Transient Behaviors in Population Dynamics
Comportements transitoires dans la dynamique des populations
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JACQUES BELAIR, Université de Montréal
Modelling the use of Fangsang shelter hospitals in Wuhan

Motivated by China's experience of using Fangcang shelter hospitals (FSHs) to successfully combat the epidemic in its initial stages, we present a two-stage, functional differential delay model considering the average waiting time of patients' admission to study the impact of hospital beds and centralized quarantine on mitigating and control of the outbreak. We compute the basic reproduction number in terms of the hospital resources, and perform a sensitivity analysis of the average waiting times of patients before admission to the hospitals. We discuss the rôle played by FSHs in mitigating and eventually curbing the epidemic.

SUE ANN CAMPBELL, University of Waterloo
Dynamics of a Diffusive Nutrient-Phytoplankton-Zooplankton Model with Spatio-Temporal Delay

We study a diffusive nutrient-phytoplankton-zooplankton (NPZ) model with spatio-temporal delay. The closed nature of the system allows the formulation of a conservation law of biomass that governs the ecosystem. We formulate stability conditions for the equilibria for a general distribution of delays and analyze the Hopf bifurcations for a specific delay kernel. We show that diffusion predominantly has a stabilizing effect. If sufficient nutrient is present, however, complex spatio-temporal dynamics, both transient and stable, may occur. This is joint work with Francis Poulin (University of Waterloo) and Yiwen Tao (Zhengzhou University).

DAVID EARN, McMaster University

AO LI, York University
Transient disease dynamics of some SIR models over patchy environments

This paper deals with the short-term or transient dynamics of some SIR infectious disease models over patchy environments. Employing the measurements of reactivity of equilibrium and amplification rates used in ecology to study the responses of an ecological system to perturbations to an equilibrium, we analyze the impact of dispersals/travels between patches, spatial heterogeneity and other disease-related parameters on the short-term dynamics of these spatial disease models. This is in contrast to most existing works on modelling the dynamics of infectious disease which are only interested in long-term disease dynamics in terms of the basic reproduction number.

MICHAEL YI LI, University of Alberta
Transient Oscillations that Are Robust in a Model for Immune Responses to Viral Infections

Oscillations are abundant in immune response dynamics. These oscillations are typically short-lived (transient) and reproducible upon repeated antigenic challenges (robust). Using a simple differential equations model for T cell responses to viral infections, I show how transient oscillations can be created as orbits near a normally hyperbolic periodic orbit. The normal hyperbolicity of the periodic orbit ensures the robustness of the observed transient oscillations.

ANKAI LIU, York's University
Properties of long transient dynamic and its applications

There has been growing interest in non-asymptotic behaviors of solutions that last for a very long time. Here we present a framework for the systematic mathematical treatment of long transient behaviors. We focus on transient centers, points near which long transient dynamics of arbitrary slowness and arbitrary duration arise. We continue the work by deriving further properties of transient centers. We expand upon some existing results on transient centers and its reachability. We demonstrate the application of the results on complicated systems such as Predator-prey models, SIR models and so on.

RONGSONG LIU, University of Wyoming
Multiple dose pharmacokinetic models predict bioavailability of toxins in vertebrate herbivores

A compartmental pharmacokinetic model is built to predict the concentration of toxic phytochemical in the gastrointestinal tract and blood following orally intake by an individual vertebrate herbivore. The existing single and multiple dose pharmacokinetic models are extended to incorporate the physiological factor that toxins can be excreted unchanged in feces due to gastrointestinal motility by impulsive differential equations. An index is defined to be the fraction of the toxin in the blood (i.e., bioavailablity) attributed to the excretion effect. Sensitivity analysis is conducted and it is found that for any toxin, the coefficient of bioavailability which is attributed to the elimination effect of gastrointestinal motility depends mostly on absorption rate of toxin from GIT into the blood, frequency of elimination due to gastrointestinal motility, and the frequency of toxin intake.

STEPHANIE PORTET, University of Manitoba
Impact of noise on the regulation of intracellular transport of intermediate filaments

Noise affects all biological processes from molecules to cells, organisms and populations. Although the effect of noise on these processes is highly variable, evidence is accumulating which shows natural stochastic fluctuations (noise) can facilitate biological functions. Herein, we investigate the effect of noise on the transport of intermediate filaments in cells by comparing the stochastic and deterministic formalizations of the bidirectional transport of intermediate filaments, long elastic polymers transported along microtubules by antagonistic motor proteins. By numerically exploring discrepancies in timescales and attractors between both formalizations, we characterize the impact of stochastic fluctuations on the individual and ensemble transport. We find that noise promotes the collective movement of intermediate filaments by reducing the impact of initial distributions of motor proteins in cells and increases the efficiency of the transport regulation by the biochemical properties of motor-cargo interactions.

HAO WANG, University of Alberta
Multi-scale and qualitative analysis of a stoichiometric algae model

Algal blooms are becoming a global concern due to the increasing prevalence of eutrophication. Here we analyze a stoichiometric model for algal dynamics with rich transient behaviour, and the driving biological mechanisms are studied and understood via a multiple time-scale analysis. We further perform global qualitative analysis. Finally, I will briefly mention our recent effort in predicting imminent algal blooms in lakes using incomplete timely data.

LIN WANG, University of New Brunswick

GAIL WOLKOWICZ, McMaster University
Transient oscillations induced by delayed growth response in the chemostat

In order to try to account for the transient oscillations observed in chemostat experiments, we consider a model of single species growth in a chemostat that involves delayed growth response. The time delay models the lag involved in the nutrient conversion process.

By applying local and global Hopf bifurcation theorems, we prove that the model has unstable periodic solutions that bifurcate from unstable nonnegative equilibria as the parameter measuring the delay passes through certain critical values and that these local periodic solutions can persist, even if the delay parameter moves far from the critical (local) bifurcation values. When there are two positive equilibria, then positive periodic solutions can exist. When there is a unique positive equilibrium, the model does not have positive periodic oscillations and the unique positive equilibrium is globally asymptotically stable. However, the model can have periodic solutions that change sign. Although these solutions are not biologically meaningful, they may still help to account for the transient oscillations that have been frequently observed in chemostat experiments provided the initial data, though positive, starts close enough to the unstable manifold of one of these periodic solutions. Numerical simulations are provided to illustrate that the model has varying degrees of transient oscillatory behavior that can be controlled by the choice of the initial data.

This is joint work with Huaxing Xia and Lin Wang.

PEI YU, Western University

Complex Bifurcations of a Predator-Prey System with Allee Effect

In this talk, we present a study on a predator-prey system with strong Allee effect in the prey growth. The stability analysis of the model is carried out, and a comprehensive bifurcation analysis is presented. By a hierarchical parametric analysis, explicit stability conditions are obtained in terms of the system parameters. In particular, it is proved that this model can exhibit codimension-5 Hopf bifurcation and codimension-4 Bogdanov-Takens bifurcation, showing much more complex dynamical behaviours compared to the system without the Allee effect.

HUAIPING ZHU, York University

Dynamics of the asymptomatic infection in the spread of SARS-CoV-2

The COVID-19 pandemic continues with multiple waves of outbreaks, Omicron changed the game one year ago and still dominates. Among many of the factors including emerging VOCs, vaccine and reinfection, nonpharmaceutical interventions, behavior and adherence of individuals, asymptomatic infection plays a special role responsible for the repeated outbreaks and therefore exit strategy. In this talk, I will present models emphasizing the role of asymptomatic infections. For a more general form of the incidence function for the asymptomatic cases, the complex dynamics are found to be associated with the Bogdanov-Takens bifurcation of codimension 2, I will explain the threshold conditions for the transient and asymptotic dynamics of the transmission. The existence of a nilpotent singularity and unstable Bogdanov-Takens bifurcations partially explains the reason and mechanisms of the repeated multiple-waves epidemics. The models were validated using data from a recent omicron wave in areas where partial test or citywide test-trace-isolate Zero-COVID policy were implemented.