**Shanghai Workshop on Differential Equations and Mathematical Biology**

**Nov. 9-10, 2016**

**Donghua University**

**Shanghai, China**

**Program**

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| **Wednesday, November9, 2016** | | |
| **Morning Session (Room 331)** | | |
| 9:00-9:15 | Opening Ceremony | |
| 9:15-9:30 | Group Photo | |
| Chair | Youshan Tao | |
| 9:40-10:20 | Roderick Edwards | |
| 10:20-10:40 | **Coffee/Tea Break** | |
| Chair | BoualemKhouider | |
| 10:40-11:20 | Youshan Tao | |
| **Afternoon Session** **(Room331)** | | |
| Chair | Chunhai Kou | |
| 14:00-14:40 | Slim Ibrahim | |
| 14:40-15:00 | **Coffee/Tea Break** | |
| Chair | Junling Ma | |
| 15:00-15:40 | Zerong He | |
| 15:40-16:20 | FengXie | |
|  | | |
| **Thursday, November10, 2016** | | |
| **Morning Session (Room331)** | | |
| Chair | | YahongPeng |
| 9:00-9:40 | | BoualemKhouider |
| 9:40-10:00 | | **Coffee/Tea Break** |
| Chair | | Roderick Edwards |
| 10:00-10:40 | | JialeHua |
| 10:40-11:20 | | Junling Ma |

Singular dynamics and sensitive dependence in qualitative gene network models

**Roderick Edwards**

Department of Mathematics and Statistics, University of Victoria, Victoria, Canada

**Abstract** Autoregulation in gene networks poses mathematical challenges in determining flow in transition regions. To be specific, competing regulation that keeps concentrations of some transcription factors at or near threshold values leads to so-called singular dynamics when steeply sigmoidal interactions are approximated by step functions. This has led to different approaches to analysis, Filippov theory for discontinuous systems on the one hand, and singular perturbation analysis on the other, which sometimes give discrepant solutions. We have argued that the nonuniqueness and spurious solutions of the Filippov approach can be largely avoided by a narrower definition of a ‘Filippov solution’, and show how these are related to the singular perturbation solution. We have also shown that an extension, due to Artstein and coauthors, of the classical singular perturbation approach is an appropriate way to handle the most complex situation, where non-trivial dynamics of fast variables occurs in singular domains. Now we show that even in this context, it is possible for non-uniqueness to arise in such a system in the case of limiting step-function interactions, even if we avoid the overly inclusive set-valued Filippov definition of solutions. Real gene networks have sigmoidal interactions, however, and in the examples considered here, it is shown that the nonuniqueness arises from a sensitivity to initial conditions in the smooth systems that leads in the limit to densely interwoven basins of attraction of different attractors.

A new critical mass phenomenon in a chemotaxismodel with indirect signal production

**Youshan Tao**

Department of Applied Mathematics, Donghua University, Shanghai, China

**Abstract**This talk addresses a chemotaxis system with indirect signal production, which models the aggregation behavior of the Mountain Pine Beetle in forest habitat. It is shown that this system exhibits a novel type of critical mass phenomenon with regard to the formation of singularities, which drastically differs from the well-known threshold property of the classical Keller-Segel system, in that it refers to blow-up in infinite time rather than in finite time.

This is a joint work with Michael Winkler (Paderborn).

Analysis of a Magneto-Hydro-Dynamic system

**Slim Ibrahim**

Department of Mathematics and Statistics, University of Victoria, Victoria, Canada

**Abstract**I will introduce a full MHD model for plasma, and survey the recent mathematical progress made.

Optimal harvesting of a diffusive population model with size random growth and distributed recruitment

**Zerong He**

Institute of Operational Research and Cybernetics, Hangzhou DianziUniversity, Hangzhou, China

**Abstract** In this talk, we consider an optimal harvesting problem for a diffusive population model with random size growth. The population is recruited in distributed way. The optimality conditions are derived by normal cone and adjoint system, and existence of unique optimal strategy is established by means of Ekeland’svariational principle.This is a joint work with Shu-Ping Wang.

A geometric approach to stationary defect solutions in one spacedimension

**FengXie**

Department of Applied Mathematics, Donghua University, Shanghai, China

**Abstract**We consider the impact of a small jump-type spatial heterogeneity on the existence of stationary localized patterns in a system of partial differential equations in one spatial dimension, i.e., defined on . This problem corresponds to analyzing a discontinuous and nonautonomous n-dimensional system,



under the assumption that the unperturbed system, i.e., the  limit system, possesses a heteroclinic orbit that connects two hyperbolic equilibrium points (plus several additional nondegeneracy conditions). The unperturbed orbit  represents a localized structure in the PDE setting. We define the (pinned) defect solutionas a heteroclinic solution to the perturbed system such that (as graphs). We distinguish between three types of defect solutions: trivial, local, and global defect solutions. The main goal of this manuscript is to develop a comprehensive and asymptotically explicit theory of the existence of local defect solutions. We find that both the dimension of the problem as well as the nature of the linearized system near the endpoints of the heteroclinic orbit  have a remarkably rich impact on the existence of these local defect solutions. We first introduce the various concepts in the setting of planar systems  and--for reasons of transparency of presentation- consider the three-dimensional problem in full detail. Then, we generalize our results to the n-dimensional problem, with special interest for the additional phenomena introduced by having . We complement the general approach by working out two explicit examples in full detail: (i) the existence of pinned local defect kink solutions in a heterogeneous Fisher-Kolmogorov equation (n = 4) and (ii) the existence of pinned local defect front and pulse solutions in a heterogeneous generalized FitzHugh-Nagumo system (n = 6).

Optimal transport for particle image velocity and variational methods for fluid flows

**Boualem Khouider**

Department of Mathematics and Statistics, University of Victoria, Victoria, Canada

**Abstract**In this talk I will present a new method for recovering the velocity field of a fluid flow using  the particle image velocimetry (PIV) based on the modern theoryof optimal transportation.PIVis a technique used by engineers to measure thevelocity field of a fluid flow in a lab experiment. It consists in immersing very small and bright particles in  the moving fluid and then successive images are taking by a fast camera while a laser beam lights the particles at regular time intervals. Traditionally, engineers use cross correlation between neighboring pixels to detect the movement of the particle clusters and infer the fluid velocity. In order to overcome the crudeness of this methods and attempts to use all available information, we compute instead the optimal transport map, between successive images, in the sense of the euclidean distance by solving the nonlinear Monge-Ampere equation. However, because the velocity field obtained through the optimal transport theory is not a solution to the Navier-Stockes equations but it is that of a pressure-less and inviscid flow, we correct the obtained velocity field through a variational technique based on the Navier-Stokes equations. This is a joint work with Louis-Phillipe Saumier and Martial Agueh.

Self-Organized Hydrodynamics with congestion and path formation in Crowds

**Jiale Hua**

Department of Applied Mathematics, Donghua University, Shanghai, China

**Abstract**A continuum model for self-organized dynamics is numerically investigated. The model describes systems of particles subject to alignment interaction and short-range repulsion. It consists of a non-conservative hyperbolic system for the density and velocity orientation. Short-range repulsion is included through a singular pressure which becomes infinite at the jamming density. The singular limit of infinite pressure stiffness leads to phase transitions from compressible to incompressible dynamics. In this talk, an Asymptotic-Preserving scheme is discussed, which takes care of the singular pressure while preventing the breakdown of the CFL stability condition near congestion. It relies on a relaxation approximation of the system and an elliptic formulation of the pressure equation. Numerical simulations of impinging clusters show the efficiency of the scheme totreat congestions. A two-fluid variant of the model provides a model of path formation in crowds.

Disease invasion risks on growing random networks

**Junling Ma**

Department of Mathematics and Statistics, University of Victoria, Victoria, Canada

**Abstract**Classical disease models predict that, if transmission rate between any pair of individuals remain constant, then the disease invasion risk in a population, measured by the basic reproduction number, increases linearly with the population size. However, on a growing random network, we found that the risk may reaches a maximum then decrease to an equilibrium risk while the population increases to an equilibrium. I will show that this is caused by the lack of proper modeling of the dynamics of contacts in classical models. After including the changes of the contact rate caused by births and deaths, classical disease models show the same behaviour in disease invasion risks.

This is a joint work with Sanling Yuan, Pauline van den Driessche, Frederick Willeboordseand ZhishengShuai.