High frequency Phononics based on Soft Materials

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Phononic crystals, *i.e.* 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. Realizing these opportunities requires strategies to deliberately 'engineer' the phononic band structure of materials in the frequency range of interest. Phononic crystals, the acoustic equivalents of the photonic crystals, are controlled by a larger number of material parameters, as phonon cannot propagate in vacuum. The study of hypersonic phononic crystals (hP_nC) 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 mesoscopic length scales commensurate with the wave length of hypersonic phonons and hence photons of the visible light. The key quantity is the dispersion $\omega(k)$ of high frequency (GHz) acoustic excitations with wave vector k which is measured by the noninvasive high resolution spontaneous Brillouin light scattering. Due to the vector nature of elastic wave propagation, polymer based 1D-hP_nC are model systems necessary to acquire comprehensive understanding, while the incorporation of defects (cavity and surface layers) holds a wealth of opportunities to engineer $\omega(k)$. Colloid-based 3D-hP_nC offer a unique introduction of local resonances.

Examples from fabricated structures based on hard spheres and ellipsoids, and core-shell and particle-brush (densely polymer tethered hard spheres) will be highlighted. Elastic wave propagation through hierarchically nanostructured matter can involve unprecedented mechanisms as observed in the dispersion diagram of the spider dragline silk.