Electrons losing weight

May 1 2017

The measured mass of electrons in solids is always larger than the value predicted by theory. The reason for this is that theoretical calculations do not account properly for various interactions with other electrons or lattice vibrations – that "dress" the electrons. EPFL scientists have now carried out a study on a lithium-containing copper oxide and have found that its electrons are 2.5 times lighter than was predicted by theoretical calculations. The work is published in *Physical Review Letters* and has made the cover.

The lab of Marco Grioni at EPFL used a spectroscopy technique called ARPES (angle-resolved photoemission spectroscopy), which allows researchers to "track" electron behavior in a solid material. In this case, the solid material was a copper oxide, a member of the transition-metal oxide family of materials, which have wide-ranging applications for their electronic, magnetic and catalytic properties. In this type of copper oxide Cu atoms have two different values of valence, making it a "mixed-valence" compound.

The researchers used ARPES to measure the energy of the electron bands in the copper oxide. This then helped them calculate the mass of its electrons. Simply put, the broader the band, the smaller the electron's mass.

Running the measurements, the scientists found that the copper oxide's electrons are actually 2.5 times lighter than the values given by theoretical predictions. "This is rather unique and unexpected," says Marco Grioni. "It goes against a widely accepted tenet of many-body

theory that says that correlation effects generally yield narrower bands and larger electron masses."

The authors state that present-day electronic structure calculation techniques may provide an intrinsically inappropriate description of ligand-to-d hybridizations in late transition metal oxides.

More information: S. Moser et al. Electronic Phase Separation and Dramatic Inverse Band Renormalization in the Mixed-Valence Cuprate, *Physical Review Letters* (2017). DOI: 10.1103/PhysRevLett.118.176404