Research into Superconductors

Tracking the Flow of Energy by Laser

Below their critical temperature they conduct the electrical current without resistance and thus extremely efficiently: Until now it has only been known that high-temperature superconductors work – but not how. Physicists at the University of Duisburg-Essen (UDE) have succeeded in tracking the redistribution of the energy in the material. To do this they used a medium which is itself fast enough to register these processes − light. The "Nature Communications" journal has just published their results.

The world's longest superconductor cable, according to the power supplier's own information, has connected two transformer substations in the centre of the City of Essen since 2014. Over a kilometre in length, it replaces the conventional ground cable in a pilot project and requires only around one tenth of the voltage (10kV vs. 110kV) to transport a quantity of electricity five times as high.

"But it's not sufficient to know that it works", explains Prof. Dr. Uwe Bovensiepen, spokesperson of the special research field *Non-equilibrium dynamic of condensed matter in the time domain*. "We physicists want to understand such complex materials." To do this, the scientists in his work group use "time-resolved, angle-resolved photoelectron spectroscopy (tr-ARPES)": With inconceivably short light pulses of only one billionth of a second, they excite the material and query the result with laser pulses emitted with a slight delay. "It's just like throwing a stone into the water and then observing the ripples", clarified Bovensiepen. In this way, they make the kinetic energy and direction of photoelectrons visible like in a film, which consists of nothing but frozen individual images – from the excitation and back to the moment in which the initial state is achieved once again.

For the first time, they observed a special type of interaction, in which the excited electrons and the atoms of the material vibrate with each other at the same frequency – like a tuning fork, which allows a single pure tone to sound. It is not yet known what effect this state has on the electrical properties of the superconductor, but "something special is in there". The researchers performed the analysis above the temperature limit of 92K in order to concentrate fully on this effect. They now want to examine its wave character more closely in the next step.

The publication was produced together with colleagues from the USA (New York, Raleigh and Washington), from Japan (Tsukuba) and from Hamburg.

Original publication:
J. D. Rameau, S. Freutel, A. F. Kemper, M. A. Sentef, J. K. Freericks, I. Avigo, M. Ligges, L. Rettig, Y. Yoshida, H. Eisaki, J. Schneeloch, R. D. Zhong, Z. J. Xu, G. D. Gu, P. D. Johnson, and U. Bovensiepen, "Energy Dissipation from a Correlated System Driven Out of Equilibrium," Nature Communications (2016)
DOI: 10.1038/NCOMMS13761

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