ECOLE D'ETE

Nonlinear Dynamics in Peyresq

Alpes de Haute-Provence, France

21 - 28 August 2015

Objectives

This summer school aims to provide a multi-disciplinary 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,...

2 specialised lectures

Spatiotemporal chaos

Paul Manneville (LadHyX, École Polytechnique, France)

We shall discuss the emergence of soft turbulence in systems with dimensions large when compared to intrinsic scales generated by instabilities. The key characteristic is the slow dynamics in time and space that results from the proximity of a bifurcation and the continuous symmetries, especially translational. An equally important factor is the continuous or discontinuous nature of the underlying bifurcation. The globally supercritical scenario occurring in the first case is amenable to analysis via multiple-scale expansions, introducing envelopes and phases, as natural frameworks for pattern formation and phase turbulence. The subcritical case implies the coexistence of separate stable states in both local phase space and physical space. In extended systems, it lends itself to spin-like reduction to be studied within the framework of statistical physics, hence an analysis in terms of phase transitions and critical phenomena of, e.g., spatiotemporal intermittency.

Machine Learning Control

Bernd Noack (Institut PPRIME, Poitiers, France & TU Braunschweig, Germany)

Closed-loop turbulence control is an academically fascinating topic with potential engineering applications of epic proportion. The current paradigm of modelling and model-based control has been successful for linear dynamics of laminar flows, but is strongly challenged for nonlinear turbulent flows. We shall discuss a novel machine learning strategy for modelling and controlling turbulent flows in an automatic unsupervised manner. We show how optimal nonlinear control laws can be obtained from experimental measurements using genetic programming without any model of the system. The nonlinear mechanisms and control opportunities are identified by a clustering of snapshots and a Markov model for the transition probabilities between corresponding clusters. All presented approaches are data-driven and can be applied to model and to control any dynamical system and any experiments even with unknown equations of motion.

2 general lectures

A brief introduction to dynamical systems and local bifurcations

Jens Rademacher (Dept. of Mathematics, Bremen, Germany)

The lectures give a brief introduction to smooth dynamical systems and then focus on two broadly applicable mathematical methods of local bifurcation theory: Lyapunov-Schmidt and center manifold reduction. These allow to reduce bifurcation problems to usually much lower dimensions for further analysis, in particular by normal form transformations. Starting with the simplest examples in ordinary differential equations, some more complex applications to partial differential equation models from fluids and active media will be considered to highlight the power of these methods. While various mathematical notions and theorems will be explained and applied, only some ideas for proofs will be given during the lectures.

Spatio-temporal instabilities in hydrodynamics

Francois Charru (IMFT, Toulouse, France)

Classical results on instabilities of open flows will be first presented, with emphasis on dimensional analysis and physical mechanisms: convective and absolute instabilities of open flows, temporal and spatial instabilities, inviscid instability of shear layers (Kelvin-Helmholtz), viscous instability of wall-bounded flows (Poiseuille flow, boundary layers). The successes and failures of basic approaches to account for the experimental observations will be discussed. More elaborated concepts will then be presented: weakly nonlinear developments (Ginzburg-Landau) and secondary instabilities, transient growth and streaks, weakly unstable nonlinear structures, intermittency.

4 introductory short lectures

Nonlinear models of shear flow transition (Y. Duguet)
How fully turbulent flow arises and how it can be controlled (B. Hof)
Rotating stratified flows: from lab to Jupiter red spot (P. Le Gal)
Chimera States: a New Paradigm in Nonlinear Science (Y. Maistrenko)

Organisation

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INVESTISSEMENTS D'AVENIR

Information

http://www.enlpeyresq.u-psud.fr/
registration fee: 300€

Pre-registration

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