Reaction-Diffusion Systems Arising in Biology

A GDRI ReaDiNet Workshop in Nancy

organisé par

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à l'Université de Lorraine

les 16 et 17 Décembre 2015

Wednesday December 16th

Conference room, second floor of IECL

10.45 - 10.50, Opening

10.50 - 11.30, Masayasu MIMURA

A reaction-diffusion system describing harmful algal blooms

11.30 - 11.50, *Coffee break*

11.50 - 12.30, Elisabeth LOGAK

An epidemic model with nonlocal diffusion on networks

12.30 - 14.30, *Lunch*

14.30 - 15.10, Robert KERSNER

Stability, pseudo-stability and instability of non-constant stationary solutions of two-species competition systems with and without cross-diffusion

15.20 - 16.00, Karim RAMDANI

State estimation for linear age-structured population diffusion models

16.00 - 16.30, *Tea break*

16.30 - 17.10, Sunho CHOI

A chemotaxis model with metric of food

17.20 - 18.00, Beomjun CHOI

Macroscopic scale convergence of a microscopic kinetic model to starvation driven diffusion

19.30 - ?, *Conference dinner*

Thursday December 17th

Room Döblin, fourth floor of IECL

10.00 - 10.40, Yong Jung KIM

Biological advection and cross-diffusion in a starvation driven dispersal

10.40 - 11.00, *Coffee break*

11.00 - 11.40, Ján ELIAŠ

Reaction-diffusion systems for a class of chemical reactions

11.50 - 12.30, Thanh Nam NGUYEN

Large time behavior and generation of interface for a nonlocal evolution equation with mass conservation

12.30 - 14.30, *Lunch*

14.30 - 15.10, El-Haj LAAMRI

Some new results of global existence for reaction-diffusion systems with a priori control of mass

15.10 - 15.30, *Tea break*

15.30 - 16.10, Hiroshi MATANO

Propagation of a plant disease in some periodic medium

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Titles and abstracts

Masayasu Mimura

A reaction-diffusion system describing harmful algal blooms

Blooms of freshwater cyanobacteria are a worldwide spread environmental issue. Despite toxin producing planktonic species are generally expected to be poor competitors for resources, dense blooms of toxic cyanobacteria, such as Microcystis, do often occur in nature. Experimental results suggest that the formation of such blooms is promoted by the predatory activity of zooplankton. In fact, such predator grazes on both the nontoxic and toxic species despite the toxicity of the latter actually inhibits its growth. We model this phenomenon through a Lotka-Volterra reaction-diffusion system. Our goal is to investigate the coupled role of toxicity and zooplankton's predation in the persistence of the toxic prey and to study the mechanisms behind the formation of spatially local toxic blooms. The results are obtained by joint working with Hideo Ikeda (Toyama University) and Tommasso Scotti (Meiji University).

Elisabeth Logak

An epidemic model with nonlocal diffusion on networks

We consider a nonlinear SIS-type system of nonlocal differential equations which is the continuous version of a discrete model for the propagation of epidemics on networks. Under the assumption of limited or nonlimited transmission, we prove the existence of a unique solution. We also prove the existence of an endemic equilibrium in a large class of networks under some threshold condition. We investigate linear stability and obtain nonlinear stability results in the case of limited transmission, that can be compared to the ones previously known for the discrete model.

Robert Kersner

Stability, pseudo-stability and instability of non-constant stationary solutions of two-species competition systems with and without cross-diffusion

I'll consider three models (RD systems) ; the first two are particular cases of the third one. In 4 or 6-dim parameter space several hypersurfaces of bifurcation-type arise which divide this space in some special way. I'll argue that the black-on-white picture of the standard stable-instable classifications are, possibly, questionable in some sense. (Joint work with Mihaly Klincsik, University of Pecs)

Karim Ramdani

State estimation for linear age-structured population diffusion models

In this talk, we investigate a state estimation problem for an infinite dimensional system appearing in population dynamics. More precisely, given a linear model for age-structured populations with spatial diffusion, we assume the initial distribution to be unknown and that we have at our disposal an observation locally distributed in both age and space. Using Luenberger observers, we solve the inverse problem of recovering asymptotically in time the distribution of population. Numerical experiments will be provided to show the feasibility of the proposed reconstruction method.

Sunho Choi

A chemotaxis model with metric of food

The meaningful migration distance of biological organisms is not necessarily given by the Euclidean metric. A distance system that counts the amount of resources such as food could be more meaningful in many cases. It is assumed in this paper that the migration distance of biological organisms is measured by the amount of food between two points. A new chemotaxis model is introduced as an application of this metric of food. It is shown that, if the length of the random walk is given by such a metric, the well-known traveling wave phenomena of the chemotaxis theory can be obtained without the typical assumption that microscopic scale bacteria may sense the macroscopic scale gradient chemical concentration. The uniqueness and existence of traveling solutions of pulse and front types are proved.

Beomjun Choi

Macroscopic scale convergence of a microscopic kinetic model to starvation driven diffusion

In this talk, we will introduce certain discrete velocity kinetic type equation which describes microscopic model for a species with two phenotypes having different motility constants. Under the assumption that the two groups have different sensitivity against starvation, we obtain macroscopic starvation driven diffusion equation under the diffusive scaling of our microscopic model. This is joint work with Yong-Jung Kim.

Yong Jung Kim

Biological advection and cross-diffusion in a starvation driven dispersal

Migration strategy of biological organisms is sometimes a key element in their survival. The starvation driven dispersal is an migration strategy that organisms increase if starvation started or the environment becomes unfavorable. Such a strategy automatically gives an advection phenomenon toward resource cross-diffusion phenomenon of avoiding other species. In this talk we will discuss about possibilities to develop advection and cross-diffusion theory for biological organisms.

Ján Eliaš

Reaction-diffusion systems for a class of chemical reactions

In this talk we will consider reaction-diffusion systems for a class of chemical reactions with mass conservation, the so-called detailed balanced reactions. Each of the systems possesses a strictly positive steady state which is a global attractor. We show exponential convergence of the solutions of the systems towards their respective steady states by means of the entropy method.

Thanh Nam Nguyen

Large time behavior and generation of interface for a nonlocal evolution equation with mass conservation

We consider an initial value problem for a nonlocal differential equation with a bistable nonlinearity in several space dimensions. The equation is an ordinary differential equation with respect to the time variable t, while the nonlocal term is expressed in terms of spatial integration.We discuss the large time behavior of solutions and prove, among other things, the convergence to steady-states. The proof that the solution orbits are relatively compact is based upon the rearrangement theory. We deduce a generation of interface property for an associated singularly perturbed nonlocal parabolic equation with mass conservation. This is joint work with Danielle Hilhorst, Hiroshi Matano, and Hendrik Weber.

El-Haj Laamri

Some new results of global existence for reaction-diffusion systems with a priori control of mass

In this talk, we present some new results of global existence in time of solutions to reaction- diffusion systems of the following type:

$$\text{for all } i = 1, ..., m, \quad \begin{cases} \partial_t u_i - \Delta\varphi_i(u_i) & = & f_i(u_1, u_2, ..., u_m) & \text{in } (0, +\infty) \times \Omega, \\ u_i(t, \cdot) & = & 0 & \text{on } (0, +\infty) \times \partial\Omega, \\ u_i(0, \cdot) & = & u_{i0} \geq 0 & \text{in } \Omega. \end{cases}$$

Here Ω is a bounded open subset of $\mathbb{R}^N$ with a regular boundary, φ_i, $i = 1, ..., m$ are continuous increasing functions from $[0, +\infty)$ into $[0, +\infty)$ with $\varphi_i(0) = 0$ and the f_i are regular functions such that the two following main properties occur :

- (P) : the nonnegativity of the solutions is preserved for all time ;
- (M) : the total mass of the components is controlled for all time (sometimes even exactly preserved).

Properties (P) and (M) are natural in applications : these systems are mathematical models for evolution phenomena undergoing at the same time spatial diffusion and (bio-)chemical type of reactions. The unknown functions are generally densities, concentrations, temperature so that their nonnegativity is required. Moreover, often a control of the total mass, sometimes even preservation of the total mass, is naturally guaranteed by the model. Interest has increased recently for these models in particular for applications in biology, ecology, environnement and population dynamics.

Hiroshi Matano

Propagation of a plant disease in some periodic medium

In this talk I will discuss a system of equations that models spatial spread of a fungal pathogen over a crop. In this model, the fungal spores diffuse freely in the field, while the growth rate of the healthy crop and the infected one varies periodically in one direction, say, x. What we have typically in mind is a spread of a fungal disease in a vineyard, in which vine plants are aligined periodically. We study conditions for the existence and non-existence of pulsating travelling waves in each direction. We then study further properties of the pulsating travelling waves. This is joint work with Arnaud Ducrot.