LadHyX Seminar – December 13, 10:45

Ory Schnitzer
(Department of Mathematics, Imperial College London)

Asymptotic models of wave propagation and resonance in micro-structured media

The study of microstructured media in acoustic settings is undergoing a considerable revival, with ideas originating from electromagnetism, photonic crystals and metamaterials influencing structured acoustic devices. Fundamentally, these advancements rely on incorporating resonances to effectively control wave propagation, localisation and attenuation. In this talk I will discuss several elementary acoustic examples, using the language of scalings and singular perturbations, where the dynamics on small length scales (compared to the wavelength) have an appreciable effect on propagation. I'll first revisit the classical problem of extraordinary transmission through narrow slits. I'll show that straining the frequency about the slit resonances and accounting for end effects using matched asymptotics yields a simple approximate theory that agrees remarkably well with available experimental data. I'll next introduce a class of phononic crystals that behave like a network of directly coupled Helmholtz resonators; such structured media exhibit nonlinear dispersion in a wide subwavelength regime (in contrast to the narrow bandwidth of traditional subwavelength metamaterials formed of weakly coupled resonators). I will consider both 2D realisations, using densely packed phononic crystals, and 3D realisations, using "phononic box crystals," namely arrays of joined perforated boxes. I'll show that such media are asymptotically governed by discrete wave equations and demonstrate their use for controlling band gaps, dynamic anisotropy, Dirac points, trapped modes, emission and slow propagation. Lastly, I'll describe surprising predictions regarding the acoustic properties of superhydrophobic surfaces, whose special properties are usually considered in the context of wetting and drag reduction.

The talk will include joint work with Jacob Holley (on extraordinary transmission), Alice Vanel and Richard Craster (on Helmholtz networks) and Rodolfo Brandao and Ehud Yariv (on acoustics of superhydrophobic surfaces).