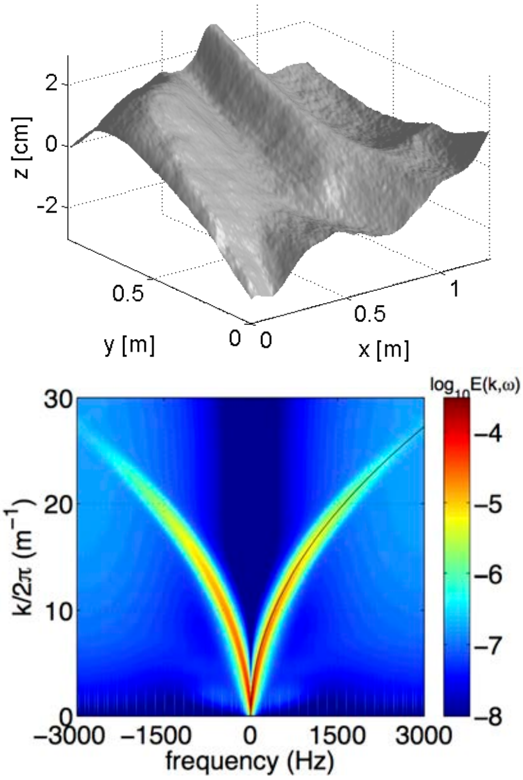
PhD thesis:
Study of turbulence of elastic or capillary waves: From weak to strong turbulence

Supervision: Nicolas Mordant (Professor at Université de Grenoble),
Place: Laboratoire des Ecoulements Géophysiques et Industriels (LEGI)
Campus universitaire de Saint Martin d'Hères (Grenoble, France)
Funding: European Research Council (ERC)
Duration: Three years, start: September 2015

General framework

The WATU project *"Wave turbulence: beyond weak turbulence"* is a 5-year research program supervised by N. Mordant and selected by ERC with a 2 millions euros funding to study the statistical properties of wave turbulence (begins in September 2015). Wave turbulence is a statistical state made of a large number of waves that are coupled by non-linear effects. The typical example of wave turbulence is that of oceanic waves (surface gravity waves) that develop a very wide spectrum of wavelengths from centimeter scale up to several tens of meters. Many other systems can lead to wave turbulence: non-linear optics in fibers, lasers, magnetohydrodynamic waves in solar winds, superfluid turbulence, confined plasmas as ITER…



Top: example of deformation of a vibrated steel plate measured at 10,000 frame/s.

Bottom: space-time Fourier spectrum of the flexion waves in such a plate. It displays frequencies from 1Hz up to several kHz.

Wave turbulence is specific in the fact that a statistical theory named "weak turbulence" has been developed in the 60's. This theory predicts in particular the time evolution of the Fourier spectrum of the waves. The predicted phenomenology resembles strongly that of the energy cascade observed in fluid turbulence: energy is injected at large scales and transferred to smaller and smaller scales until it is ultimately dissipated. Following this theory, the field of wave turbulence was the object of many theoretical developments that actually lack experimental support. The goal of the WATU project is to provide a strong effort so that to fill the gap between theory and experiment. We will gather advanced experimental information in the framework of weak turbulence as well as in the case of strongly non-linear waves.

During this project, we will be interested in several types of waves: elastic flexion waves in the thin vibrated plate (see figure), gravity or capillary waves at the surface of a fluid, internal gravity and inertia waves in a rotating and stratified fluid. All these waves exhibit various dimensionalities from 1D to 3D, non-linear coupling mechanisms involving 3 to 5 waves. Furthermore several kinds of cascades have been predicted and we will test their existence in the laboratory. From the experimental

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LEGI LABORATOIRE DES ECOULEMENTS GEOPHYSIQUES ET INDUSTRIELS viewpoint, our goal is to develop measurement techniques so that to resolve the wave motion both in time and space. In this way, we will be able to finely test the wave structure and the non-linear couplings in conditions of weak or strong turbulence. These experiments will also show various sizes: experiments in small containers or in the 36 m wave flume or in the Coriolis facility (13m diameter turntable).

Topic of the PhD thesis

The present PhD thesis will be focused on the case of the vibrated thin elastic plate and that of capillary waves at the interface between two fluids. The elastic plate is a very rich framework that reproduces the phenomenology of the weak turbulence theory at moderate forcing. Further more, the measurement by a high speed 2D profilometry can be compared to numerical simulations made possible by the purely 2D character of the motion of thin plates. Capillary waves seem also to follow some theoretical predictions but recent investigations tend to question these previous results. The graduate student wil have to develop a new experiment on capillary waves and will also perform experiments and numerical simulations on an elastic thin plate. He will use statistical analysis tools to investigate the non linear coupling among waves in the various systems. We will also study the case of strong forcing that is beyond the current state of the theory. The student will also be associated to the other experiments of the WATU project (gravity waves in 1D, 2D, or 3D in the large facilities of LEGI: 1D wave flume, or Coriolis facility) in order to setup similar data analysis techniques.

Prerequisite

The applicant should have preferably a formation in non-linear physics and/or in fluid mechanics, with notions about turbulence. Skills in statistical data analysis will be appreciated as well as skills in experimental fluid dynamics.

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Information on LEGI: http://www.legi.grenoble-inp.fr

In order to apply, please send a CV and the name of a person and contact info for recommendation.

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