Internship proposal: streaming at the water surface induced by complex surface wave field

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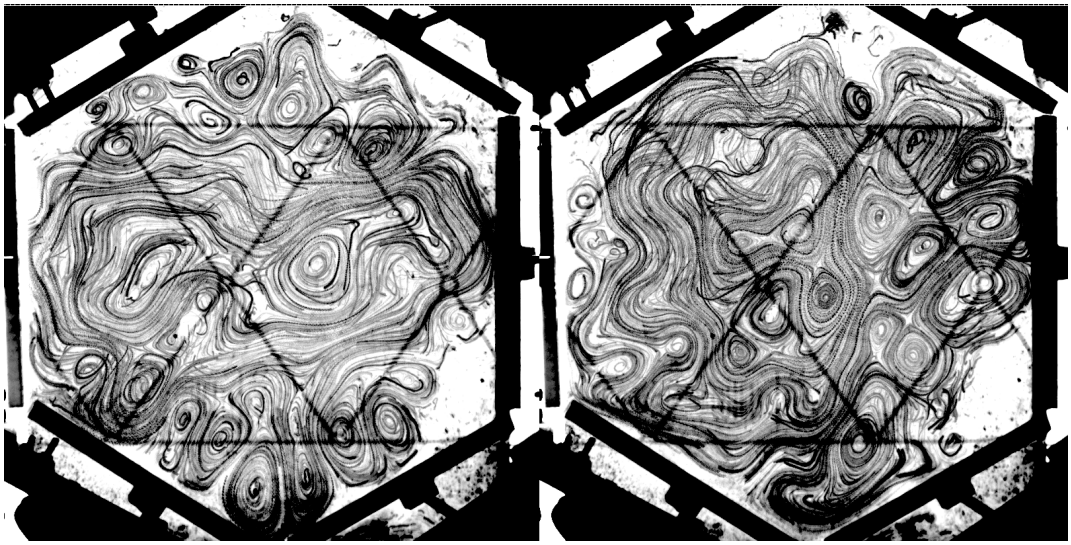

Figure 1: Two examples of streaming at the water surface induced by complex surface wave field. The wave field is sent from independently vibrating hexagonal edges. The black lines represent trajectories of small particles placed at the water surface (diamond patterns are defects on the tank's bottom and are not significant).

When a wave propagates at the water surface, it is well known that it can generate surface streaming. For instance, a plane wave generates a flow along its propagation direction, known as Stokes flow. In a square wave pattern generated by two orthogonal plane waves, the problem becomes more complicated and the streaming strongly depends on the relative phase between the two waves. Fundamentally, this sensitivity to phase difference comes from non-nonlinearities, as one cannot simply sum-up the expected streaming for each wave.

The present internship proposes to study experimentally and theoretically the streaming pattern induced by arbitrary wave field i.e. sums of arbitrary plane waves. Preliminary results have shown that the generated flow display complex, yet reproducible patterns made of counter-rotating vertices separated by "rivers" (see pictures). As for the square lattice, the shape of the flow strongly depends on the relative phase between all the waves. The present internship aims to focus on one (or several) of the following questions depending on the candidate's interest. For a given wave field, can one predict the main features of the flow (location of vertices, number of rivers...) ? Conversely, can one always find a wave field to generated a given target flow ? Are there some universal statistical properties of the flow whatever the underlying wave field ? Can one use standard models for disordered systems in condensed matter to predict the trajectory of a tracer in such flow ?

The proposed topic is quite flexible and combines experimental and theoretical approaches. All graduate students with strong background in physics (or mathematics) are welcome to apply. Basic knowledge in fluid mechanics/non-linear physics and Python programming are recommended, but not mandatory. The internship will take place in Laboratoire de Physique de l'ENS Lyon (site Monod), where the experimental setup is already running.

Starting date and duration: flexible, starting fall 2026

Possibility to apply for PhD fundings (CDSN, ED...) on the same topic.