Autonomous rotors and active spinners in wave-driven flows

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The manipulation of objects at a fluid surface and their self-assembly into organised patterns have been the subject of extensive research efforts with promising applications in material science and bioengineering. Surface waves are a powerful tool which can be used to control objects at the liquid surface. In this talk, I will describe two new approaches to the manipulation of floating objects based on wave-driven flows.

The first approach takes advantage of the recently discovered wave-driven vortex lattice [1]. Such flows are produced by periodic patterns of rotating surface waves. The wave angular momentum is transferred to passive fluid particles and generates a spatially periodic flow that resembles a vortex lattice. When active spinning particles are placed inside such vortex lattice, one makes a powerful tool which allows manipulation and self-assembly of spinners, turning them into vehicles capable of navigating inside the vortex lattice. The crucial ingredient of this effect is the self-propulsion of the spinners in the periodic flow. I will discuss how the hydrodynamic forces acting on the spinner allow us to control its location in the lattice, its orbital motion in a lattice unit cell and the self-organisation of stable patterns made of multiple spinners.

The second method relies on wave-driven turbulence [2]. It has recently been discovered that 2D turbulent flows can be forced by steep Faraday waves at a fluid surface. The focus will be on the dynamics of asymmetric floating objects, the autonomous “rotors”, which show a biased random rotation fuelled by the wave-driven fluid motion. Central to the effect is the coupling of the rotor geometry with the underlying Lagrangian structure of wave-driven turbulence. The results uncover how the Lagrangian description of turbulence can help to design new methods to harvest the energy stored in turbulent fluctuations. It also has consequences on the understanding of the turbulent transport of anisotropic objects in presence of coherent structures.

[1] Francois N, Xia H, Punzmann H, Fontana PW, Shats M., *Nat. Commun.*, 7, 14325 (2017).
[2] Francois N, Xia H, Punzmann H, Shats M., *Phys. Rev. Lett.,* 110, 194501 (2013).