solid gives information about the dynamics of electrons as well as their energy and momentum distribution. This type of information is particularly useful for the study of superconductivity. We performed Raman Spectroscopy measurements with polarized light to study electronic properties of the electron-doped high-temperature superconductor $Pr_{2-x}Ce_xCuO_{4-\delta}$ (PCCO). The electronic properties of this material were studied as a function of Ce doping, temperature and magnetic field. In superconductors, there is a redistribution of Raman scattering intensity in the superconducting state upon cooling the samples below their critical transition temperatures (T_c). A coherence peak appears at an energy equal to that required to break a pair of electrons in the superconducting state. Its position depends on the strength of the pairing interaction and varies with doping. A magnetic field quenches superconductivity above a critical field (H_{c2}). In the figure we show the effect of the magnetic field upon the coherence peaks for an optimally doped and an over-doped PCCO crystal. We find that H_{c2} is dramatically lower for the over-doped sample compared to the optimally-doped sample. Moreover, the coherence peak position decreases with increasing magnetic field. These results are quite different from what is found in conventional superconductors and they should enhance our understanding of high-temperature superconductivity.

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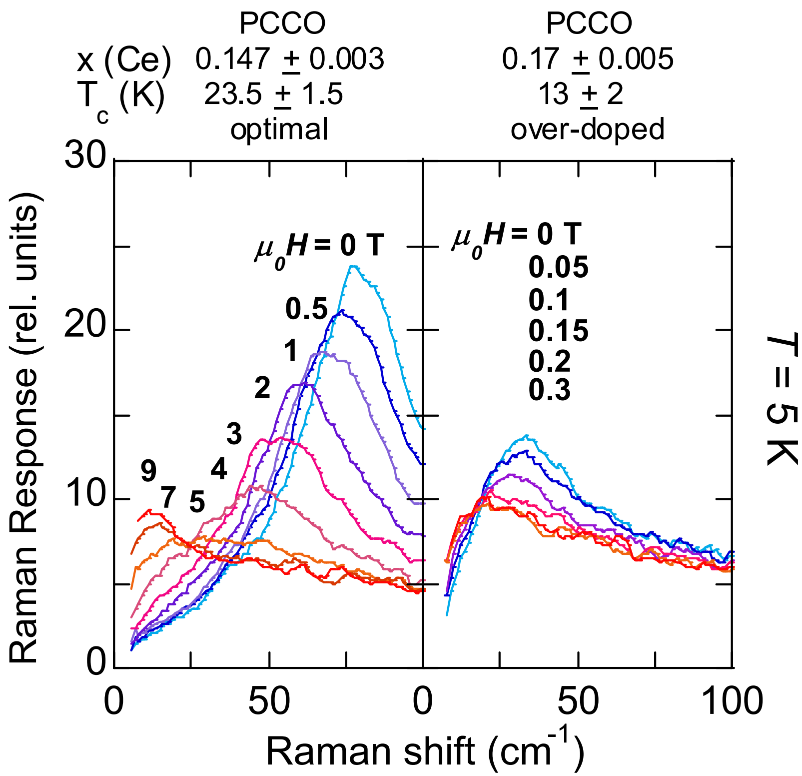

Raman response for two single crystals of PCCO with different Ce dopings. The data is obtained below T_c at T = 5 K and shows the evolution and eventual disappearance of the coherence peaks with increasing magnetic field.

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Education

Two undergraduates (Chris Hill and Matt Barr) and one graduate student (Mumtaz Qazilbash) contributed to this work. Chris Hill has graduated and will be applying to graduate school next year. Matt Barr is a senior and will apply to graduate school this year. Mumtaz Qazilbash received his Ph.D. in 2004 and is presently searching for a postdoc position in the USA.

Societal Impact

An understanding of the mechanism causing high temperature superconductivity may enable the development of new materials that are superconducting above room temperature. This would have a large impact on electronic devices and electricity generation and distribution.