Using light to modulate the properties of a copper-based superconductor

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A study just published in *Nature Communications* and carried out by a collaboration of several Italian and international centres, including SISSA, used a technique based on applying short flashes of light to observe and analyse the features of a superconductor at high critical temperature, a material with major prospects for technological applications. In addition to providing an explanation for the peculiar behaviour of the material, the study also opens to the possibility of controlling its characteristics by means of laser pulses.

Superconductors are futuristic materials that will hopefully have a broad range of technological applications at some time in the future (medical imaging, transport…). Today's use is limited by the extremely low temperatures (close to absolute zero) required for superconductivity to manifest. However, some families of these materials work at "relatively" high temperatures (about - 200° C), and it's on these that scientists are focusing their attention. Among them are copper-based superconductors, which have very unique characteristics. A study conducted by researchers of the International School for Advanced Studies (SISSA) of Trieste, the iLamp laboratory of the Catholic University of the Sacred Heart (Brescia), the T-Rex laboratory of the Elettra Synchrotron (Trieste), the Department of Physics of the University of Trieste and other international centres analysed a phenomenon typical of these materials and known to scientists as the pseudogap.

"When the material is heated to above the critical temperature, under which superconductivity manifests itself", explains Massimo Capone a

SISSA researcher who took part in the study, "some of the features of the superconductive state are preserved, even though the main one is lost. This condition is called a pseudogap".

The team conducting the study induced a pseudogap state in the material, which it then subjected to very short pulses of laser light. "This treatment made the superconductor temporarily more 'metallic', a state not normally manifested in this condition. We then interrupted the pulses and observed how the material behaved when it returned to its original state", continues Capone. "What we induced is in fact a transient state - lasting less than a picosecond - which we realised was related to electron-electron interactions. The light pulses remove these interactions, making the electrons freer to flow: hence the metallic state".

Capone, whose role in this (mainly experimental) study was to contribute to interpreting the data collected, explains that it's most probably the electron-electron interactions that are responsible for the pseudogap state.

"In addition to offering a theoretical framework for the phenomenon and providing new insight into this major family of superconductors, our study opens to an important possibility of controlling and modulating the characteristics of superconductors through the use of laser light".

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