QUANTUM CRITICALLITY IN CUPRATES: PRL REPORT

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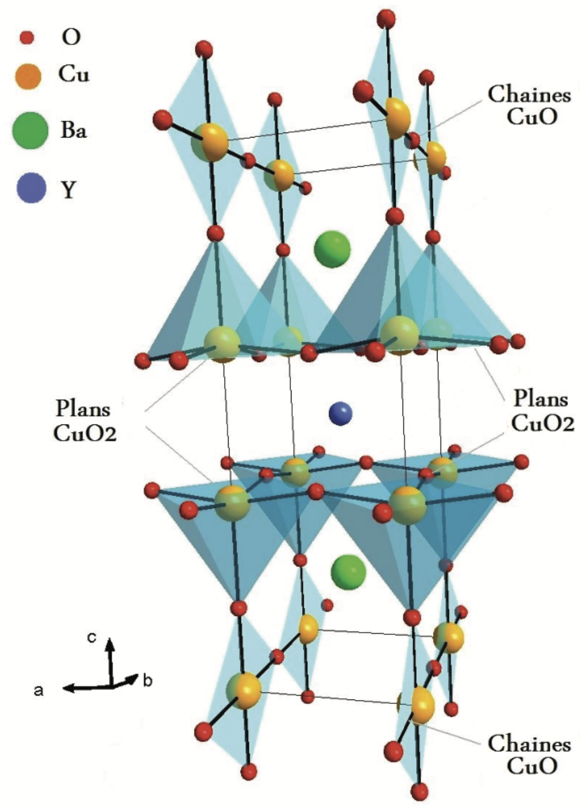

Figure 1: Crystal structure of a Cuprate (YBCO)

Abstract

1 INTRODUCTION

1.1 Cuprates: High-Temperature Superconductors

Cuprates are a class of superconductors with high critical temperature that have been subject to intense research since their discovery in 1986. They exhibit rich physical behavior, specially in their various phases.

The origin of their superconductivity is still a mystery, but it is believed to be related to the quantum critical point (QCP) that is present in the phase diagram of these materials. The existence of this QCP is the subject of this research project.

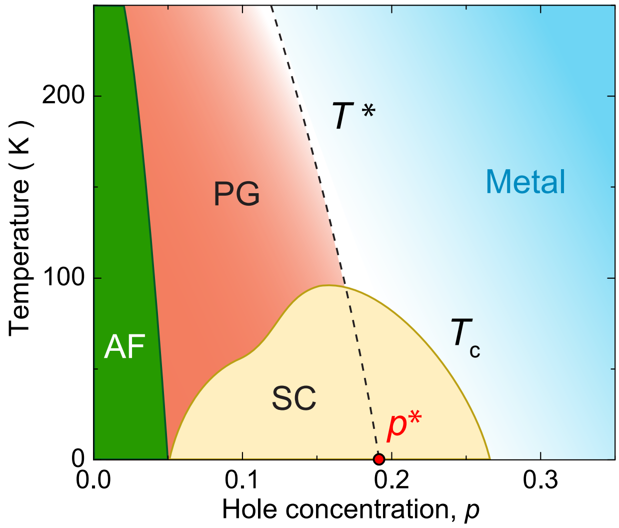

Figure 2: Phase diagram of Cuprates

A quantum critical point is a point in the phase diagram of a material where it goes through a phase transition at zero temperature. In Cuprates, the phase transition occurs by increasing the doping level of the material.

1.2 Evidence for the QCP: Specific Heat

In their 2019 paper, Michon et al. measured the specific heat of LSCO Cuprates and found a peak in the specific heat at the critical doping level. This peak is a signature of the QCP.

1.3 Evidence against the QCP: Optical Conductivity

In their 2022 paper, Legros et al. measured the optical conductivity of LSCO Cuprates and, contrary to the specific heat results, found no evidence of a QCP in the optical conductivity.

They used the Drude model to fit the optical conductivity and extracted the cyclotron mass. They argue this is the same as the effective mass of the charge carriers, which is proportional to the specific heat and is expected to diverge at the QCP. They found a simple linear dependence of the cyclotron mass with the doping level, which contradicts the specific heat results.

We believe the use of the Drude model is not appropriate in this case, because it works well when the Fermi surface is roughly isotropic, but we have a highly anisotropic Fermi surface in Cuprates. We propose to use the Boltzmann transport equation to fit the optical conductivity and extract the effective mass of the charge carriers.

2 METHODS

2.1 Reproduction of Drude Fits

2.2 Bolzmann Transport and Chambers Formula for Optical Conductivity

2.3 Fitting Procedure

3 RESULTS