Postdoc position – spring 2020

Non-linear evolution of viscous wind-waves

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Project page: (movies and papers http://www.fast.u-psud.fr/~moisy/windwaves/)

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When wind blows over a liquid surface, waves can be generated and propagate downstream. Even though this simple phenomenon has inspired over a century of research, understanding the physics of wind wave generation is still a challenge.

The aim of the present project is to identify the importance of non-linear effects in the evolution of the wave pattern. Among them, the shift towards larger wavelength and smaller frequency for increasing distances, a phenomenon known as frequency downshift. This nonlinear effect is well-documented in the oceanic literature (Huang et al. 1996) and several mechanisms have been proposed to explain its physical origin. A first class of mechanisms involve finite amplitude effects (which modify the dispersion relation), interaction with the surface current, or the Benjamin-Feir instability of the dominant wave.

Within the present project, experiments with viscous liquids should provide some new clues about the dominant mechanism(s). Preliminary results obtained in the FAST wind tunnel (for a single liquid viscosity) suggest that frequency downshift also occurs in viscous liquids, even close to onset and for waves of very small amplitude (Paquier 2015). Varying the liquid viscosity appears as a promising way to elucidate the origin of this phenomenon.

Recently, using a wavemaker we were able to measure the growth or decay rates of waves as a function of forcing frequency and wind speed. These results clearly demonstrate that beyond the instability threshold a band of unstable frequencies appears, and that this band rapidly widens as the wind velocity increases. The quality of these curves proves that a thorough control of the experimental conditions, necessary for the investigation of nonlinear effects, is clearly achieved in this experiment.

During this Postdoc, we propose to investigate the interaction of waves of different frequencies generated by this wavemaker. The spatio-temporal evolution of the wave packet will allow us to assess the relevance mechanism in this system. By considering the superposition of two waves with different frequencies and wavenumbers (both linearly unstable, or one stable and the other unstable) we will be in position to investigate resonance mechanisms and possibly period doubling (an efficient mechanism for frequency downshift). Wave amplitudes will be measured either by Synthetic Schlieren method (Paquier 2015) or by laser sheet profilometry (Aulnette 2019).

Applicants should have a strong background in fluid mechanics, and an interest for experimental technics and data analysis.

N. E. Huang, S. R. Long, and Z. Shen. The mechanism for frequency downshift in nonlinear wave evolution. Advances in applied mechanics, 32:59–117C (1996).

A. Paquier, F. Moisy and M. Rabaud. Surface deformations and wave generation by wind blowing over a viscous liquid. Phys. Fluids, **27**, 122103 (2015).

A. Paquier, F. Moisy and M. Rabaud. Viscosity effects in wind wave generation. Phys. Rev. Fluids **1**, 083901 (2016).

S. Perrard, A. Lozano-Durán, M. Rabaud, M. Benzaquen, and F. Moisy. Turbulent windprint on a liquid surface. Journal of Fluid Mechanics, **873**:1020–1054 (2019).

M. Aulnette, M. Rabaud, and F. Moisy. Wind-sustained viscous solitons. Phys. Rev. Fluids, **4**:084003 (2019).