LadHyX Seminar – July 8, 11:00

Eva Kanso
(University of Southern California)

Waves in ciliary carpets

Motile cilia are fundamental fluid micro-actuators in cellular biology. In our lungs, brains, and reproductive tracts, thousands of multiciliated cells, each containing hundreds of cilia, coordinate their activity into metachronal wave patterns that drive flows at length and time scales much larger than size and beat period of the individual cilium. However, the mechanisms that lead to these emergent waves remain opaque. Here, I will discuss how large arrays of hydrodynamically interacting cilia self-organize into states that collectively break symmetry and pump flows. I will show, via discrete simulations and continuum modeling, that isotropic and synchronized ciliary states are unstable, and I will provide theoretical predictions of the growth rates of the instabilities leading to metachronal waves that match quantitatively with numerical experiments. These findings indicate that the emergent waves are global attractors, with wavelength and direction determined by the microstructure and activity at the cilium level. Our theory opens up the prospect of establishing causal explanations of the effect of individual cilia oscillations on symmetry-breaking, large scale coordination, and fluid transport in ciliary carpets.