Lectures in Nonlinear Analysis and Differential Equations

Doctoral School in Mathematics and Computer Science
Department of Mathematics and Computer Science, University of Calabria

April 20-24, 2020

General Information

The course, organized within the Ph.D. programme in Mathematics and Computer Science, is intended for doctoral students and young researchers interested in Nonlinear Analysis and Differential Equations. Parallel to the Course, some talks given by some of the participants are foreseen.

Course Lecturers

- **Elaine Crooks**, Swansea University, United Kingdom, E.C.M.Crooks@swansea.ac.uk,
  Front propagation and singular limits.

  These lectures will centre on two themes in nonlinear PDE that arise in modelling in biology and are motivated by phenomena such as strong competition and spatial segregation in population dynamics and biological invasions. The first half of the course will be concerned with competition-diffusion models, starting with the role played by equilibria in the long-time behaviour of solutions, including the effect of the shape of the spatial domain and the boundary conditions, followed by a discussion of large -interaction limits and how such limits can be used to deduce information about the behaviour of the competition-diffusion system. The second half of the course will focus on propagating-front solutions of reaction-diffusion equations and systems, including speeds of fronts, linear determinacy, the role of convection, and some examples of front-propagation problems from biology and physics.

- **Feliz Minhós**, University of Évora, Portugal, fminhos@uevora.pt,
  Introduction to some topological methods for nonlinear boundary value problems.

  The aim of this course is to present some techniques and topological methods to deal with nonlinear boundary value problems, along the following lectures plan:

  1. Integral equations: Green functions. Fixed point theory.
  2. Lower and upper solutions method: Introduction to lower and upper solutions method with some particular Boundary Value Problems. Nagumo condition and a priori estimates.
  3. Degree theory: Brouwer degree. Properties. Leray-Schauder degree.
  4. Existence, localization and multiplicity results.

- **Radu Precup**, Babeş-Bolyai University of Cluj-Napoca, Romania, r.precup@math.ubbcluj.ro,
  Hybrid fixed point and variational methods.

  1. We present fixed point theorems for operators defined on a Cartesian product of sets under heterogeneous conditions on the factor sets and the operator components. The results combine Banach-Perov contraction principle with topological fixed point theorems of Monch type in strong and weak topologies. Applications are given to operator systems.

2. A vector notion of linking is introduced in order to obtain, via a minimax principle, the existence and componentwise localization of solutions to systems of gradient type. The new approach allows the energy functional to combine minimization properties with respect to some of the variables, and the mountain pass geometry for the others.

Course Schedule

MONDAY 20 APRIL:

9:00-11:00	Elaine Crooks
	Front propagation and singular limits (Part 1)
11:00-13:00	Feliz Minhós
	Introduction to some topological methods for nonlinear boundary value problems (Part 1)

TUESDAY 21 APRIL:

9:00-11:00	Elaine Crooks
	Front propagation and singular limits (Part 2)
11:00-13:00	Radu Precup
	Hybrid fixed point and variational methods (Part 1)

WEDNESDAY 22 APRIL:

9:00-11:00	Elaine Crooks
	Front propagation and singular limits (Part 3)
11:00-13:00	Feliz Minhós
	Introduction to some topological methods for nonlinear boundary value problems (Part 2)

THURSDAY 23 APRIL:

9:00-11:00	Radu Precup
	Hybrid fixed point and variational methods (Part 2)
11:00-13:00	Feliz Minhós
	Introduction to some topological methods for nonlinear boundary value problems (Part 3)

FRIDAY 24 APRIL:

9:00-11:00	Radu Precup
	Hybrid fixed point and variational methods (Part 3)
11:00-13:00	Course Lecturers
	Tutorials