Magneto-Optical Response of Electron Doped Cuprates $Pr_{2-x}Ce_xCuO_4$

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Abstract. We report mid-infrared transmission measurements of electron doped $Pr_{2-x}Ce_xCuO_4$ (PCCO) thin films for a wide range of dopings, in the large energy pseudogap regime both as a function of temperature and magnetic field. While the temperature dependent measurements show clear signatures of pseudogap, there is no magnetic field induced effect.

Keywords: PCCO, Magnetic field, Optics, Pseudogap
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INTRODUCTION

The normal state of cuprates shows many anomalous properties, attributed at present to the formation of a pseudogap. In the *ab*-plane, the pseudogap shows up as a drop in the optically defined scattering rate for hole-doped cuprates [1], whereas for electron-doped materials it appears directly in the conductivity [2, 3] spectra at around 0.15 eV. This high energy pseudogap has been attributed to changes in antiferromagnetic spin correlations [2] and spin density waves (SDW) [3] respectively. In this paper, we present magnetic-field and temperature dependent transmission data in the large energy pseudogap region.

EXPERIMENT

Thin Films of $Pr_{2-x}Ce_xCuO_4$ (PCCO) of several compositions were grown on $LaSrGaO_4$ (LSGO) substrates using pulsed laser deposition [4]. The films used in this experiment included a highly underdoped (x = 0.11) non-superconducting sample, an optimally doped (x = 0.15) sample and an overdoped (x = 0.18) sample. The mid-infrared studies in magnetic field were performed at the National High Magnetic Field Laboratory, using a Bruker 113v spectrometer with custom-built light-pipe optics to carry the mid-infrared radiation through the sample and on to a 4.2 K helium-cooled bolometer detector [5]. We employed a 30 T resistive magnet and measured the 4.2 K transmittance ratio, $\mathscr{T}(\mathscr{H})/\mathscr{T}(0)$. Two different sample holders were used, one where the *ab*-plane of the sample was $\perp$ to the magnetic field and one where the *ab*-plane was at an angle of $\theta = 25^0$ to the magnetic field, ensuring an in-plane $\mathscr{H}$ component.

ZERO FIELD DATA

Figure 1 shows the temperature dependent transmission of the three PCCO samples (with $x = 0.11$, $x = 0.15$, $x = 0.18$) at 0 T. The most prominent changes can be seen for the highly underdoped sample at around $1500\ cm^{-1}$. This behavior is in accord with the results of reflectance studies presented earlier [3]. In comparison, transmission changes in optimally doped and overdoped samples are small. This large increase in transmission (not due to the substrate) is observed as the temperature is lowered and the pseudogap is established.

MAGNETIC FIELD DATA

In contrast to its strong temperature dependence, the magneto-transmission of the underdoped PCCO, with magnetic field $\perp$ to the *ab*-plane did not show any change within the experimental signal to noise of $\pm1\%$, as shown in Fig. 2. For the optimally doped sample, we measured the effect of having components of the magnetic field both along the *ab*-plane and along the *c*-axis. This oblique configuration has revealed doping-dependent properties in the DC resistivity and has been attributed to a quantum critical point in these materials [6]. No magneto-optical effect exceeding $\pm2\%$ was observed. Finally, the overdoped sample with magnetic field $\perp$ to *ab*-plane also does not show any change in

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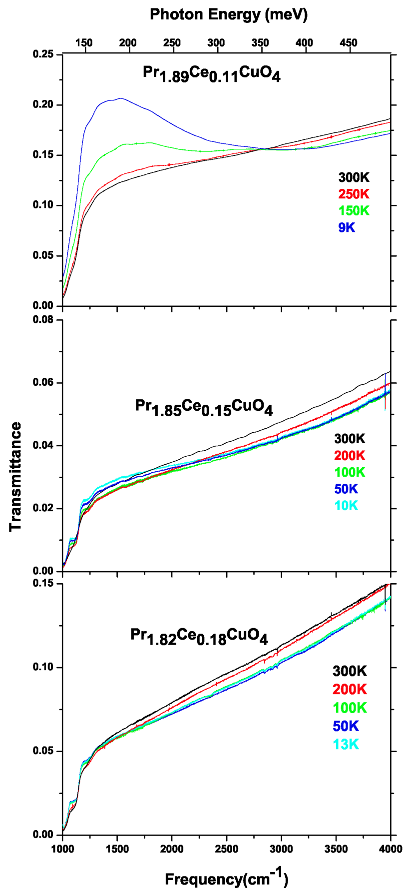

FIGURE 1. Transmission at various temperatures of PCCO at 0 T for $x = 0.11$, $x = 0.15$ and $x = 0.18$. The low frequency cutoff comes from the transmission cutoff of the LSGO substrate.

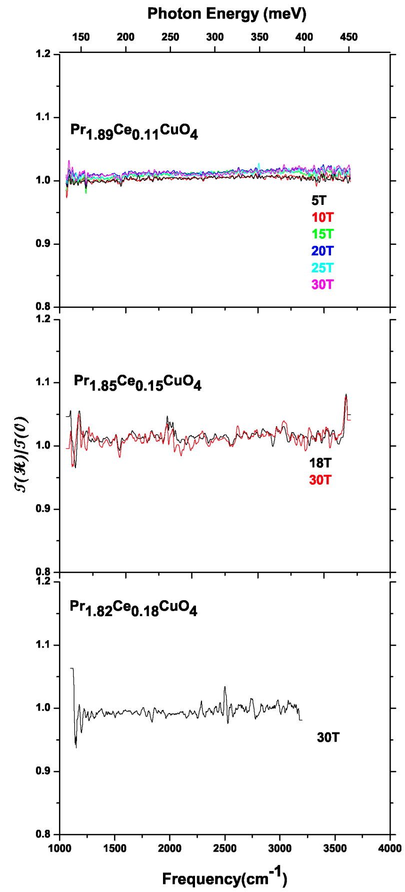

FIGURE 2. Normalized (to 0 T) magneto-transmission spectra at 4.2 K of PCCO for $x = 0.11$, $x = 0.15$ and $x = 0.18$.

transmission within experimental signal to noise resolution of $\pm 3\%$.

CONCLUSIONS

These experiments indicate that the high energy pseudogap is unaffected by magnetic field. This result is probably due to the fact that the Zeeman energy of the field (about 3 meV) is small compared to the energy scale of the antiferromagnetic correlation (0.12 eV), so the *ab*-plane spins are perturbed very little by the applied magnetic field.

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