ECOLE D'ETE

Nonlinear Dynamics in Peyresq

Alpes de Haute-Provence, France

23 - 30 August 2013

Objectives

This CNRS thematic summer school aims to provide a multidisciplinary lecture program to enable the understanding, the study, and the development of research in the field of nonlinear dynamics. The focus is on describing the field from numerous viewpoints including physics, mathematics, mechanics, chemistry, biology, optics, electronics, signal processing,...

3 specialised lectures

Rogue waves in large and small scales

Nail Akhmediev (ANU, Dpt. Theor. Physics, Canberra, Australia)

"Rogue waves", "freak waves", "killer waves" and similar names have been the topic of many recent research publications related to giant waves appearing in the ocean from "nowhere". Their tiny analogs in various branches of optics do not have killing powers but have much in common with "monsters of the deep". Nonlinear dynamics of these objects in conservative or dissipative systems emerges naturally from the science of solitons well developed in previous decades. Attempts to encounter giant waves in the open ocean could be a dangerous exercise in the life of a scientist but we have variety of ways to model rogue waves in a laboratory. Fundamental theory is one of the basic ingredients in understanding the mystery of these exciting objects.

Asymptotic models for water waves

David Lannes (Ecole Normale Supérieure, Paris, France)

We will review a general method for the derivation of asymptotic nonlinear models in shallow water for various regimes (e.g. weakly, or strongly nonlinear); this method starts from the Hamiltonian formulation of the water wave equations with the surface elevation and the velocity potential at the free surface as main unknowns. It relies on a simple asymptotic analysis in terms of the shallowness parameter (depth over wavelength) and/or amplitude parameter (amplitude over depth). We will show how models such as the Serre / Green-Naghdi equations can be derived with this method and discuss the relevance of various variants of these models in several contexts: modeling of strongly dispersive effects, numerical implementation, etc... Several extensions of this method will also be addressed, such as deep water modeling and the influence of the presence of a non zero three-dimensional vorticity field.

Nonlinear propagation of light pulses in optical fiber

Goëry Genty (Tampere Univ. of Technology, Optics, Finland)

In the year 2000, it was demonstrated that the injection of ultra-fast optical pulses into a fiber that can confine light within a tiny area resulted in the generation of a white light super-continuum, a laser rainbow extending from the visible into the near infrared. Supercontinuum laser sources have revolutionized research in nonlinear optics not only because all the immediate applications they have found but also because of the need to understand the physics involved in the generation of such broad spectra. In fact, progress in understanding the complex mechanisms behind supercontinuum generation has led far beyond the expectations, unravelling unexpected analogies between the nonlinear dynamics of waves propagating in an optical fiber with other nonlinear systems, including for example the event horizon found around black holes or freak waves suddenly appearing in the oceans.

2 general lectures

Instabilities in steady patterns

Sylvie Benzoni-Gavage (Inst. Camille Jordan, Lyon, France)

The lecture will start by reviewing classical results on stability/instability of stationary solutions to ordinary differential equations, with special emphasis on methods of proof that are also valid in infinite dimensions. Then I will turn to stability issues regarding traveling wave solutions to PDEs, especially those endowed with a Hamiltonian structure. On the one hand, the lack of a dissipative mechanism makes nonlinear stability a subtle and difficult question. On the other hand, conserved quantities lead to several interesting notions that fruitfully complement linear tools. In particular, I will discuss modulational instability in connection with spectral instabilities of periodic waves, as well as transverse instabilities.

Numerical approaches to nonlinear evolution equations

Christian Klein (Inst. de Math. de Bourgogne, Dijon, France)

We present an introduction to numerical methods for nonlinear partial differential equations, mainly from hydrodynamics and nonlinear optics. The spatial part of the PDEs will be treated with spectral methods because of their excellent approximation properties for smooth functions. For periodic boundary conditions, Fourier spectral methods will be used by employing fast algorithms for the discrete Fourier transform. For more general boundary conditions, polynomial interpolants are discussed. The boundary conditions will be implemented via tau-methods. After the spatial discretization, the PDE is treated as a high dimensional system of ODEs in time, an approach referred to as method of lines. The time integration is carried out with high order finite difference schemes. We discuss the notion of stiffness of a differential system, and the stability of explicit numerical schemes. Several explicit and implicit methods adapted to stiff systems are presented. The methods are applied to concrete examples to illustrate where they are most efficient.

4 introductory short lectures

Early derivation of the Nonlinear Schrödinger Equation (S. Metens)
Some instabilities in granular flows (A. Amon)
Nonlinear dynamics in whispering gallery resonators (Y. Chembo)
Local and global bifurcations illustrated by examples (L. Pastur)

Organisation

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Information

http://www.enlpeyresq.u-psud.fr/

registration: 100€ (lectures + lodging + meals)

No fees for CNRS affiliates

Pre-registration

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