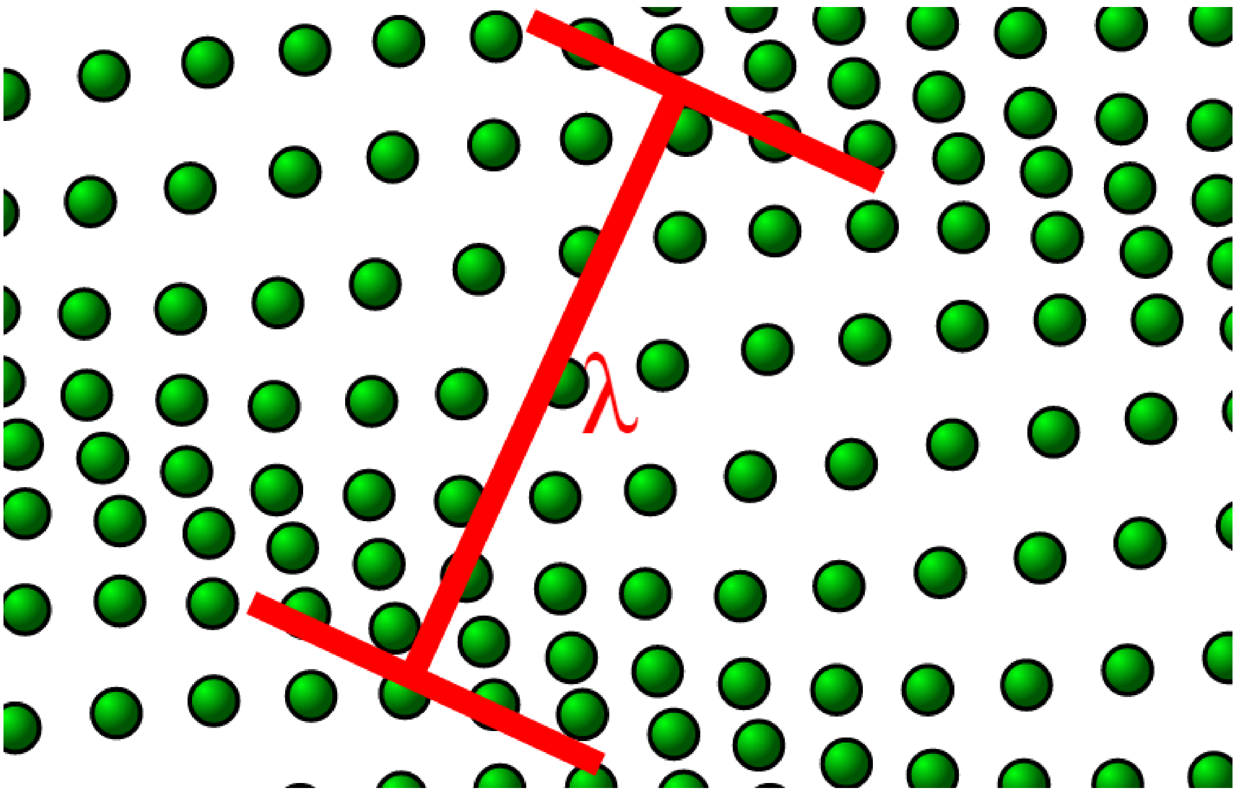
Coherent phonon dynamics realized in spatially separated mechanical resonators

March 4 2020, by Liu Jia



Phonon propagating through a square lattice (atom displacements greatly exaggerated). Credit: Wikipedia

A research group led by Prof. Guo Guoping, Song Xiangxiang, Deng Guangwei (now at UESTC), from University of Science and Technology of China (USTC) of the Chinese Academy of Sciences, in collaboration with Prof. Tian Lin from University of California, Merced, and Origin Quantum Company Limited, made progress in nanomechanical resonators. They realized coherent phonon manipulations within spatially separated mechanical resonators. The study was published online in *PNAS*.

With the rapid development of nanotechnology, devices like surface acoustic wave resonators and nanomechanical resonators are found to be suitable for generation, storage, and manipulation of few or even single phonon, which can be further applied in both classical and quantum information process. The realization of the various applications requires coherent manipulation between different phonon modes.

Coherent manipulations within neighboring phonon modes have been reported previously, while controllable coherent information transfer between spatially separated phonon modes, remains technically challenging. Focusing on this goal, the researchers designed a novel device based on their previous achievements.

Taking advantages of the extraordinary electronic and mechanical properties of graphene, they realized tunable strong coupling between non-neighboring phonon modes, mediated by the center phonon mode. By improving sample structure design and measurement technique, the coupling strengths and quality factors are enhanced by one and two orders of magnitude, respectively, comparing to their previous work. The cooperativity reaches 107, which is several orders of magnitude higher than other works.

With combined properties of high tuneability, large coupling strength, and excellent coherence, the researchers demonstrated electrically tunable Rabi oscillations and Ramsey interferences between non-neighboring phonon modes in this system.

This study is the first experimental realization of tunable coherent phonon dynamics between non-neighboring phonon modes. It shows new possibilities towards information storage and processing using phonon modes in nanomechanical resonators, and hybrid devices based on nanophononics.

"These results clearly go beyond what has been achieved thus far on the coherent manipulation of resonators in the classical regime," said the reviewers of this study. Taking advantages of the cooling technologies, this study also shed lights on coherent manipulations of phonons in the quantum regime and development of phonon-based novel quantum devices.

More information: Zhuo-Zhi Zhang et al. Coherent phonon dynamics in spatially separated graphene mechanical resonators, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.1916978117

Provided by Chinese Academy of Sciences