

**Zeitschrift:** Helvetica Physica Acta  
**Band:** 65 (1992)  
**Heft:** 2-3

**Artikel:** Optical response of CuO<sub>2</sub>-plane and CuO-chain in YBaCuO  
**Autor:** Bucher, B. / Wachter, P.  
**DOI:** <https://doi.org/10.5169/seals-116448>

#### Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

#### Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

#### Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

**Download PDF:** 05.08.2025

**ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>**

# Optical Response of CuO<sub>2</sub>-plane and CuO-chain in YBaCuO

B. Bucher and P. Wachter

*Laboratorium für Festkörperphysik, ETH Zürich, 8093 Zürich, Switzerland*

## Abstract

We have measured the polarized reflectivity of YBa<sub>2</sub>Cu<sub>3.5</sub>O<sub>7.5</sub> with  $\vec{E}$  parallel to the **a**- and **b** axes. With a model of shunted conduction channels, we could evaluate the optical conductivity of the CuO<sub>2</sub>-plane and the CuO-chain, respectively.

## Introduction

The well studied YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> (123) superconductor has the disadvantage to be twinned. Thus, the socalled "ab-plane" response is rather an average of the CuO<sub>2</sub>-plane and the CuO-chain (along the b-axis) properties. Untwinned YBa<sub>2</sub>Cu<sub>3.5</sub>O<sub>7.5</sub> provides the opportunity to measure the polarized reflectivity along the **a**-direction i. e. the genuine reflectivity of the 2D CuO<sub>2</sub>-plane.

## Results

Fig.1 shows the reflectivity of a  $T_c = 70$  K sample at 300 K and 4.2 K. The light was polarized along the **a**- and **b** axes. A large anisotropy exists in the IR spectral range, coming from the additional response of the chains. The anisotropy exists down to zero frequency i. e. the chains contribute to  $\sigma_{DC}$  [1]. Below  $T_c$ , an additional plasma edge has developed around 20 meV.

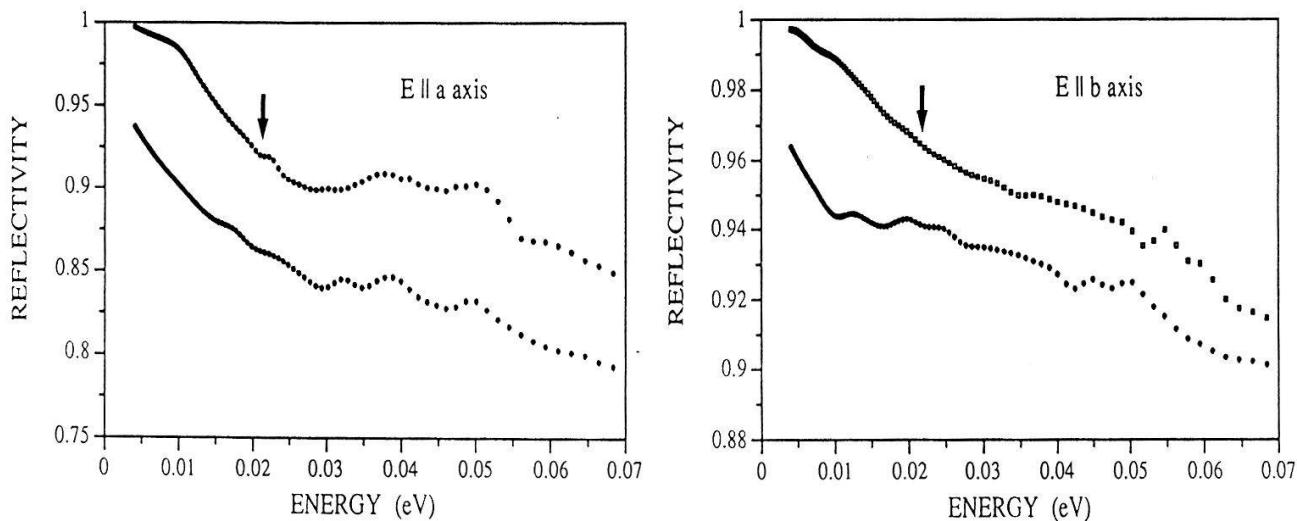


Figure 1: Near normal reflectivity of YBa<sub>2</sub>Cu<sub>3.5</sub>O<sub>7.5</sub> at 300 K (lower curves) and 4 K (upper curves) for  $\vec{E} \parallel \mathbf{a}$  (left panel) and  $\vec{E} \parallel \mathbf{b}$  (right panel) axes, respectively.

On the reflectivities (4 meV - 12 eV), we performed the Kramers-Kronig transformation. The real part of the optical conductivity  $\sigma_1$  is depicted in fig.2. If we postulate a model of shunted conduction channels for the **b** direction ( $\sigma_1^b = \sigma_{1,chain}^b + \sigma_{1,plane}^b$ ), we can extract the conductivity of the chain alone, assuming  $\sigma_{1,plane}^b = \sigma_1^a$  (fig.2).

## Discussion

The response of the CuO<sub>2</sub> plane  $\sigma_1^a(\omega)$  has been analyzed [2], in order to take into account unusual (non-Drude) excitations, with a frequency dependent scattering rate  $\Gamma(\omega)$

$$\sigma(\omega) = \frac{ne^2}{m^*} \cdot \frac{1}{\Gamma^*(\omega) - i\omega}$$

with  $m^*(\omega)$  a renormalized mass and  $\Gamma^*(\omega)$  a renormalized scattering rate (fig.3). An astonishing linearity comes out for the scattering rate  $\Gamma^*(\omega)$  which has been thought of as an evidence of a nearly localized Fermi liquid [3].

The steep increase of the reflectivity below  $T_c$  around 20 meV (fig.1) can be simulated by a two-fluid model [2], where the superconducting fraction is described by the London model. The poles of the real dielectric constant in the SC state  $\epsilon_1^{sup} = \epsilon_1^{normal} - \omega_{ps}^2/\omega^2$  determines right the additional plasma edge with  $\omega_{ps}^2$  the plasma frequency of the condensed Bosons (e.g. bipolarons).

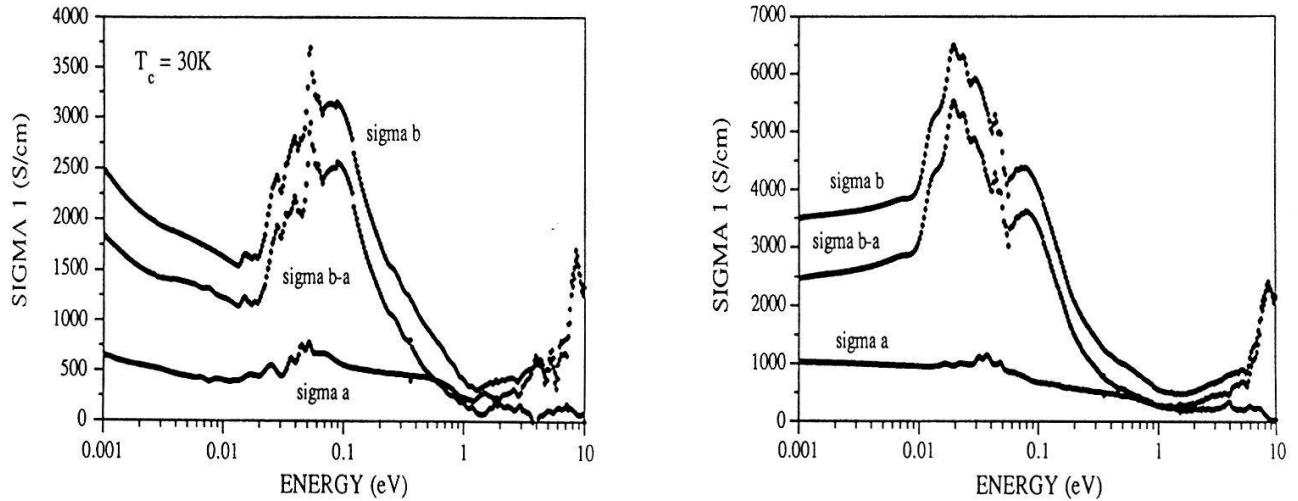


Figure 2: Optical conductivity  $\sigma_1^a(\omega)$  and  $\sigma_1^b(\omega)$  for the **a**- and **b** direction, respectively, for a  $T_c = 30$  K (left) and  $T_c = 70$  K (right) sample. Also shown is the response of the chain alone.

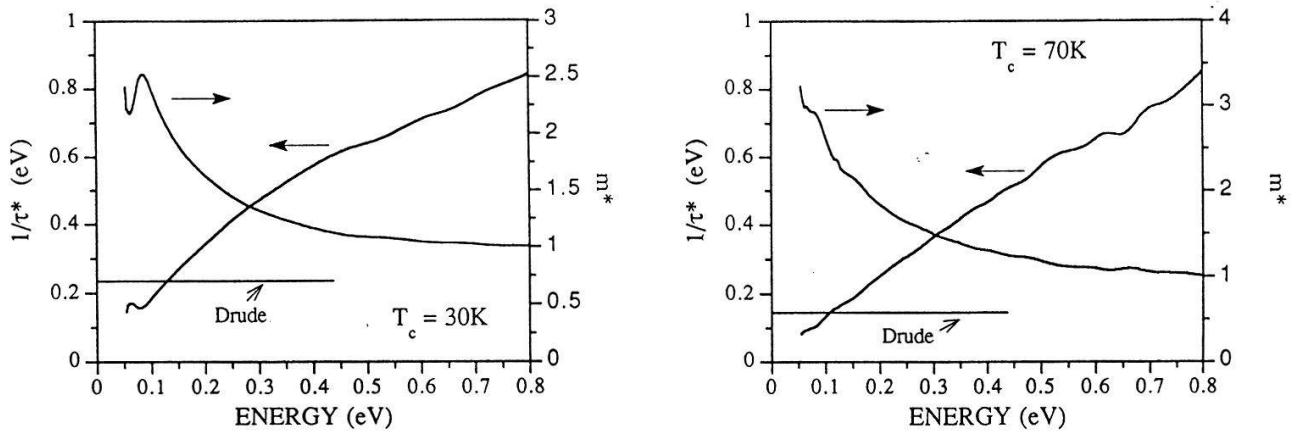


Figure 3: Frequency dependent scattering rate  $\Gamma^*(\omega)$  and renormalized mass  $m^*$  of the **a**-direction for a  $T_c = 30$  K (left) and  $T_c = 70$  K (right) sample. Also shown is  $1/\tau_{Drude}$  as fitted in Ref. [2].

## References

- [1] B.Bucher, J.Karpinski, E.Kaldis and P.Wachter, Physica C **167** (1990), 324
- [2] B.Bucher, J.Karpinski, E.Kaldis and P.Wachter, to be published
- [3] C.M.Varma, P.B.Littlewood, S.Schmitt-Rink,E.Abrahams, A.E.Ruckenstein, PRL **63** (1989), 1996