Swarnendu Banerjee (Utrecht University)

Title: Ecosystems evade tipping via spatial pattern formation

Abstract: Vegetation patterns has been classically linked to catastrophic shifts in ecosystems but recent advances suggest stability and more gradual change in patterned ecosystems in response to environmental change. These findings are based on recent mathematical analyses of spatial models and on observations of real ecosystems. For a given parametric condition, there may exist multiple ecologically observable stable patterned state and changing climatic condition may only lead to reorganization of patterns without any abrupt change at the ecosystem level. In spite of continuing interest in savanna ecology, spatial self-organization in the savanna has been mostly overlooked. We use partial differential equations to model savanna-forest boundary which is so far thought to be prone to tipping, and show gradual invasion of savanna into forest and vice-versa under different environmental conditions. The interface of such invading state may exhibit rich patterned structures that could potentially reverse biome transition in savannas. This study will advance our understanding of predicting the response of the savannas to changes in land use and climatic condition.

Churong Chen (TU Dresden)

Title: Stability of a fractional difference equation and its application to cobweb models

Abstract: In this talk, we first review asymptotic expansion formulae for continuous Mittag--Leffler functions and establish some results on discrete Mittag--Leffler functions, especially their asymptotic behaviors. Using the method of successive approximations, the solution of a specific fractional difference equation is acquired. Moreover, a sufficient condition for stability of the solution is presented. In the end, we conclude with an application on a discrete fractional economic cobweb model.

Qiyao Peng (Leiden University)

Title: A Mathematical Model describing Cell Shape Evolution and the Impact of Cellular Forces on the Extracellular Matrix during Cell Invasion through a Flexible Channel

Abstract:

1. Introduction

It has been widely documented that cell geometry influences cellular activities like cell growth and death, cell mobility and adhesion to the direct environment. The shape of a motile cell is determined by its boundaries, which dynamically varies with a local balance between retraction and protrusion. For cancer cell metastasis, which is the main reason of death among cancer patients, cancer cells need to deform in order to adapt to obstacles during invasion and they are observed to apply traction forces on their immediate environment. Hence, a lot of research has been done on cell penetration the micro-tubes to mimic the tissue-like environment where cells are allowed to transmigrate through cavities.

2. Materials and Methods

We extended the phenomenological model [1] to simulate cell shape evolution during cell migration. In our model, the cell membrane is split into line segments by nodal points, and each point is

connected to the cell center as well as the neighboring points by springs to maintain the cell cytoskeleton. Furthermore, a cell is divided into head and tail part with different properties. Together with chemo-taxis/mechanotaxis, passive convection, focal adhesion and random walk, the displacement of the nodal point is determined. Hence, the cell shape evolves over time.

We consider a series of cells that penetrate through a flexible narrow channel (the width of the channel is narrower than the cell size) sequentially, of which the walls are plastically deformable due to the forces exerted by the cell. The leading cells open up the channel such that the other cells penetrate more easily.

3. Results

Results are given in the terms of the duration time of the cell penetrating through the channel completely. We consider two circumstances: (1) the next cell enters the channel when the previous one has left completely, i.e. there is no mechanical contact between the cells; (2) cells enter the channel following each other, and the mechanical contact may take place, then they exert pushing force on each other. There is significant reduction in transmigration time of the subsequent cells in Case (1), whereas in Case (2) there is less significant reduction. For both cases, we fix the initial positions of the first cell and other settings of the model as much as possible. Then, it can be seen that for Case (2), the first cell might benefit from the second cell exerting the pushing force when they have mechanical contact. To investigate further regarding how the subsequent cells can benefit from the leading cell, Monte Carlo simulations will be conducted.

Table 1: Duration time of cell penetrating through the channel in both cases

Duration Time (min)	1st Cell	2nd Cell	3rd Cell
Case (1)	85.47	66.85	61.39
Case (2)	76.51	75.95	N.A.

4. Discussion and Conclusions

We extended our model in [1] to make it more realistic and investigate how the subsequent cells can benefit from the leading cell when they need to penetrate through a channel or a pore which are much smaller than the cell size. It can be concluded from the simulation that cells collaborate by opening up the channel or the pore in the substrate, such that the other cells transmigrate more easily and faster.

5. References

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Cordula Reisch (Technische Universität Braunschweig)

Title: Reaction-diffusion equations for modeling liver infections

Abstract: I present a model family with linear and nonlinear reaction-diffusion models, stationary models and reduced space-independent models describing the interactions of the virus and the cells of the immune system during a liver infection.

Depending on the extension of the domain and parameters like the reaction change rate and the diffusion strength, we find solutions tending to zero (healing infection courses) or solutions tending towards a stationary spatially inhomogeneous state (chronic infection courses).

Entropy methods are used for showing the importance of the Allee effect and the influence of strong immune reactions.

Different models of the model family provide insight to different aspects of the system, for example the relevance of chemotactic effects or the tendency towards inhomogeneous states.

Nikita Simonov (Universite d'Evry Val d'Essonne)

Title: Fast diffusion equations, tails and convergence rates

Abstract: Understanding the intermediate asymptotic and computing convergence rates towards equilibria are among the major problems in the study of parabolic equations. Convergence rates depend on the tail behaviour of solutions. This observation raised the following question: how can we understand the tail behaviour of solutions from the tail behaviour of the initial datum?

In this talk, I will discuss the asymptotic behaviour of solutions to the fast diffusion equation. It is well known that non-negative solutions behave for large times as the Barenblatt (or fundamental) solution, which has an explicit expression. In this setting, I will introduce the Global Harnack Principle (GHP), precise global pointwise upper and lower estimates of non-negative solutions in terms of the Barenblatt profile. I will characterize the maximal (hence optimal) class of initial data such that the GHP holds by means of an integral tail condition. As a consequence, I will provide rates of convergence towards the Barenblatt profile in entropy and in stronger norms such as the uniform relative error.

Evdokiia Slepukhina (University of Hohenheim)

Title: Noise-induced mixed-mode oscillations in the canard region of the three-dimensional cardiac action potential model

Abstract: We study the influence of random disturbances on the cardiac action potential model [1,2] described by a system of three ordinary differential equations. We show that the parameter region where the dynamics of the original deterministic system is characterized by limit cycles of canard type, noise can induce mixed-mode oscillations. We analyze the probabilistic mechanism of this stochastic phenomenon by means of the constructive approach based on the stochastic sensitivity function technique, Mahalanobis metrics, and the method of confidence domains [3,4]. Using this approach, we find a critical value of the parameter corresponding to the supersensitive cycle and show that for this value, stochastic splitting of oscillations is observed.

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