Scientists succeed in cooling solid material with laser

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A team of researchers at the University of the Basque Country have experimentally demonstrated something that other scientists have been trying to achieve for decades: the cooling of erbium-doped materials with laser light.

Joaquín Fernández, Chair at the Department of Applied Physics at the Bilbao School of Engineering, is leading the team consisting of Professor Rolindes Balda and the Ramón y Cajal researcher, Ángel García Adeva. The findings have been published in *Physical Review Letters* (Volume 97, Number 3).

Optical cooling is a phenomenon that has sparked great interest over the last couple of decades, particularly in the field of the optical cooling of atomic gases (Bose-Einstein condensed [1]). Cooling solids using laser radiation is much more difficult and, in fact, a very small number of doped materials have been cooled, i.e. materials to which a tiny amount of ions of another element have been added. What has never been achieved to date is the cooling of materials doped with erbium.

Erbium is a metal element belonging to the Rare Earth group [2]. Its ions have the property whereby when light of a certain wavelength falls on them, they are capable of amplifying them. This effect is used, for example, to construct light amplifiers in the field of optical telecommunications. To this end, in order to compensate for the weakening of the light signal as it journeys down an optic fibre, the fibre is doped with erbium ions.

In the case of the research undertaken by the UPV/EHU team, the luminous emission of erbium has been used to achieve the cooling of material in which these ions are housed by exciting these ions with laser light. This discovery is not only important for the technical difficulties involved, but also because the optical refrigeration of devices doped with erbium occur at wavelengths and potentials similar to those with which conventional diode lasers operate, thus making these materials ideal candidates for possible applications, unlike other doped materials that have previously been cooled.

Amongst these applications are high-power optical fibre lasers, medical diagnostic techniques using laser (optical tomography) and phototherapy. These devices would function by means of dual laser pumping in which the light wavelengths would be used for the laser pumping and the other wavelength (close to the previous one) to produce optical cooling that would counteract the heating produced by the laser action. This heating causes a number of adverse effects. It can alter the properties and even burn the material being worked with.

The main reasons why this team of researchers have managed to obtain a net optical cooling of these erbium-doped materials are the extraordinary optical quality of the materials employed and the fact that the losses due to thermal vibrations in these are very small.

Notes:

(1) Bose-Einstein condensed is an aggregated state of the material that certain materials have at very low temperatures. It is characterised by the property of a macroscopic amount of the particles of the material pass to the level of minimum energy, known as the fundamental state.

(2) Rare Earths: these are elements known as Lantanides and Actinides and have an electronic structure in which the f orbitals are incomplete.

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Practically all the rare earth elements have radioactive isotopes.

Source: Elhuyar Fundazioa