UNIVERSITÀ DELLA CALABRIA

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

Ph.D. programme
in Mathematics and Computer Science

Title: **Lectures in Nonlinear Analysis and Differential Equations**

Speakers: ***Alberto Cabada,*** *University of Santiago de Compostela, Spain*
Aleksander Cwiszewski, *Nicolaus Copernicus University, Poland*
Tibor Krisztin, *University of Szeged, Hungary*

Course Program:

- **Monotone Iterative Techniques for Ordinary Differential Equations, by Alberto Cabada**
  The Iterative methods are a fundamental tool in order to ensure the existence of solutions of Nonlinear BVPs. This theory is valid both for ODEs and PDEs. Such theory is strongly related to the method of lower and upper solutions. In particular, we obtain information not only about the existence of solutions, but also about the location of some of them. The combination of the lower and upper solutions method and monotone iterative techniques allow us to approximate the given solutions. This recursive method has also a deep dependence on comparison results for suitable linear operators. Such comparison results are equivalent to the constant sign of the kernel of the so-called Green's function. Since to calculate the expression of these functions is, in general, very complicated, we have developed aMathematica package, where the exact expression of the Green's function is obtained when the coefficients of the linear equation are constant. Even in such a case, the obtained expressions are very complicated to deal with. Is for this that, for a wider set of two-point boundary conditions and when non-constant coefficients are considered, by means of spectral theory, we can give the exact value of the parameters for which such Green's function has constant sign without calculate their exact expression.

- **Topological Approach to Dynamics of PDEs, by Aleksander Cwiszewski**

1. Dynamical systems: semi-flows, stationary points, full orbits, Lyapunov functionals and attractors in finite dimensional spaces.
2. Construction of semi-flows for parabolic and hyperbolic PDEs and their compactness properties.
3. Towards topological approach: invariant sets, isolating blocks, homotopy types, Conley and Rybakowski-Conley indices and how they capture dynamics.
4. Computation formulae for Conley index and its relations with fixed point index.
5. Stationary solutions, connecting orbits and bifurcations via topological tools.

- **Delay Differential Equations, by Tibor Krisztin**
  Delay differential equations (DDEs) form a particular class of infinite dimensional dynamical systems. The time delay arises naturally in phenomena where the rate of change of the system depends not only on the present but also on the past states of the system. There is a wide range of applications in physics, chemistry, biology, and social sciences. In particular systems with a feedback control involve time delays. In this introductory course we present the fundamental ideas emphasizing the similarities and differences between DDEs and ordinary differential equations and some partial differential equations. Recent global results will be explained concerning the geometric structure of global attractors for some equations with monotone and non-monotone feedback functions. We discuss open problems and possible future directions as well.

Course organization :

Monday, 8 april, 2019: 9:00 - 13:00, room PITAGORA - 30B
Tuesday, 9 april, 2019: 9:00 - 13:00, room PITAGORA - 30B
Wednesday, 10 april, 2019: 9:00 - 13:00, room PITAGORA - 30B
Thursday, 11 april, 2019: 9:00 - 13:00, room PITAGORA - 30B
Friday, 12 april, 2019: 9:00 - 13:00, room PITAGORA - 30B