Workshop on

PDEs from biology, ecology and life sciences: models and analysis

10 – 11 July 2018

Sponsors:
The AMSS-PolyU Joint Research Institute
The Hong Kong Polytechnic University

Organizer:
Zhian Wang The Hong Kong Polytechnic University

Schedule

Time: 10 July 2018 (Wednesday)
Venue: Room TU801, 8/F, Core T, Yip Kit Chuen Building, PolyU

Day 1	**10 July (Tuesday)**
08:55-9:00	Opening remarks
Session Chair	Zhian Wang
09:00-09:40	**Hyung Ju Hwang**, Pohang University of Science and Technology Chemotaxis model in the immunology
09:40-10:20	**Yao Yao**, Georgia Institute of Technology Enhancement of biological reaction by chemotaxis
10:20-10:40	Coffee and Tea Break
Session Chair	Hyung Ju Hwang
10:40-11:20	**Qi Wang,** Southwestern University of Finance and Economics Steady states of Keller-Segel systems with porous medium diffusion: existence, classification and stability.
11:20-12:00	**Yuxiang Li,** Southeast University Global weak solutions and boundedness for 3-D chemotaxis-fluid system with p-Laplacian diffusion
12:00-14:30	Lunch
Session Chair	Yao Yao
14:30-15:10	**Peter Hinow**, University of Wisconsin-Milwaukee Size-structured populations with distributed states at birth
15:10-15:50	**Zhi-Cheng Wang**, Lanzhou University Propagation dynamics of a time periodic and delayed reaction-diffusion model without quasi-monotonicity
15:50-16:10	Coffee and Tea Break
Session Chair	Qi Wang
16:10-16:50	**Xiangsheng Wang,** University of Louisiana at Lafayette Steady-state and dynamical solutions of Poisson-Nernst-Planck systems
6:50-17:30	**Hongyin Shu**, Shanxi Normal University Threshold dynamics of a partially degenerate viral infection model with spatial heterogeneity
18:00-20:30	**Dinner (all speakers are invited)**

Schedule

Time: 11 July 2018 (Wednesday)
Venue: Room TU801, 8/F, Core T, Yip Kit Chuen Building, PolyU

Day 2	**11 July 2018 (Wednesday)**
Session Chair	Zhian Wang
09:00-09:40	**Jose Antonio Carrillo,** Imperial College London Nonlinear Aggregation-Diffusion equations in the diffusion-dominated and fair-competitions regimes
09:40-10:20	**King-Yeung Lam,** The Ohio State University Invasion of open space by two competing species
10:20-10:40	Coffee and Tea Break
Session Chair	King-Yeung Lam
10:40-11:20	**Haiyang Jin,** South China University of Technology Boundedness, stabilization and pattern formation of the prey-taxis systems with nonrandom motion
11:20-12:00	**Chunhua Jin,** South China Normal University Global solvability and large time behavior to a chemotaxis model with nonlinear diffusion
12:00-14:00	Lunch
14:00-16:00	**Free Discussion**

Title and Abstract

Title: Nonlinear Aggregation-Diffusion Equations in the Diffusion-dominated and Fair-competitions Regimes
Speaker: Jose Antonio Carrillo, Imperial College London, UK
Abstract: We analyse under which conditions equilibration between two competing effects, repulsion modelled by nonlinear diffusion and attraction modelled by nonlocal interaction, occurs. I will discuss several regimes that appear in aggregation diffusion problems with homogeneous kernels. I will first concentrate in the fair competition case distinguishing among porous medium like cases and fast diffusion like ones. I will discuss the main qualitative properties in terms of stationary states and minimizers of the free energies. In particular, all the porous medium cases are critical while the fast diffusion are not. In the second part, I will discuss the diffusion dominated case in which this balance leads to continuous compactly supported radially decreasing equilibrium configurations for all masses. All stationary states with suitable regularity are shown to be radially symmetric by means of continuous Steiner symmetrisation techniques. Calculus of variations tools allow us to show the existence of global minimizers among these equilibria. Finally, in the particular case of Newtonian interaction in two dimensions they lead to uniqueness of equilibria for any given mass up to translation and to the convergence of solutions of the associated nonlinear aggregation-diffusion equations towards this unique equilibrium profile up to translations as time tends to infinity. This talk is based on works in collaboration with S. Hittmeir, B. Volzone and Y. Yao and with V. Calvez and F. Hoffmann.

Title: Size-structured populations with distributed states at birth
Speaker: Peter Hinow, University of Wisconsin-Milwaukee, USA
Abstract: Age-structured models have been employed successfully in population dynamics for a long time and are considerably well understood. In contrast to such models where every individual is born at the same age 0, size-structured models allow to take into account different, distributed birth sizes. "Size" here can be a quite general concept, for example mass, energy content or pathogen load in a disease model. This results a birth operator that takes values in an infinite-dimensional Banach space and complicates greatly the mathematical analysis. In this survey, we will describe some examples of models that we investigated in a series of joint papers with Jozsef Farkas (University of Stirling, United Kingdom). The emphasis will be on questions such as asymptotic growth for linear models and the existence and stability of steady states for

nonlinear models.

Title: Global Solvability and Large Time Behavior to a Chemotaxis Model with Nonlinear Diffusion
Speaker: Chunhua Jin, South China Normal University, China
Abstract: In this talk, we discuss a chemotaxis model with porous medium slow diffusion $\Delta u^m (m > 1)$. We consider this problem in a bounded domain of R^3 with zero-flux boundary condition, and it is shown that for any large initial datum, for any m > 1, the problem admits a global uniformly bounded weak solution. Subsequently, the large time behavior of the solutions are also discussed. The methods and results of this paper are also applicable for the coupled chemotaxis-Stokes system. In particular, for the case without bacteria proliferation, the present results improved the work of Tao, Winkler et.al [2013, Ann. I. H. Poincar´e AN; 2015, CVPDE; 2018, JDE], in which the global existence or boundedness is established for $m>\frac76$, $m>\frac87$, $m>\frac98$, respectively.

Title: Boundedness, stabilization and pattern formation of the prey-taxis systems with nonrandom motion
Speaker: Haiyang Jin, South China University of Technology, China
Abstract: In this talk, we shall establish the global boundedness and stability of the predator-prey system with non-random motion in a two-dimensional bounded domain with Neumman boundary conditions. We first establish the existence of classical solution with uniform-in time bound. Then by constructing Lyapunov functionals, we establish the global stability of the prey-only steady states and coexistence steady states under certain conditions on parameters. At last, we also discuss the pattern formations with numerical simulations. This is a joint work with Prof. Zhi-An Wang (PolyU).

Title: Chemotaxis model in the immunology
Speaker: Hyung Ju Hwang, Pohang University of Science and Technology (POSTECH), South Korea
Abstract: In this talk, we discuss how chemotaxis affects immune system by proposing a minimal mathematical model, a reaction-diffusin-advection system, describing a cross-talk between antigens and immune cells via chemokines. We analyze stability and instability arising in our chemotaxis model and find their conditions for different chemotactic strengths and numerical simulations are also performed to the model. We study the global well-posedness of the system and analyze the stability and instability arising in our chemotaxis model. Then we find their conditions for different chemotactic

strengths by using energy estimates, spectral analysis and bootstrap argument. Furthermore we also analyze the bifurcation to investigate the instability type. From the analytical and numerical results for our model, we explain not only the effective attraction of immune cells toward the site of infection, but also hypersensitivity when chemotactic strength is greater than some threshold.

Title: Invasion of Open Space by Two Competing Species
Speaker: Adrian Lam, Ohio State University, USA
Abstract: I will discuss a question raised by Shigesada and Kawasaki in Chapter 7 of their monograph, concerning the spreading properties of two competing species on the real line when the initial values are null or exponentially decaying in a right half-line. In the case of compactly supported initial values, we prove that the first species spreads with the KPP speed of the single species, whereas the speed of the second species can be given by an exact formula depending on the speed of the first species. This is joint work with Leo Girardin (Paris VI). If time allows, I will also talk about some recent progress obtained with Qian Liu (OSU and Renmin Univ. of China).

Title: Global weak solutions and boundedness for 3-D chemotaxis-fluid system with p-Laplacian diffusion
Speaker: Yuxiang Li, Southeast University, China
Abstract: We consider an incompressible chemotaxis-Navier-Stokes system with p-Laplacian diffusion under homogeneous boundary conditions of Neumann type for density of bacteria and concentration of nutrient, and of Dirichlet type for fluid in a bounded convex domain with smooth boundary in R^3. First we prove that if p>32/15 and under appropriate structural assumptions on parameters, for all sufficiently smooth initial data, the model possesses at least one global weak solution. Then we prove that for the incompressible chemotaxis-Stokes system, the global weak solutions is bounded whenever p>25/12.

Title: Threshold dynamics of a partially degenerate viral infection model with spatial heterogeneity
Speaker: Hongying Shu, Shanxi Normal University, China
Abstract: In this talk, we study a general viral infection model with spatial diffusion in virus and two types of infection mechanisms. The
model is a partially degenerate reaction-diffusion system, whose solution map is not compact. We identify the basic reproduction number R_0 and explore the properties

of R_0 when the virus diffusion parameter varies from zero to infinity. Moreover, we demonstrate that the basic reproduction number is a threshold parameter for the global dynamics of our model system: the infection and virus will be cleared out if $R_0\leq1$, while if $R_0>1$, the infection persists and the model admits a unique positive infection steady state which is globally attractive. Numerical simulation supports
our theoretical results and suggests an interesting phenomenon: boundary layer and internal layer may occur when the diffusion parameter tends to zero.

Title: Steady States of Keller-Segel Systems with Porous Medium Diffusion: Existence, Classification and Stability
Speaker: Qi Wang, Southwestern University of Finance and Economics, China
Abstract: In this talk, we study the steady states of a Keller-Segel system with porous medium diffusion over a finite interval. In particular, we classify, in terms of the chemo--attraction rate, and investigate the existence and stability of the followings: i) constant steady states; ii) positive steady states; iii) compactly supported steady states. This talk is based on a work joint with Xinfu Chen (University of Pittsburgh) and Zhian Wang (Hong Kong Polytechnic University).

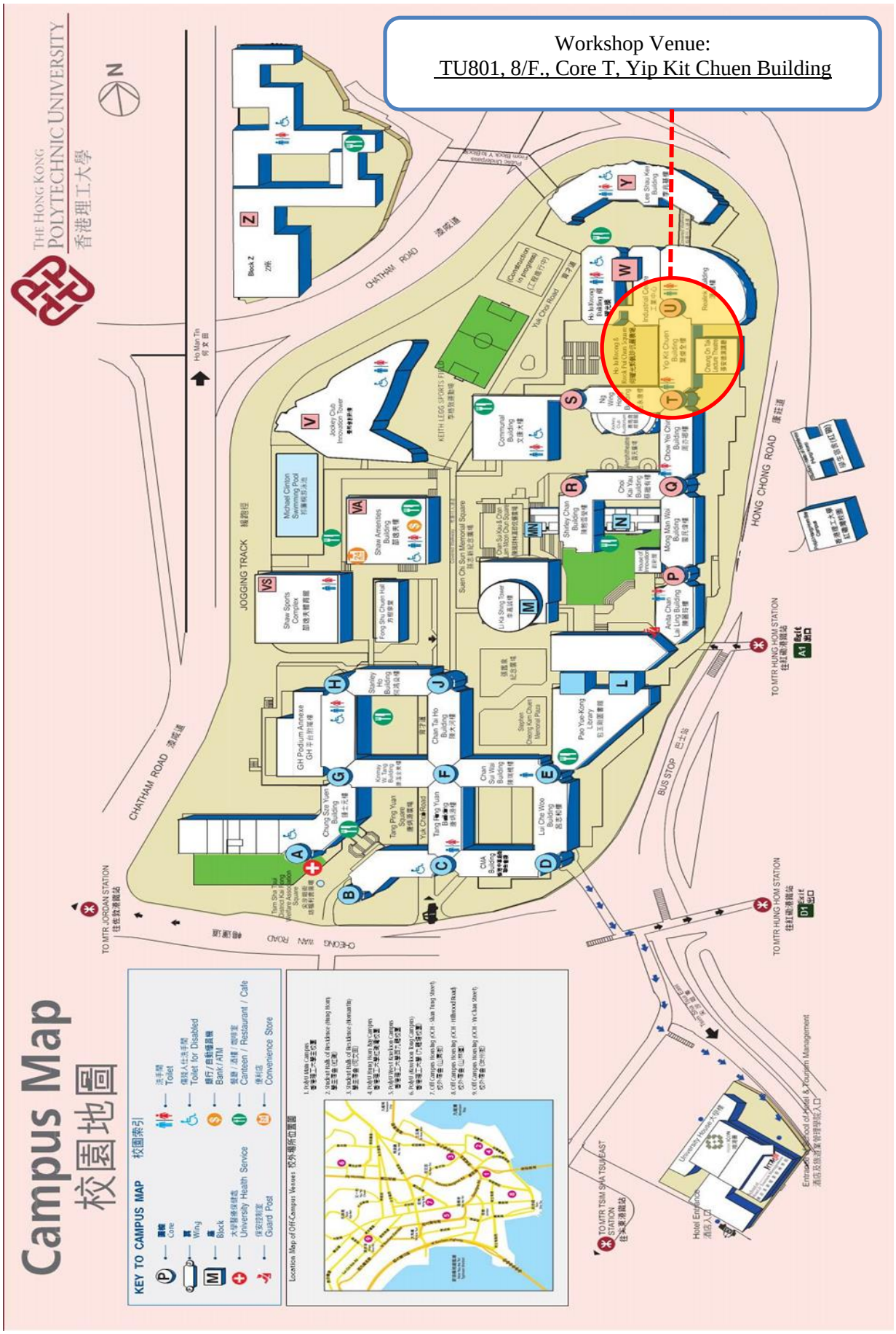
Title: Steady-state and dynamical solutions of Poisson-Nernst-Planck systems
Speaker: Xiang-Sheng Wang, University of Louisiana at Lafayette, USA
Abstract: Poisson-Nernst-Planck systems are used to model the dynamics of ions in a narrow membrane channel. The potential distribution is governed by the electric balance of different ions, while the ion fluxes are the combinations of random movement and the electric drift induced by the potential gradient. We will derive asymptotic formulas for the steady-state and dynamical solutions to the model system which couples an elliptic equation with several parabolic equations.

Title: Propagation dynamics of a time periodic and delayed reaction-diffusion model without quasi-monotonicity
Speaker: Zhi-Cheng Wang, Lanzhou University, China
Abstract: In this talk, we consider a time periodic non-monotone and nonlocal delayed reaction-diffusion population model with stage structure. We first prove the existence of the asymptotic speed c^* of spread by virtue of two auxiliary equations and comparison arguments. We then establish the existence of time periodic traveling wave

solutions with speed $c\geq c^*$. Finally, we obtain the nonexistence of traveling wave solutions for speed $c<c^*$.

Title: Enhancement of biological reaction by chemotaxis
Speaker: Yao Yao, Georgia Institute of Technology, USA
Abstract: In this talk, we consider a system of equations arising from reproduction processes in biology, where two densities evolve under diffusion, absorbing reaction and chemotaxis. We prove that chemotaxis plays a crucial role to ensure the efficiency of reaction: Namely, the reaction between the two densities is very slow in the pure diffusion case, while adding a chemotaxis term greatly enhances reaction. While proving our main results we also obtain a weighted Poincare's inequality for the Fokker-Planck equation, which might be of independent interest.

Campus Map


Workshop Venue:
TU801, 8/F., Core T, Yip Kit Chuen Building
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學
Campus Map
校園地圖
KEY TO CAMPUS MAP
CHATHAM ROAD
JOGGING TRACK
HONG CHONG ROAD
CHEONG MAN ROAD
BUS STOP
TO MTR JORDAN STATION
TO MTR HUNG HOM STATION
TO MTR TSIM SHA TSUI EAST STATION
Hotel Entrance

Guidance for Ground Transportation

The transportation from Hong Kong/Shenzhen airport to the Harbour Plaza Metropolis hotel or Best Western PLUS Hotel Kowloon or Hong Kong Polytechnic University

If you are traveling from the Hong Kong International Airport, there are four options available:

- **By Airport Bus A21** (HK$ 33 per person): Following the sign after getting out the exit (i.e. pick up area) in the arrival hall and then follow the sign to find the bus station to take the Airport Bus A21. If your hotel is **Harbour Plaza Metropolis hotel**, then please get off the bus at the terminal station Hung Hom and then walk to the Harbour Plaza Metropolis hotel in about 10 minutes. If your hotel is **Best Western PLUS Hotel Kowloon**, then please get off the bus at the 17th (the last third) stop Granville Road (Chatham Road South) which is right front of the hotel. Highly recommend if you want to save money and have a sightview of the Hong Kong. It takes about 50 minutes.
- **By Hotel-Link Shuttle Bus** (HK$ 150 per person): When you get out the exit in the Arrival Hall, please approach Counter B01 which is opposite to EXIT B and then show your hotel information to the staff. After purchasing the ticket there, you will be led by the staff to get on the shuttle bus. This shuttle bus takes you to the Harbour Plaza Metropolis hotel directly. There is a picture of the arrival hall available HERE.
- **By Airport Express** (HK$ 100): First take the airport express train to Kowloon station. After getting out the exit at Kowloon station, then follow the sign to take free transit bus K1 to the hotel directly.
- **By Urban taxi (Red)**, which costs approximately HK$ 280.

If you are traveling from the Shenzhen International Airport, then

- Please take taxi (or airport shuttle bus) to Lo Wu station. After cross the border control, take the East Rail Line train (which is also the only train) to Hung Hom station which is the terminus of this line. Please get out from EXIT C at Hung Hom station and then walk to the Harbour Plaza Metropolis hotel, or EXIT D at Hung Hom station and walk to Best Western PLUS Hotel Kowloon, or EXIT A1 to Hong Kong Polytechnic University