TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	June 18	June 19	June 20	June 21	June 22
9.00 - 9.45	Registration	Nazarenko	Falkovich	Nazarenko	Suret
9.45 - 10.30	Falkovich	Nazarenko	Falkovich	Nazarenko	Suret
11.00 - 11.45	Falkovich	Falkovich	Proment	Onorato	Proment
11.45 - 12.30	Chibbaro	Falkovich	Proment	Onorato	Chibbaro
14.00 - 14.45	Nazarenko	Josserand	workshop	Suret	
14.45 - 15.30	Nazarenko	Josserand	workshop	Suret	
16.00 - 16.45	Josserand	Suret	workshop	Proment	
16.45 - 17.30	Josserand	Suret	workshop	Proment	
18.00	Welcome Aperitif				

ADMISSION AND ACCOMMODATION

The registration fee is 600.00 Euro + VAT*, where applicable (bank charges are not included). The registration fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes and wi-fi internet access.

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through the following web site: http://www.cism.it. A message of confirmation will be sent to accepted participants. Applicants requiring assistance with the registration should contact the secretariat at the following email address cism@cism.it.

Applicants may cancel their course registration and receive a full refund by notifying CISM Secretariat in writing (by email to cism@cism.it) no later than two weeks prior to the start of the course.

Cancellation requests received during the two weeks prior to the start of the course will be charged a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered lodging and/or board, if available, in a reasonably priced hotel or student guest house.

Requests should be sent to CISM Secretariat by **April 18, 2018** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on the web site www.cism.it, or can be mailed upon request.

* Italian VAT is 22%.

For further information please contact:
CISM
Palazzo del Torso
Piazza Garibaldi 18
33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
fax +39 0432 248550
e-mail: cism@cism.it

ACADEMIC YEAR 2018
The Cowin Session

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

WAVE TURBULENCE AND EXTREME EVENTS

Advanced School
coordinated by

Sergio Chibbaro
Sorbonne Université, UPMC, France

Miguel Onorato
University of Turin, Italy

Udine ***June 18 - 22*** 2018

WAVE TURBULENCE AND EXTREME EVENTS

When the number of degrees of freedom of a wave system is very large, a deterministic description is not feasible anymore and a statistical one is required. Wave turbulence (WT) can be generally defined as the out-of-equilibrium statistical mechanics of random dispersive nonlinear waves. It has been applied to a variety of fields from quantum to astrophysical scales. WT finds its application in the description of ocean waves: the nonlinear interactions provided by the WT theory are an important ingredient in the operational ocean wave forecasting models. WT concepts have also been applied to internal waves that are responsible for the turbulent mixing in the ocean; quantized vortex lines which are important for understanding superfluids turbulence; Alfvén waves in astrophysical application; planetary Rossby waves, relevant in weather and climate studies; waves in Bose–Einstein condensates and in nonlinear optics; a great variety of waves in plasmas of fusion devices; waves on vibrating elastic plates, capillary waves, and many other physical systems.

After introducing the general concepts of turbulence in fluids, the purpose of the course is to give a general and compact introduction to WT and make it accessible for graduate students and non-specialist researchers who are willing to master it and possibly to apply it in their own field of research.

The course will be as self-consistent as possible, trying to insist on conceptual issues, but giving all the mathematical details needed to tackle properly the problem. The aim will be to propose a formal but yet simplified picture of the key aspects and properties of the Wave Turbulence theory and to provide insights into physical situations and practical problems. Specifically, the course will propose a general presentation of the mathematical background suitable for physicists and engineers. The different lecturers will propose examples extracted from their research fields with particular attention to surface gravity waves, elastic waves, optical waves and quantum turbulence. Differences between fluid turbulence (Navier-Stokes) and WT will be examined.

The limits and failure of the Wave Turbulence theory, including the observation of the phenomenon of intermittency observed in many incoherent wave systems, will be reviewed. Finally, some interesting and new perspectives to be pursued in the future will be presented. With respect to this scope, an illustration of the more general framework of extreme events (like rogue waves in the ocean) and large deviations will be given.

The course is addressed to master students, doctoral students, young and senior researchers interested in general physics, fluid mechanics, geophysics, nonlinear optics, turbulence, statistical mechanics and condensed-matter.

PRELIMINARY SUGGESTED READINGS

Nazarenko, Sergey. Wave turbulence. Vol. 825. Springer Science & Business Media, 2011.

Zakharov, Vladimir E., Victor S. L'vov, and Gregory Falkovich. Kolmogorov spectra of turbulence I: Wave turbulence. Springer Science & Business Media, 2012.

Vulpiani, Angelo, et al. Large Deviations in Physics. Lecture Notes in Physics, Berlin Springer Verlag. Vol. 885. 2014.

Onorato, Miguel, Stefania Residori, and Fabio Baronio, eds. Rogue and shock waves in nonlinear dispersive media. Vol. 926. Springer, 2016.

Randoux, Stéphane, et al. Nonlinear random optical waves: integrable turbulence, rogue waves and intermittency. Physica D: Nonlinear Phenomena 333 (2016): 323-335.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

INVITED LECTURERS

Sergio Chibbaro - Sorbonne Université, UPMC France
2 lectures on: The interplay between extreme/rare events in turbulence and wave turbulence will be discussed; the lectures will include a brief introduction to some probability concepts for turbulence.

Gregory Falkovich - Weizmann Institute of Science, Rehovot, Israel
6 lectures on: These lectures are intended to analyze the theory of turbulence in general and wave turbulence in particular. Kolmogorov turbulence as well as refined version of the theory will be presented. Then, starting from introducing the general formalism for Hamiltonian systems, the theory of Kolmogorov-Zakharov cascade for wave-turbulence will be also discussed. Some general aspects of irreversibility will be discussed in the spirit of field-theoretical anomalies.

Christophe Josserand - Sorbonne Université, UPMC, France.
4 lectures on: The course will tackle some technical aspects in fluid mechanics phenomena in the context of wave turbulence. A particular attention will be paid to asymptotic multi-scale methods and on the phenomenological description of the theory. Then, the lectures will focus on wave turbulence in elastic media by discussing both the theory and some numerical and experimental applications. Recent development and extension of this theory towards strong turbulence will also be discussed.

Sergey Nazarenko - University of Warwick, Coventry, UK
6 lectures on: A general introduction to wave turbulence and its formalism will be presented. The role played by the wave kinetic equation and its non-equilibrium solutions will be discussed. The challenges for the future investigations as well as the open issues will be addressed at the end.

Miguel Onorato - Università degli Studi di Torino, Italy
2 lectures on: The application of the wave turbulence theory to ocean waves will be discussed. The intriguing phenomenon of rogue waves in the ocean will be presented, including lab and field data.

Davide Proment - University of East Anglia, Norwich, UK
5 lectures on: The lectures will present the types of turbulence arising in superfluids and Bose—Einstein condensates. Using mainly the Gross-Pitaevskii equation, the different wave turbulence regimes will be derived and compared to the most recent experimental and numerical results. Strong turbulence states occurring in the presence of quantized vortices will be also discussed, together with turbulence developing when Kelvin waves propagating on the vortex filaments interact.

Pierre Suret - Université de Lille, France
6 lectures on: The course will discuss the most recent research on nonlinear random waves in the context of nonlinear optics. In particular, the very recent development of ultrafast measurement techniques will be explained. Experimental and theoretical results will be discussed in the framework of wave turbulence and integrable turbulence. In particular, the phenomena of rogue waves and intermittency in integrable turbulence will be described.