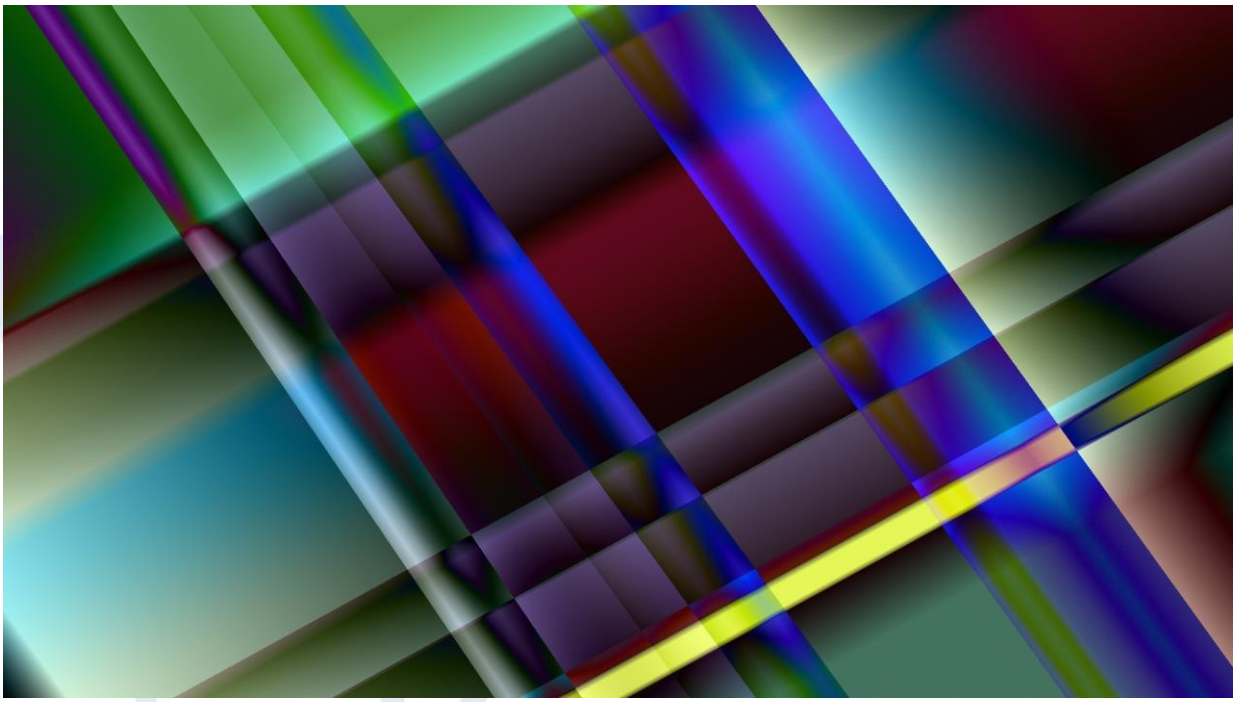
PRESS RELEASE

New states of matter in a flash of light



In collaboration with the Université Paris-Sud, SISSA researchers have established the theoretical basis for studying through laser pulse manipulation new states of materials absent in thermal equilibrium

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A laser pulse can drive materials towards new states where they acquire proprieties potentially useful for innovative microelectronics applications. This promising scientific area has been investigated by an international team headed by professor Michele Fabrizio from SISSA, Trieste, Italy, and professor Marino Marsi from Université Paris-Sud, Orsay, France. The research has just been published in *Nature Communications*.

In this study, SISSA researchers have established the theoretical basis of an unexpected phenomenon experimentally observed by the scientists of the Université Paris-Sud.
Prof. Michele Fabrizio explains: «The experiment that has been performed is of the *pump and probe* type where **a sample of material is hit by a very intense ultra-short laser pulse, as short**

as one millionth of one billionth of a second. The excited sample relaxes back to equilibrium in nanoseconds, but before, namely from femto- to hundreds of picoseconds, its properties are probed by means of different, optical and spectroscopic, techniques as function of the time delay from the pump pulse».

The material used in the experiment, named V_2O_3, is a compound with a rich phase diagram that includes metallic and isolating phases. «Probing the optical properties of V_2O_3 after the laser pulse irradiation, the Orsay's team had noticed a substantial hardening, which was counterintuitive as light usually warms up materials, making them softer. There was no explanation for such an unusual phenomenon and that has been our theoretical contribution» says Fabrizio. «Our theory rationalised the experimental evidence and, furthermore, predicted that, together with the hardening, other proprieties would also change. In particular, we expected that the material would acquire a more metallic character».

That's exactly what the next time-resolved photoemission experiments have verified: «This result has proved the correctness of our theory. Moreover, it gave us a hint of possible developments beyond basic research. The possible ultra-rapid switch of materials' proprieties using a light pulse is one of them».

In terms of applications, there are several points of interest: «In the field of the microelectronics, for example, **switching a material from a metallic to an isolating phase – and the other way round – in a ultra short time using a laser pulse, could bring big advantages to that area».** Furthermore, says Fabrizio: «The evidence that new phases, absent in thermal equilibrium, emerge as a result of an intense light pulse irradiation opens up new appealing perspectives ». For instance, as a metastable state of carbon, diamond has totally different features from its stable state, which is graphite. «**When we hit the matter with an intense pulse, we bring it to highly excited non-thermal states. In these non-equilibrium conditions, a material may present proprieties otherwise not observable. If we could stabilize the matter in these specific metastable conditions there would be several possible applications».**

An example? «These kinds of materials could be used for data storage in a computer memory. It's a long-term perspective but in the scientific community there is a strong interest in ultra-rapid control of materials using light pulses ».

LINKS:

The original paper: http://www.nature.com/articles/ncomms13917

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