Abstract

Fronts and pulses in FitzHugh-Nagumo equations

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There are many patterns and waves observed in FitzHugh-Nagumo equations. Fronts and pulses are basic local structures to be discussed in this talk.

Competitive Exclusion and Coexistence in a Two-Strain Pathogen Model with Diffusion

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We consider a two-strain pathogen model described by a system of reaction-diffusion equations. We define a basic reproduction number R_0 and show that when the model parameters are constant (spatially homogeneous), if $R_0 > 1$ then one strain will outcompete the other strain and drive it to extinction, but if $R_0 \leq 1$ then the disease-free equilibrium is globally attractive. When we assume that the diffusion rates are equal while the transmission and recovery rates are heterogeneous, then there are two possible outcomes under the condition $R_0 > 1$: 1) Competitive exclusion where one strain dies out. 2) Coexistence between the two strains. Thus, spatial heterogeneity promotes coexistence.

Bistable traveling waves for monotone semiflows

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In this talk, I will first recall some classical results on the existence of traveling waves connecting two stable steady states for typical reaction-diffusion equations and their analogues. Such an existence result is then established for a class of bistable evolution systems in homogeneous/periodic environment from a monotone dynamical system point of view. Finally, the obtained results are illustrated with concrete models that may arise from population ecology. This talk is based on a joint work with Xiaoqiang Zhao.

Traveling waves for a lattice dynamical system arising in a diffusive endemic model

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We are concerned with a lattice dynamical system modeling the evolution of susceptible and infective individuals at discrete niches. We prove the existence of traveling waves connecting the disease-free state to non-trivial leftover concentrations. We also characterize the minimal speed of traveling waves and prove the non-existence of waves with smaller speeds

Temporal Patterns and Circulation of Influenza Virus Strains in Taiwan, 2008-2014: Implications of 2009 pH1N1 Pandemic

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It has been observed that historically, strains of pandemic influenza led to succeeding seasonal waves, albeit with decidedly different patterns. Recent studies suggest that the 2009 A(H1N1)pdm09 pandemic has had an impact on the circulation patterns of seasonal influenza strains in the post-pandemic years. In this work we aim to investigate this issue and also to compare the relative transmissibility of these waves of differing strains using Taiwan influenza surveillance data before, during and after the pandemic.

We make use of the Taiwan Center for Disease Control and Prevention influenza surveillance data on laboratory-confirmed subtyping of samples and the Richards model to determine the waves of circulating (and co-circulating) H1, H3 and B virus strains in Taiwan during 2008-2014; or namely, short before, during and after the 2009 pandemic. We further pinpoint the turning points and relative transmissibility of each wave, in order to ascertain whether any temporal pattern exists.

For two consecutive years following the 2009 pandemic, A(H1N1)pdm09 circulated in Taiwan (as in most of Northern Hemisphere), sometimes co-circulating with AH3. From the evolution point of view, A(H1N1)pdm09 and AH3 were able to sustain their circulation patterns to the end of 2010. In fact, A(H1N1)pdm09 virus circulated in six separate waves in Taiwan between summer of 2009 and spring of 2014. Since 2009, a wave of A(H1N1)pmd09 occurred every fall/winter influenza season during our study period except 2011-2012 season, when mainly influenza strain B circulated.

Estimates of R for seasonal influenza are consistent with that of temperate and tropical-subtropical regions, while estimate of R for A(H1N1)pdm09 is comparatively less than countries in Europe and North America, but similar to that of tropical-subtropical regions. This offers indication of regional differences in transmissibility of influenza virus that exists only for pandemic influenza. Despite obvious limitations in the data used, this study, designed to qualitatively compare the temporal patterns and transmissibility of the waves of different strains, illustrates how influenza subtyping data can be utilized to explore the mechanism for various influenza strains to compete or to circulate, to possibly provide predictors of future trends in the evolution of influenza viruses of various subtypes, and perhaps more importantly, to be of use to future annual seasonal influenza vaccine design.

Stability of Boundary Layer Solutions of Poisson-Nernst-Planck Systems

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The Poisson-Nernst-Planck (PNP) system has been widely used to describe the ion transport of ionic solutions, and plays a crucial role in the study of many physical and biological problems. In order to see Debye layers, which occur in ionic liquids near electrodes and have many applications in the fields of chemical physics and biophysics, boundary layer solutions need to be investigated. If the Robin boundary condition is imposed for the electrostatic potential, the PNP system admits a boundary layer solution as a steady state. We study the stability of boundary layer solutions of PNP system. By transforming the perturbed problem into another parabolic system with a new and useful energy law, we prove that the H^{-1}-norm of the solution of the perturbed problem decays exponentially.

TBA

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R0 Analysis of a Benthic-Drift Model for a Stream Population

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One key issue for theory in stream ecology is how much stream flow can be changed while still maintaining an intact stream ecology, instream flow needs (IFNs); the study of determining IFNs is challenging due to the complex and dynamic nature of the interaction between the stream environment and the biological community. We develop a process-oriented benthic-drift model that links changes in the flow regime and habitat availability with population dynamics. In the model, the stream is divided into two zones, drift zone and benthic zone, and the population is divided into two interacting compartments, individuals residing in the benthic zone and individuals dispersing in the drift zone. We study the population persistence criteria, based on the net reproductive rate R0 and on related measures. We develop new theory to calculate these quantities and use them to investigate how the various flow regimes, population birth rate, individual transfer rates between zones, and river heterogeneity affect population persistence. The theory developed here provides the basis for effective decision-making tools for water managers.

Epidemic Models in Multiplex Networks

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In this talk, we consider epidemic models in multiplex networks in which the dynamics of susceptible-aware-susceptible(SIS) process in the physical world interplays with that of a cyclic process of unaware-aware-unaware(UAU) in the virtual world. Those models contain rich phase diagram of intertwined competition effects between three possible equilibria: the disease and information free equilibrium , the disease free and information saturated equilibrium, and epidemic and information saturated equilibrium. We will also present the global analysis of the models.

Modified PNP_steric equations: a new model of ion transport through channels

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To describe ion transport through biological channels, we derive a new Poisson-Nernst-Planck (PNP) type model called the modified PNP_steric equations with derivative terms up to the fourth order using infinite expansion (in increasing order of derivatives) of the energy with the approximate Lennard-Jones (L J) potential. The fourth-order derivative terms of the modified PNP_steric equations may stabilize the dynamics of the modified PNP_steric equations even though the coefficients of the second-order derivative terms are located in the symmetry breaking regime which may give multiple equilibriums of the original PNP_steric equations (with B. Eisenberg, Nonlinearity 28 (2015) 2053–2080). Our numerical results show that the energy of the modified PNP_steric equations may behave like a decreasing piecewise constant function of time. Such a model and computational method would be useful for the study of ion transport through channels. This is a joint work with Yi-Ping Lo and Chun-Hao Teng.

A general ODE model for population growth with many stages

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In this talk, I will present a model of ordinary differential equations for populations which are structured by many stages. The model is general enough to apply to many biological system. Our analysis identifies a basic reproduction number that acts as a threshold between population extinction and persistence. We establish conditions for the existence and uniqueness of nonzero equilibria and show that their local stability cannot be expected in general. Boundedness of solutions remains an open problem though we give some sufficient conditions.

This talk is based on joint work with Guiding Fan, Horst R. Thieme and Jianhong Wu.

Spatial Heterogeneity and Time Periodicity in Lotka-Volterra Competition-Diffusion Systems

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In this lecture I shall report some of the recent progress on the 2x2 Lotka-Volterra competition-diffusion systems when spatial heterogeneity and/or temporal periodicity are present.

The entry-exit function and geometric singular perturbation theory

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Motivated by the problem of finding periodic traveling waves in the diffusive Holling-Tanner predator-prey model, we revisit the classical problem $\dot{x} = \varepsilon$, $\dot{z} = h(x,z)z$, with $h(x,0) < 0$ for $x < 0$, $h(x,0) > 0$ for $x > 0$, and $\varepsilon > 0$ small. This ODE admits solutions that start near the negative x-axis, rapidly approach it, drift along it, and eventually rapidly leave it. The relation between the limiting attraction and repulsion points is given by the well-known entry-exit function. For $h(x,z)z$ replaced by $h(x,z)z^2$, we explain this phenomenon using Geometric Singular Perturbation Theory (joint work with Peter De Maesschalck). It turns out that the linear case can be reduced to the quadratic case. We also discuss an even more recent approach to the entry-exit function, due to Ting-Hao Hsu, that uses the Exchange Lemma of GSPT and extra variables. Along the way we will give background about Geometric Singular Perturbation Theory, loss of normal hyperbolicity, and the Exchange Lemma.

On Neural Field Models

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Neural fields model macroscopic parts of the cortex which involve several populations of neurons. In this lecture, I plan to introduce several neural field models which are represented by integro-differential equations with space-dependent transmission time delays. We then discuss absolute stability of the systems. This notion is associated with the neuronal dynamics in the sense that absolutely stable system evolves to a state which only depends on the input, not the initial state. We investigate absolute stability by a new approach termed sequential contracting, instead of the conventional Lyapunov functional technique. Sufficient conditions for the absolute stability, stability of the stationary solutions, and synchronization of the systems are then established, respectively.

This is a joint work with Chiu-Yen Kao and Chang-Hong Wu.

Synchronization of coupled cells

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In this talk, we present a novel approach to establish synchronization of coupled cells and coupled systems. Under this approach, individual subsystems can be non-autonomous, and the coupling configuration is rather general. With an iteration scheme, the problem of synchronization is transformed into solving a corresponding linear system of algebraic equations. Subsequently, delay-dependent and delay-independent criteria for global synchronization can be established. We start by considering a cell-to-cell system under symmetric coupling to present the main idea of the approach. The framework is then extended to the N-cell system. The developed scheme can accommodate a wide range of coupled systems.
We demonstrate the applications of the present approach to establish synchronization for a gene regulation model and a neuronal model. This is a joint work with Chih-Wen Shih (NCTU).

An approach to the asymptotic behavior of traveling waves for some lattice dynamical systems

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We develop an approach to deal with the asymptotic behavior of traveling waves in a class of lattice dynamical system. Some applications will be discussed.

Global dynamics and traveling wave solutions of three species intraguild predator models

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In this work, we consider the community of three species food web models with or without diffusion and the nonlinear interaction is the predator-prey Lotka-Volterra type. Without diffusion and in the absence of other species, each species follows the traditional logistical growth model and the top predator is an omnivore which is defined as feeding on the other two species. It can be seen as a model with one basal resource and two generalist predators, and pairwise interactions of all species are predator-prey type. It is well known that the omnivory module blends the attributes of several well-studied community modules, such as food chains (food chain models), exploitative competition (two predators-one prey models), and apparent competition (one predator-two preys models). With a mild biological restriction, we completely classify all parameters. All local dynamics and most parts of global dynamics are established corresponding to the classification. Moreover, the system is uniformly persistent whenever the coexistence appears. In the case of without diffusion, we conclude by discussing the strategy of inferior species to survive and the mechanism of uniform persistence for the three species ecosystem. With diffusion and presence of stable positive equilibrium, we show the existence of traveling wave front solution from the trivial solution to the positive equilibrium by the method of upper-lower solution. Some biological interpretation are also given.

Propagation phenomena for a reaction-advection-diffusion competition model in a periodic habitat

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In this talk, I will report our recent research on a reaction-advection-diffusion competition model in a periodic habitat. We first investigate the global attractivity of a semi-trivial steady state (i.e., the competitive exclusion) for the periodic initial value problem. Then we establish the existence of the rightward spreading speed and its coincidence with the minimal wave speed for spatially periodic rightward traveling waves. Further, we obtain a set of sufficient conditions for the rightward spreading speed to be linearly determinate. Finally, we apply the obtained results to a prototypical reaction-diffusion model. Our method involves monotone semiflows, principal eigenvalues, lower and upper solutions. This talk is based on a joint work with Dr. Xiao Yu.