Monday, July 23rd, 11:40 **Room: C8.2.10**

MINISYMPOSIUM

DYNAMICS AND OSCILLATIONS OF REACTION NETWORKS

Organizer:
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This minisymposium deals with the dynamical behaviour of systems of ordinary differential equations (ODEs) arising from chemical reaction networks. In particular, we wish to investigate the boundaries (in the parameter space) between (global) stability of an equilibrium and the occurrence of oscillatory behaviour.

Oscillating chemical reactions have a long history: the Belousov–Zhabotinsky reactions, the Lotka reactions, the Brusselator, the Oregonator, the Wilhelm & Heinrich oscillator, . . .

In this minisymposium we will revisit some of these classical systems, such as the Lotka system, but now within the framework of generalized mass–action kinetics.

This will be followed by three talks on concrete models, that show oscillations: the glycolytic oscillator model (Alan Rendall), phosphorylation networks (Anne Shiu), and a protein synthesis model (Maya Mincheva).

In the last talk, Antoni Ferragut will explain general techniques to find first integrals and conservative oscillations.

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DYNAMICS OF GENERALIZED MASS–ACTION SYSTEMS

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Joint work with B. Boros (Budapest), S. Müller (Vienna), G. Regensburger (Linz)

Keywords: Power-law systems, Global stability, Limit cycles, Center–focus problem.

In this talk I will start by introducing the minisymposium and outlining the history and open questions, such as finding criteria for the (global) stability of equilibria of generalized mass–action systems.

Then I will present some recent progress [1] in the analysis of 2d systems, such as the Lotka reactions [2] and planar S-systems. For these, we can characterise global stability of the unique equilibrium, find examples of such systems with multiple limit cycles, and solve the center problem.

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BOUNDED AND UNBOUNDED OSCILLATIONS IN THE SELKOV MODEL OF GLYCOLYSIS

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Joint work with Pia Brechmann (University of Mainz)

Keywords: Glycolysis, Stability, Compactification, Heteroclinic cycle.

The Selkov model [3] is a two-dimensional system of ODE which was introduced to describe glycolytic oscillations. We discuss the existence, uniqueness and stability of periodic solutions of this system. We also treat the issue of the existence of solutions which are unbounded at late times, either in a monotone or oscillatory way. Among the techniques used in this analysis are the Poincaré compactification and blow-up of degenerate steady states.

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MULTISITE PHOSPHORYLATION SYSTEMS: BISTABILITY, OSCILLATIONS, AND A RATIONAL PARAMETRIZATION OF STEADY STATES

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Joint work with Carsten Conradi (Hochschule für Technik und Wirtschaft Berlin), Maya Mincheva (Northern Illinois University)

Keywords: Bistability, Oscillations, Rational parametrization, Binomial, Multisite phosphorylation.

This talk focuses on certain biological signaling networks, namely, multisite phosphorylation networks. Many of these systems exhibit "toric steady states" (that is, the ODEs generate a binomial ideal), and more generally the set of steady states admits a rational parametrization [4]. We describe how such a parametrization allows us to investigate the dynamics of two multisite phosphorylation networks: the emergence of bistability in a network underlying ERK regulation, and the capacity for oscillations in a mixed processive/distributive phosphorylation network.

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PARAMETRIC SENSITIVITY ANALYSIS OF A GENE REGULATION DELAY MODEL

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Keywords: Gene network, Protein synthesis, Delay differential equation.

Delay-differential equations are often used to model gene expression networks. An oscillatory protein synthesis model whose properties are modulated by sRNA will be discussed. Sensitivity analysis of the extrema and the period of oscillations are carried out at several operating points. Comments on the evolutionary implications of the results will be offered.

References

[1] B. Boros, J. Hofbauer, S. Müller, G. Regensburger (2017). *Planar S-systems: Global stability and the center problem.* http://arxiv.org/abs/1707.02104

[2] A. J. Lotka (1920): *Undamped oscillations derived from the law of mass action.* J. Am. Chem. Soc., 42: 1595–1599.

[3] E. E. Sel'kov (1968): *Self-oscillations in glycolysis.* Eur. J. Biochem. 4, 79–86.

[4] M. Thomson and J. Gunawardena (2009): *The rational parameterisation theorem for multisite post-translational modification systems.* J. Theor. Biology 261, 626–636.