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George Fytas et al., J Phys Chem Biophys 2017, 7:4(Suppl)
DOI: 10.4172/2161-0398-C1-025

4th International Conference on

PHYSICAL AND THEORETICAL CHEMISTRY

September 18-19, 2017 Dublin, Ireland

Soft based hypersonic phononics

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Phononic structures (composite materials) in which a periodic distribution of elastic parameters facilitates control of the propagation of phonons, hold the promise to enable transformative material technologies in areas ranging from acoustic and thermal cloaking to thermoelectric devices. This requires strategies to deliberately engineer the phononic band structure of materials in the frequency range of interest. Phononics, the acoustic equivalents of the photonics are controlled by a larger number of material parameters, as phonon cannot propagate in vacuum. The study of hypersonic phononics (hPnC) imposes substantial demand on fabrication and characterization techniques. Colloid and polymer science offer methods to create novel materials that possess periodic variations of density and elastic properties at length scales commensurate with the wave length of hypersonic phonons and hence visible photons. The key quantity is the dispersion ω(q) of high frequency (GHz) acoustic excitations with wave vector q which is measured by the noninvasive high resolution Brillouin light scattering. The approach involves the exploitation of Bragg-type band gaps (BGs) that result from the destructive interference of waves in periodic media. However, the sensitivity of BG formation to structural disorder limits the application of self-assembly methods that are susceptible to defect formation. Hybridization gaps (HG), originating from the anti-crossing between local resonant and propagating modes, are robust to structural disorder and occur at wavelengths much larger than the size of the resonant unit. Here, examples based on hierarchical structures will be highlighted: 1D-hPnC to acquire comprehensive understanding, while the incorporation of defects holds a wealth of opportunities to engineer ω(q); in colloid based phononics, ω(q) has revealed both types of band gabs; particle brush materials with controlled architecture of the grafted chains enable a new strategy to realize HG's and; hierarchically nanostructured matter can involve unprecedented phonon phono propagation mechanisms.

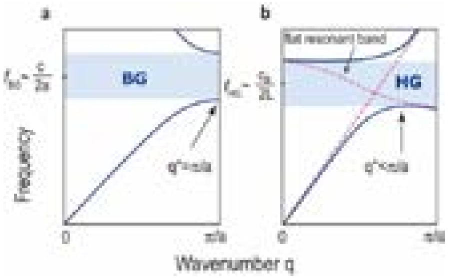

Figure 1: Schematic phononic band diagram for structure directed interference (BG in a) and particle-resonance induced hybridization (HG in b) band gap where the wave vector q* is along the Brillouin zone. a, L are the lattice constant and the particle dimension and c, cp the sound velocity in the structure and particle, respectively.

Biography

George Fytas is a Professor of Physical Chemistry in Department of Materials Science and Technology at University of Crete and External Member of the Max Planck Society since 1998. He holds PhD degree in Physical Chemistry at Technical University of Hannover, Germany; completed his Post-doctorate research at Stony Brook in USA and; Habilitation at University of Bielefeld in Germany. He has received Humboldt Senior Research Award (2002), became a Fellow of the American Physical Society (2004) and he was Adjunct Professor at University of Akron in 2013.

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