Nanophononic Potentials Based on Band Engineering

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Acoustic phonons in the GHz-THz range appear as a suitable platform to study complex wave phenomena, motivating the development of nanophononic devices[1]. The strong interactions with other excitations in solids extend the range of applications to other fields such as electronics and optomechanics[2,3]. In this work we propose a new kind of resonator based on the engineering of the phononic band structures associated to periodic superlattices that allows us to mimic arbitrary electronic potentials.
By modulating the thickness ratio of the two materials forming a one-dimensional periodic superlattice we can adiabatically close and reopen a minigap along the structure. The edges of this engineered bandgap generate the equivalent of a potential well. We can control the energy and the number of bounded nanophononic modes (see Fig. 1). This spatial modulation of the effective band structure allows us to control the symmetries of the edge modes, enabling the implementation of a phononic topological transition that changes not only the energy of the confined modes but also their number and nature.
Acoustic nanocavities[4,5] as the ones showed in this work present confined states similar to the confined electronic levels in atoms and quantum wells. Following this idea, by modulating a minigap following a parabolic curve, one can design a device that confines states in an analogous way of a quantum harmonic oscillator. Such a device is described and the role of different parameters is studied.
The proposed structures can be grown by actual molecular beam epitaxy technology, and experimentally studied through standard coherent phonon generation techniques.

References

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Figures

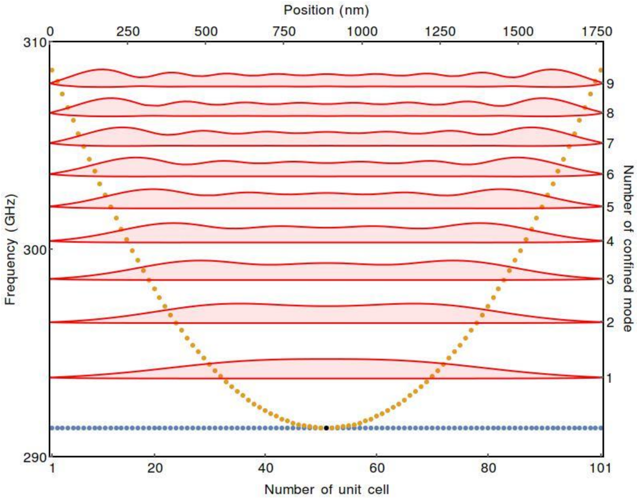

Figure 1: Spatial profile of the displacement amplitude for each confined mode plotted on top of the acoustic band structure with its symmetries encoded in color.