Introduction to Mathematical Modeling of Biophysical Phenomena

Stefanella Boatto

Main Topics:

1. ODE: Dynamics of Continuous Biophysical Processes: A practioner's review.

   Planar dynamics, classification of fixed points, limit cycles.
   Bifurcation theory.
   The models of Bela-Novak for the cellular cycle.
   Mitotic oscillator and the cellular cycle.
   The Cardiac Rythm; Circadian Rythm
   Applications of Continuous Models to Population Dynamics:
   -- Models for Single-Species Populations:
      Malths' Model
      Logistic Growth
      Allee Effect
      Grompetz Growth in Tumors
   -- Predator-Prey Systems and the Lotka-Volterra Equations
   -- Populations in Competition
   Rythms in ecology and in populations dynamics

2. PDE: Spatially Distributed Systems.

   PDE and Diffusion in Biological systems
   Bacteria motion (from a probabilistic point of view) in the spirit of Cerrai and Prodi.
   Structured population dynamics (connecting with the minicourse taught by B. Perthame – ENS, Paris.)
   Wave motion driven by diffusion
   Reaction diffusion equations and cancer modeling
   Fluid dynamics: blood circulation

3. Multiscale Analysis:

   Multiscale models for cancer: The cell, tissue and organism scales. Coupling EDOs with PDEs; optimization.
   P. Maini-Alarçon model.
   Levi-Clairambault-Basdevant model.

4. Further Topics: Variational Approaches:

   Protein and DNA modeling. (connecting with the minicourse taught by J. Mitchell – U. of Wisconsin)
   The shape of red-blood cells: an energy-minimization problem.

Basic Bibliography:

Mathematical Models in Biology – Leah Edelstein-Keshet (SIAM - 2005)
Modelli Matematici nelle Scienze Biologiche – Paolo Freguglia
Oscillations en Biologie - J-P. Françoise (Springer - 2004)

The course will be taught in English but questions and homeworks could be formulated in Portuguese, Spanish, French, or Italian.