COLLOQUE DE PHYSIQUE

Vendredi 10 février 2023, 14h15

École de Physique, Auditoire Stueckelberg

« Modulational Instability and Wave Breaking of Two-Dimensional and Three-Dimensional Water Waves »

Prof. Alexander V. Babanin

University of Melbourne, Australia

Modulational instability of nonlinear waves is a physical mechanism which brings together waves in plasmas, in optics and other electromagnetic environments. In ocean waves, it has particular prominence because is broadly regarded to be responsible for rogue waves, for wave breaking, for influencing swell propagation. We note that, while be analytically considered a one-dimensional phenomenon, in the ocean this mechanism necessarily applies to two-dimensional surface.

The breaking of deep-water waves, which is the main topic of this seminar, is one of elusive mechanisms in the wave dynamics. Like the so-called rogue waves, breaking waves are anomalous waves in a sense of their height with respect to the neighbouring waves in a wave train/field. There are essential indications that both processes have a similar genesis and result from the modulational instability of nonlinear wave trains. If so, distinction between the two phenomena has to be made and, since the wave breaking is much more frequent, it can be further employed for investigating dynamics of the modulational instability in oceanic wave fields.

The modulational instability is usually associated with two-dimensional wave trains. There exists argument, both analytical and experimental, that this kind of instability is impaired or even suppressed in three-dimensional (directional) wave systems.

In the presentation, results of two-dimensional numerical and laboratory experiments featuring wave breaking due to modulational instability will be described. Then, experimental evidences which relate the wave breaking in oceanic conditions to such features of two-dimensional breaking waves due to modulational instability will be demonstrated. These will be followed by discussion of direct measurements of such instability-caused breaking in a directional wave tank with directional spread and mean steepness typical of those in the field. The modulational instability appears to be active in such conditions, and therefore conclusions on what is a possible maximal height of an individual wave due to such evolution of nonlinear wave trains can be proposed. Role of the wind forcing on the modulational instability of water waves will also be outlined. Links of the instability observed in surface waves to the modulational instabilities in other physical environments will be discussed.