An optomechanical crystal to study interactions among colocalized photons and phonons

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A photon is the quantum particle of light and electromagnetic radiation. A phonon is its equivalent when it comes to mechanical vibrations of matter and heat transmission. Although it might seem surprising, electromagnetic radiation and mechanical vibrations of matter interact and exchange energy at the nanometric scale. This phenomenon has only been described in recent years, and the experimental basis to study such interactions with precision is still being established. Researchers from the Institut Català de Nanociència i Nanotecnologia's (ICN2) Phononic and Photonic nanostructures (P2N) Group, led by the ICREA Research Professor Clivia Sotomayor-Torres, publish today an article in *Nature Communications* presenting a silicon 1D Optomechanical crystal built up so that it allows to localize in a stable way both phonons and photons. Dr. Jordi Gomis-Bresco and Dr. Daniel Navarro-Urrios are the first authors of the work.

Optomechanical coupling is the interaction between photons and phonons. This phenomenon can be greatly enhanced by confining both electromagnetic radiation and mechanical displacement in the same cavity. By nanostructuring silicon to form such cavities researchers create artificial crystals at will. Optomechanical crystals are simultaneously photonic and phononic crystals that confine in the same structure photons and phonons. When engineered properly they can lead to strong photon-phonon interaction.

One of the major issues when working with photon-phonon interaction is the difficulty to properly isolate quantum particles of vibration. Different types of phonons coexist and it has not been possible yet to create the ideal environment where only one phonon family is completely isolated. The work presented today by ICN2's researchers in *Nature Communications* explains how to design a crystal cavity where optical and mechanical properties can be manipulated separately. Such approach uncouples effectively the design of the optical and the mechanical properties which allows simultaneously achieving a full 1D phononic isolation for mechanical modes and a photonic isolation for transverse electrical optical modes.

Exchanging energy from photons to phonons might be useful, for instance, to manipulate heat dissipation with light. The energy of photons ordered in a laser beam allows the emission of coherent beams of phonons. Confining quantum bits of information will be essential to design quantum computers. All these applications will only become real when the basic research successes achieved recently are consolidated into practical knowledge. Thanks to a new step forward led by ICN2, the study of Optomechanical properties will now be easier and more precise.

More information: J. Gomis-Bresco, D. Navarro-Urrios, M. Oudich, S. El-Jallal, A. Griol, D. Puerto, E. Chavez, Y. Pennec, B. Djafari-Rouhani, F. Alzina, A. Martínez and C. M. Sotomayor Torres. A 1D Optomechanical crystal with a complete phononic band gap. *Nature Communications*, 2014.
http://arxiv.org/abs/1401.1691

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