Ciclo di seminari

PHYSICS COLLOQUIA

Unità di Ricerca di Fisica Non Lineare e Modelli Matematici

Giovedì **23 gennaio**, dalle **10:30**, **aula R2**
Università Campus Bio-Medico di Roma
Via Álvaro del Portillo, 21

EMERGENT COMPLEX DYNAMICS AND MIXED-MODE OSCILLATIONS DUE TO COUPLING IN ENDOCRINE AND NEURONAL SYSTEMS

Speaker: Morten Gram Pedersen

Affiliation: University of Padova

ABSTRACT

Cell-to-cell coupling underlies many important physiological processes and can give rise to dynamics that the single units do not produce. For example, pancreatic beta-cells are electrically coupled, and we show – inspired by earlier work – that coupling can give rise to a new type of bursting dynamics, where small-amplitude oscillations in the action potential height precede transitions to square-wave bursting. This behavior is related to a pitchfork-of-limit-cycles bifurcation in the fast subsystem caused by symmetry breaking.

Similar behavior can be found in models of mutual inhibition between neurons and neuronal populations, a common motive in neuroscience. Typically, inhibition between identical neuronal units generate anti-phase oscillations, which have been studied extensively using modeling and dynamical systems theory. At the onset of such oscillatory behavior, mixed-mode oscillations, consisting of alternating small- and large-amplitude of oscillations, can be observed.

The slow-fast nature of the systems permits the application of singular geometric perturbation theory and the notion of folded singularities. I will show that the recently introduced folded cusp singularities plays an important role in organizing the small-amplitude oscillations in these systems.

The results highlight and clarify how complex dynamics can arise from coupling between biological units that, when isolated, have trivial dynamics.

BIOSKETCH

Morten Gram Pedersen holds a Ph.D. in Applied Mathematics from the Technical university of Denmark. He is Associate Professor of Bioengineering at the University of Padova. His research focuses on modeling and analysis of biophysical events at the cellular level in collaboration with experimental and theoretical researchers. The main topics regard electrical activity, calcium dynamics and hormone release in endocrine cells and neurons, and the activity spans from data analysis and development of new models to mathematical analysis using tools from dynamical systems theory.

NUMERICAL METHODS FOR BRAIN MULTIPHYSICS

Speaker: Ricardo Ruiz Baier

Affiliation: Monash University

ABSTRACT

A great example of a multiphysics problem is the phenomenon of waste transport and clearance in the brain. Different physical mechanisms such as the flow of cerebrospinal and interstitial fluids and the deformation of the brain tissue play a crucial role in clearing away, mostly during sleep, the waste created during the day. I will show some simplified models that involve interface interactions between flow and deformation of porous structures, their mathematical structure, and explain why - even in this reduced complexity - they are difficult to solve numerically in an efficient manner.

BIOSKETCH

Ricardo Ruiz Baier is Professor of Computational Mathematics at Monash University. Ricardo works on the design and analysis of numerical methods for linear and nonlinear partial differential equations. His areas of interest and expertise also include fundamental topics in scientific computing, as well as a number of applications in multiphysics coupled mechanisms such as multiphase flow and transport in porous media and cardiac electromechanics.

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