Informations générales

Intitulé de la formation :	Nonlinear waves and solitons
Spécialité (s)	Acoustique, Genie Mecanique, Mécanique des Milieux Fluides, Mécanique des Solides, des Matériaux, des structures et des surfaces
Responsable	Vassos Achilleos
Unité / Laboratoire	LAUM UMR CNRS 6613
Intervenant(s)	Vassos Achilleos
Site[1] (de préférence plusieurs sites)	Le Mans
Lieu (établissement)	Le Mans Université
Téléphone :	
E-mail (responsable)	Achilleos.Vassos@univ-lemans.fr
Volume horaire (Cours/TD/TP) :	3 courses of two hours plus 4 hours of practical on numerical simulations
Mots-clés :	Nonlinear waves, solitons, shock waves, numerical simulation of partial differential equations
Période/planning	Second semester
Participation uniquement sur le site	Oui
■	☐
Si oui, quels sites	Le Mans

Domaine(s), spécialité(s) et publics concernés

Les **spécialités** de l'école doctorale SPI sont :

- Acoustique
- Architecture et Etudes Urbaines
- Energétique-Thermique-Combustion
- Génie Civil
- Génie Mécanique
- Génie des Procédés et Bioprocédés
- Génie Industriel
- Génie des Matériaux
- Génie électrique
- Productique – Mécanique
- Procédés de Fabrication, Optimisation de Process et de produits
- Robotique – Mécanique
- Mécanique des Milieux Fluides
- Mécanique des Solides, des Matériaux, des structures et des surfaces

Ce formulaire peut être complété par toute informations permettant d'apprécier l'offre (CV du formateur, plaquettes, etc.).

[1] Angers, Brest, Le Mans, Lorient, Nantes & Rennes.

Détails de la formation

Prérequis :

- General knowledge of basic wave phenomena in 1D (propagation of waves, dispersion relation, scattering etc.)
- Basics of mathematical physcis especially solving ordinary/partial differential equations
- Some experience with numerical programming

Contexte/problématique :

The study of nonlinear systems has quietly and steadily revolutionized the realm of science over recent years. It is known that for nonlinear systems new structures emerge that have their features and peculiar ways of interacting. Examples of such structures abound in nature and include: shock waves and solitons (bits of information used in optical fiber communications, water waves, tsunamis, humps of coherent matter waves, etc). The course will be based on the study of thwo fundamental models. I) The Burgers' equation which is a fundamental partial differential equation from fluid mechanics and occurs in various areas, such as modeling of gas dynamics and traffic flow. II) The Nonlinear Schrödinger equation (NLSE) whose principal applications are to the propagation of light in nonlinear optical fibers and planar waveguides and also superfuids. More generally, the NLSE appears as one of universal equations that describe the evolution of slowly varying wavepackets in dispersive, weakly nonlinear media.

This course is intended as an introduction to the theory and of Nonlinear Waves and their applications in many areas including Engineering, Physics, Chemistry, Biology, etc. Examples from interdisciplinary areas will be covered. Most of the concepts and examples will be supplemented with Matlab-based codes. As part of the course, students will be given access to a computer laboratory to complete the computerbased coursework.

Objectifs pédagogiques :

The students will learn techniques on how to obtain solitary wave solutions in nonlinear wave equation and will also treat the problem of shock waves. The notion of stability of nonlinear solutions will be introduced. Basic properties of solitons including elastic collisions will be covered. Numerical methods to solve nonlinear partial differential equations will be tought.

Description détaillée du contenu de la formation :

- Solutions of the Burger's equation (2h+1h)
  - The invicid case and shock waves
  - Numerical solution and observation of the shock formation
  - The viscous Burgers equation and its solution

- The Nonlinear Schrödinger (NLS) equation (2h+2h)
  - Properties and exact solutions of the linear limit (plane waves, wavepacket dispersion)
  - Exact soliton solutions of the focusing and defocusing NLS
    a. How to obtain « bright » solitons solutions and their properties
    b. How to obtain dark soliton solutions and their properties
- Numerical integration of the NLS equation and the modulational instability (2h+1h)
  - Examples of soliton interactions
  - The instability of plane waves for the focusing NLS equation
  - Theory of the Modulational instability and its consequence

Indications complémentaires :

- For most examples presented in the course, a relevant research publication will be presented to the students in order to appreciate how to use the skills provided to them.
- All of the theoretical results will be complemented with numerical simulations.