Abstracts
Workshop on Mathematical Biology and Nonlinear Analysis, December 19-21 2014

Afrah Abdou aabdou@kau.edu.sa

Title: Common Fixed Point for Infinite Mappings in Modular Metric Spaces

Afrah A.N. Abdou
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The notion of a modular metric on an arbitrary set and the corresponding modular spaces, generalizing classical modular over linear spaces like Orlicz spaces, were recently introduced. In this paper, we investigate the existence of common fixed points of a family of infinite multivalued mappings in more general setting in modular metric spaces.

Folashade B. Agusto fbagusto@gmail.com

Title: Mathematical Model of an Age-Structured Transmission Dynamics of Chikungunya Virus

F.B. Agusto, Shamise Easley, Kenneth Freeman and Madison Thomas
Austin Peay State University

Abstract
In this paper, we developed an age-structure deterministic model for the transmission dynamics of chikungunya virus. The model is analyzed to gain insights into the qualitative features of its associated equilibria. Some of the theoretical and epidemiological findings indicates that the model has locally asymptotically stable (LAS) disease free equilibrium when the associated reproduction number is less than unity. Furthermore, the model undergoes the phenomenon of backward bifurcation, where the stable disease-free equilibrium of the model coexists with a stable endemic equilibrium when the associated reproduction number is less than unity. Further analyzes of the model indicates that the qualitative dynamics (with respect to the existence and asymptotic stability of the associated equilibria and the backward bifurcation property) of the model is not alter by the inclusion of age-structure to the chikungunya virus transmission model. A global uncertainty and sensitivity to determine the impact of the model parameters is implemented using Latin hypercube sampling and partial rank correlation coefficients methods. Following the results from the sensitivity analysis, three control strategies (mosquito-reduction, personal protection, and a universal strategy) are implemented. Numerical simulations indicates that the personal protection strategy is more

effective than the mosquito-reduction strategy and that the universal strategy is the most effective strategy in reducing chikungunya disease burden.

Eric Avila-Vales avila@uady.mx

Title: Dynamics of an SIR epidemic model with nonlinear incidence rate, vertical transmission vaccination for the newborns and the capacity of treatment

We study the dynamics of an SIR epidemic model with nonlinear incidence rate, vertical transmission vaccination for the newborns and the capacity of treatment. Treatment takes into account the limitedness of the medical resources and the efficiency of the supply of available medical resources. Under some conditions we prove the existence of backward bifurcation, the stability and the direction of Hopf bifurcation. We also explore how the mechanism of backward bifurcation affects the control of the infectious disease. Numerical simulations are presented to illustrate the theoretical findings.

Alfonso Castro castro@g.hmc.edu, alfonso_castro@hmc.edu

Title: Existence of non-degenerate continua of singular radial solutions for several classes of semilinear elliptic problems

We establish the existence of countably many branches of uncountably many solutions to elliptic boundary value problems with subcritical, and sub-super critical growth. We also prove the existence of two branches of uncountably many solutions to a problem with *jumping nonlinearities*. This case is remarkable since, generically, this problem has only finitely many regular solutions.

Jing Chen j.chen@math.miami.edu

Title: Modeling the geographic spread of rabies in China

Abstract: Human rabies is one of the major public health problems in China. In the last 20 years or so, rural communities and areas in Mainland China invaded by rabies are gradually and significantly enlarged. Dogs are the main infection source, which contribute 85%-95% of human cases in China. Some provinces such as Shaanxi and Shanxi, used to be rabies free, have increasing numbers of human infections cases now. Recent phylogeographical analyses of rabies virus clades indicate that the human rabies cases in different and geographically unconnected provinces in China are epidemiologically related. In order to investigate how the movement of dogs changes the geographically inter-provincial spread of rabies in Mainland China, we propose a multi-patch model for the transmission dynamics of rabies between dogs and humans, in which each province is regarded as a patch. In each patch the submodel consists of susceptible, exposed, infectious, and recovered subpopulations of both dogs and humans and describes the spread of rabies among dogs and from infectious

dogs to humans. The existence of the disease-free equilibrium and the basic reproduction number will be discussed and calculated, and how the moving rates of dogs between patches affect the basic reproduction number will be studied. To investigate the rabies virus clades lineages observed in the phylogeographical analyses, the two-patch model will be used to simulate the human rabies data to study the inter-provincial spread of rabies between Guangxi and Guizhou, Fujian and Hebei and Sichuan and Guizhou, respectively. In order to reduce and prevent geographical spread of rabies in China, our results suggest that the management of dog market and trade need to be regulated and transportation of dogs need to be better monitored and under constant surveillance.

Jerome Coville jerome.coville@avignon.inra.fr

Title: Persistence criteria in some nonlocal model in unbounded domain and applications

I will report on a recent study made in collaboration with H.Berestycki and H. Vo concerning persistence criteria in some nonlocal models in R^N. I will first present the persistence criteria that we have obtained and then, I will discuss the behaviour of this criteria with respect to the dispersal operator when it is conditioned by a cost function.

Donald L. DeAngelis ddeangelis@bio.miami.edu

Title: Effects of dispersal on total biomass in a patchy, heterogeneous system: Analysis and experiment

D. L. DeAngelis, U. S. Geological Survey and University of Miami, Bo Zhang, University of Miami, Wei-Ming Ni, University of Minnesota and Center for Partial Differential Equations, East China Normal University,

Abstract
A recent result for a reaction-diffusion partial differential equation is that a population diffusing at an intermediate rate in an environment in which resources vary spatially will reach a higher total equilibrium biomass than the population in an environment in which the same total resources are distributed homogeneously. This has so far been proven only for the case in which the reaction term has only one parameter, m(x), varying with spatial distance x, which serves as both the growth rate coefficient and carrying capacity of the population. This result is too limited to apply to real populations. In order to make the model more relevant for ecologists, we have extended it to a logistic reaction term, with independent parameters, r(x) for intrinsic growth rate, and K(x) for carrying capacity. When r(x) and K(x) are proportional, the logistic equation takes a particularly simple form, and the earlier results still hold. We have proven the results for the more general case of a non-negative correlation between r(x) and K(x). We review natural and laboratory systems to which these

results are relevant and discuss the implications of the results to population theory and conservation ecology. We show some preliminary tests of this in an experimental laboratory system

Keng Deng deng@louisiana.edu

Title: Asymptotic behavior for a reaction-diffusion population model with delay

In this paper, we study a reaction-diffusion population model with time delay. We establish a comparison principle for coupled upper/lower solutions and prove the existence/uniqueness result for the model. We then show the global asymptotic behavior of the model.

Yihong Du ydu@turing.une.edu.au

Title: Long-time behavior of nonlinear free boundary problems

In this talk I'll report some recent results obtained with collaborators on a one dimensional nonlinear free boundary problem of the form u_t-u_{xx}=f(u), where x varies over the changing interval $(g(t), h(t))$, and $x=g(t)$, $x=h(t)$ are free boundaries whose evolution is governed by $g'(t)=-\mu u_x(t, g(t))$, $h'(t)=-\mu u_x(t, h(t))$, $u(t,g(t))=u(t, h(t))=0$. For monotstable, bistable, and combustion types of $f(u)$, we obtain a rather complete description of the long-time behavior of the positive solutions of this problem, which may be viewed as a model for the spreading of a new or invasive species, with population density u and spreading fronts $x=g(t)$ and $x=h(t)$.

Arnaud Ducrot, arnaud.ducrot@u-bordeaux2.fr

Title: Asymptotic behaviour of travelling waves for the delayed Fisher-KPP equation

In this talk we discuss the behaviour of travelling wave solutions for the diffusive logistic equation with time delay. Using a phase plane analysis we prove the existence of travelling wave solution for each wave speed $c \geq 2$. We show that for each given and admissible wave speed, such travelling wave solutions converge to a unique maximal wavetrain. As a consequence the existence of a nontrivial maximal wavetrain is equivalent to the existence of travelling wave solution non-converging to the stationary state $u = 1$.
This is a joint work with Grégoire Nadin, Univ. Paris 6.

William Fagan bfagan@umd.edu

Title: Animal Movement: Memory, Learning, and Autocorrelation

Real landscapes are dynamic in space and time, and the scales over which such variation occurs can determine the success of different conservation strategies for resident species. Within such landscapes, real species rely on a variety of individual-level behaviors for movement and navigation. Movement behaviors such as long-distance searching and fine-scale foraging are often intermixed but operate on vastly different spatial and temporal scales. Individual experience, life-history traits, and resource dynamics combine to shape population-level patterns such as range residency, migration, and nomadism.

I will discuss how a combination of empirical movement data and powerful statistical approaches ("animal models" of pedigree effects; semi-variance functions that leverage autocorrelations present in animal tracking data) can be used to inform our understanding of animal movement on large spatial scales. Animal models can be used to control for genetic variation among individuals while exploring alternative hypotheses about other factors, such as learning and experience, that influence animal movement. Semi-variance approaches can be used to identify multiple movement modes and solve the sampling rate problem for tracking data, allowing for the identification of critical scales for movement and the delineation of animal home ranges. Together these approaches can help reveal the relationships among individual movements, landscape dynamics, and population level patterns.

Louis Fan ariesfanhk@gmail.com

Title: Stochastic spatial models for chemotaxis

This talk highlights the connections between stochastic particle systems and a variety of PDE models for chemotaxis. These PDE models include the classical Keller-Segel model and its variations studied in the past decade. I will also mention the biological motivations of these models and the implications of advances in probability theory on the study of the stochastic particle systems.

Zhilan Feng zfeng@math.purdue.edu

Modeling the synergy between HSV-2 and HIV and potential impact of HSV-2 therapy

Zhilan Feng, Zhipeng Qiu, Zi Sang, Christina Lorenzo and John Glasser

Mathematical models are formulated to study the joint disease dynamics of HIV and HSV-2. The model takes into account the fact that an HSV-2 infection may increase susceptibility to HIV infection and that co-infection of both diseases may

increase infectiousness. Heterogeneous mixing between a male group and two female groups is also included. The models are used to investigate the role of antiviral treatment of people with HSV-2 in mitigating the incidence of HIV in populations where both pathogens occur, and to demonstrate how the disease dynamics can be influenced by the gender structure of the population.

Daozhou Gao Daozhou.Gao@ucsf.edu

Title: Tragedy of the commons in antibiotic use

The emergence and spread of antibiotic resistance has become a major public health threat. Individual incentives lead to the overuse of antibiotics, whereas restrictions to limit use would benefit society as a whole. Under such circumstances, the goals of the individual conflict with the goals of the community, a “tragedy of the commons” may result. The decision to prescribe antibiotics can be analyzed as a mathematical game through the analysis of individual incentives and community outcomes. We developed several mathematical models of the transmission of antibiotic resistance, and found that a tragedy of the commons can occur in both single disease (treatment of mild or early infection) and multiple diseases (treatment of one disease can lead to drug resistance in another organism) settings.

Juan Gutierrez jgutierr@uga.edu

Title: Hemodynamic model of malaria infection with detailed immune response

Half the world population is currently at risk of malaria infection, with 200 million clinical cases and 600,000 deaths in 2012. Even though this disease has attracted substantial research resources in the last century, the detailed characterization of the dynamics of malaria is still an open question. Existing mathematical models of malaria infection are rudimentary, and lack the immune data to expand the level of detail to useful predictive levels. The Malaria Host Pathogen Interaction Center (MaHPIC), a research consortium comprised by UGA, Emory, GT, and CDC is producing information about the disease at unprecedented levels of detail. In this talk I will present recent developments by our MaHPIC group in the mathematical modeling of the blood stage of malaria infection using a coupled system of differential equations comprised of two transport PDEs and a set of ODEs. I will also present the challenges in calibrating this type of model with 'omic technologies (transcriptomics, lipidomics, proteomics, metabolomics, and clinical data). Our preliminary model is able to reproduce the clinical presentation of malaria: severe anemia on first infection, and coexistence of host and parasites in subsequent infections.

Xiaoqing He he@umn.edu

Title: Global dynamics of the two-species Lotka-Volterra competition-diffusion system

In this talk, we investigate the combined effects of diffusion, spatial variation and competition ability on the global dynamics of a classical Lotka-Volterra competition-diffusion system. We establish the main results which determine the global asymptotic stability of semi-trivial as well as co-existence steady states. Hence a complete understanding of the change in dynamics is obtained immediately.

Carol Horvitz carolhorvitz@miami.edu

Title: Transient elasticities and the expected effects of an insect bio-control on the short term dynamics of an invasive pest plant in Hawaii

Carol C. Horvitz University of Miami
Julie S. Denslow, Institute of Pacific Islands Forestry, USDA Forest Service
Orou Gaoue, University of Hawaii at Manoa
Tracy Johnson, Institute of Pacific Islands Forestry, USDA Forest Service

The goal bio-control is to reduce populations of targeted pests. Success has most often been measured by whether or not the control agent achieves a self-sustaining population. However, a better criterion would be whether or not the agent reduces the targeted pest population in the short and long term, measured respectively by transient and asymptotic dynamics. Even in the absence of bio-control agents, pest dynamics vary over space and time. Thus, it is important, as a first step, to obtain and analyze pre-release demographic data on the pest in the context of such variation. Here, to address this step for an invasive pest plant, we model pre-release dynamics based on detailed spatially replicated, demographic data collected over multiple pre-release years. We utilize an integral projection model of population dynamics, combining one continuous domain for larger individuals (where the state variable is *stem diameter at breast height*) with six discrete stages for small, seedling-sized individuals. We perform proportional sensitivity analyses to determine expected effects of an insect bio-control agent (*Tectococcus ovatus*) on the transient dynamics of *Psidium cattleianum* (Strawberry guava) at each of 4 sites in Hawaii. We found that pre-release asymptotic annual per-capita rates of population growth (λ) vary across the sites from 0.99 to 1.20. We explore, through site-specific transient elasticity analyses, how the expected impact of consumers would be dynamic in the short term and how they would differ among sites. The changing stage distribution of a population during the transient phase coupled with the analytical transient elasticities drive these changes and differences.

Jon Jacobsen jacobsen@math.hmc.edu

Title: Integrodifference Models for Persistence in Temporally Varying River Environments

We consider integrodifference population models for growth and dispersal in the presence of advective flow and study population persistence in the context of both periodic and random kernel parameters. For the random setting we consider two persistence metrics and show they are mathematically equivalent. This is joint work with Yu Jin and Mark Lewis.

Yun Kang Yun.Kang@asu.edu

Title: A two-patch prey-predator model with dispersal in predators driven by the strength of prey-predator interactions

Foraging movements of predator play an important role in population dynamics of prey-predator interactions, which also can be considered as mechanisms that contributes to spatial self-organization. In nature, there are many examples of prey-predator interactions where prey is immobile while predator disperses between patches non-randomly through different factors such as stimuli following the encounter of a prey. In this work, we formulate a Rosenzweig-MacArthur prey-predator two patch model with mobility only in predator and the assumption that predators move towards patches with more concentrated prey-predator interactions. We provide local and global analysis of our model. Our analytical results combined with bifurcation diagrams suggest that: (1) dispersal may stabilize or destabilize the coupled system; (2) dispersal may general multiple interior equilibria that lead to rich bistable dynamics or may destroy interior equilibria that lead to the extinction of predator in one patch or both patches; (3) Under certain conditions, the large dispersal can promote the permanence of the system. In addition, we compare the dynamics of our model to the classic two patch model to obtain a better understanding how different dispersal strategies may have different impacts on the dynamics and spatial patterns.

Michael R. (Mike)" Kelly kelly.1156@osu.edu

Title: Optimal fish harvesting for a population modeled by a nonlinear, parabolic partial differential equation

As the human population continues to grow, there is a need for better management of our natural resources in order for our planet to be able to produce enough to sustain us. One important resource we must consider is marine fish populations. The tool of optimal control is used to investigate harvesting strategies for maximizing yield of a fish population in a heterogeneous, finite domain. We determine whether these solutions include no-

take marine reserves as part of the optimal solution. The fishery stock is modeled using a nonlinear, parabolic partial differential equation with logistic growth, movement by diffusion and advection, and with Robin boundary conditions. The objective for the problem is to find the harvest rate that maximizes the discounted yield. Optimal harvesting strategies are found numerically.

Yang Kuang kuang@asu.edu

Title: A data-validated density-dependent diffusion model of glioblastoma growth

Glioblastoma multiforme is an aggressive brain cancer that is extremely fatal. It is characterized by both proliferation and large amounts of migration, which contributes to the difficulty of treatment. Previous models of this type of cancer growth often include two separate equations to model proliferation or migration. We propose a single equation which uses density dependent diffusion to capture the behavior of both proliferation and migration. We analyze the model to determine the existence of traveling wave solutions. To support the viability of the density-dependent diffusion function chosen, we compare our model with well-known in vitro experimental data.

This is a joint work with Tracy Stepien and Erica Rutter

King Yeung (Adrian) Lam lam.184@osu.edu

Title: Resident-invader dynamics in infinite-dimensional dynamical systems

We study the resident-invader dynamics for a class of models of spatial population with a one-dimensional trait, or strategy. We prove various global dynamical results on coexistence and exclusion, based on local invasibility criterions including the notions of evolutionary stability and convergence stability in adaptive dynamics. Applications of our abstract results include reaction-diffusion-advection models and nonlocal dispersal models. This leads to the novel conclusion that a recently established evolutionarily stable dispersal strategy in [Lam-Lou, J. Math. Biol. (2013)] is a neighborhood invader strategy. This is joint work with R.S. Cantrell (Miami) and C. Cosner (Miami).

Dung Le dle@math.utsa.edu

Title: Global existence of classical solutions to cross diffusion systems of more than 2 equations given on a planar domain

The global existence of classical solutions to cross diffusion systems of more than 2 equations given on a planar domain is established. The results can apply to generalized Shigesada-Kawasaki-Teramoto (SKT) and food pyramid models whose diffusion and reaction can have polynomial growth of any order. If time

permits I will also talk about the existence of their attractors and how the results can be extended to arbitrary dimension domains.

Suzanne Lenhart lenhart@math.utk.edu

Title: Modeling of Johne's disease in dairy cattle

Johne's disease in dairy cattle is a chronic infectious disease in the intestines caused by the bacilli, Mycobacterium avium ssp. paratuberculosis. We have modeled this disease with several approaches to illustrate different features. A system of difference equations represented an epidemiological situation in dairy farm to compare the effects of two types of diagnostic tests. Then an agent based model at the farm level was developed to see the effects of stochasticity. Lastly, a PDE/ODE model illustrated a novel way to link a within-host model with an epidemiological model

Simon Levin slevin@princeton.edu

Title: Critical transitions in space and time

A fundamental characteristic of complex systems, and especially of complex adaptive systems, is the potential for sudden shifts from one basin of attraction to another in relation to temporal, spatial and other gradients. Many, but not all, such transitions are anticipated by more modest, reversible changes that warn of impending irreversible shifts. This lecture will discuss some examples from ecological systems, with possible extensions to social dynamics and a range of other applications.

Xing Liang xliang@ustc.edu.cn

Title: Spreading speed of integro-difference models in periodic habitat

The main aim of this work is to understand what kind of diffusion mechanism can guarantee the existence of the spreading speed for an evolution system in the periodic media. The following three parts are included in this work: First, the uniform irreducibility of Radon measures on the circle is defined, and it is proved that the generalized convolution operator generated by a uniformly irreducible and nonnegative measure has the principal eigenvalue. Next, an abstract framework of the spreading speeds for general spatially periodic noncompact systems is established, the variational formula of the spreading speeds is given under the hypothesis that the principal eigenvalues of the linearized systems exist. Finally, based on the above two preparations, it is shown that the uniform

irreducibility of the diffusion can guarantee the existence of the spreading speed in the periodic media through investigating the integro-difference system.

Rongsong Liu rongsong.liu@uwyo.edu

Title: An advection and age-structured approach to modeling bird migration and indirect transmission of avian influenza

We model indirect transmission, via contact with viruses, of avian influenza in migratory and non-migratory birds, taking into account age-structure. Migration is modeled via a reaction-advection equation on a closed loop parameterized by arc length (the migration flyway) that starts and ends at the location where birds breed in summer. Our modeling keeps the birds together as a flock, the position of which is implicitly determined and known for all future time. Births occur when the flock passes the breeding location and are modeled using ideas from impulsive differential equations. For a migratory species the model derivation starts from age structured reaction-advection equations with location-dependent parameters that describe local conditions. In the derivation of delay equations for the time-dependent variables representing numbers of juvenile and adult birds, these location-dependent parameters are evaluated at the flock's position, so that seasonal effects are captured indirectly but through rigorous modeling whereby we keep track of the flock's exact position and local conditions there. Sufficient conditions are obtained for the local stability of the disease-free equilibrium (for a non-migratory species) and for the disease-free periodic solution (for a migratory species).

Julián López Gómez julian@mat.ucm.es A
Title: The theorem of characterization of the maximum principle for periodic-parabolic systems of cooperative type and the existence of principal eigenvalues for a class of associated weighted boundary value problems.

We are generalizing a classical result by I. Antón and the author published in 1996 in the Proceedings of the First World Congress of Nonlinear Analysts, Tampa, Florida. August 19-26, 1992, when Hurricane Andrew heated Florida. This result generalized the theorem of characterization of the maximum principle by M. Molina-Meyer and the author in DIE 1994, later generalized by the author and H. Amann in JDE 1998, who was the leitmotiv of the book of the author on Second Order Linear Elliptic Operators, WSP, Singapore 2013. The main result is used to derive a number of improvements of some very classical, extremely elegant, results pioneered by R. S. Cantrell together with K. Schmitt in SIAM JMA 1986.

Oleg Makarenkov makarenkov@utdallas.edu

Title: Topological degree in the generalized Gause prey-predator model

We consider a generalized Gause prey-predator model with T-periodic continuous coefficients. In the case where the Poincare map P over time T is well defined, the result of the paper can be explained as follows: we locate a subset U of R^2 such that the topological degree d(I-P,U) equals +1. The novelty of the paper is that the later is done under only continuity and (some) monotonicity assumptions for the coefficients of the model. The approach uses a perturbation technique to locate a trapping region for the perturbed system and discovers suitable a-priori estimates that make it possible to catch the periodic solutions when the perturbation gradually disappears. We then introduce an integral operator that corresponds to the periodic problem for the system under consideration and use a version of Krasnoselski's irreversibility theorem to compute the topological degree of this operator. The formula for the topological degree can be used by future researchers to investigate periodic solutions of Gause prey-predator models with delays and other functionals. The full paper is available at http://dx.doi.org/10.1016/j.jmaa.2013.08.052.
The work is partially supported by RFBR Grant 13-01-00347

Raul Manasevich manasevi@dim.uchile.cl

Title: Solutions with a prescribed number of zeros for a nonlinear elliptic equation with weights on R^d

We consider the existence of radial sign-changing solutions, with prescribed number of zeros for the problem
div (a∇u)+ bf (u) = 0 ,
lim u(x) = 0
|x|→+∞
where a and b are two positive, radial, smooth functions defined on $R^d \setminus \{0\}$, with $f \in C(R)$, and satisfying some additional conditions. We give a proof that also holds for solutions with compact support unifying in this form previous results. The results can be extended to the p-laplace operator with weights. This talk is based on a work in cooperation with Carmen Cortazar, Jean Dolbeault and Marta Garcia Huidobro.

Salomé Martíınez, samartin@dim.uchile.cl

Title: Integrable steady states for a nonlocal equation.

We consider the following nonlocal equation

$\int J\left(\frac{x-y}{g(y)}\right)\frac{u(y)}{g(y)}dy - u(x) = 0$ for $x \in R$, where J is an even, compactly supported, Hölder continuous kernel with unit integral and g is a continuous positive function. Our main concern will be with unbounded functions g. More precisely, we study the influence of the growth of g at infinity on the integrability of positive solutions of this equation, therefore determining the asymptotic behavior as $t \to \infty$ of the solutions to the associated evolution problem in terms of the growth of g.

Dan Munther danielsmunther@gmail.com

Title: Invading the ideal free distribution

Recently, the ideal free dispersal strategy has been proven to be evolutionarily stable in the spatially discrete as well as continuous setting. That is, at equilibrium a species adopting the strategy is immune against invasion by any species carrying a different dispersal strategy, other conditions being held equal. In this talk, I will consider a two-species competition model where one of the species adopts an ideal free dispersal strategy, but is penalized by a weak Allee effect. In this case, the ideal free disperser is invasible by a range of non-ideal free strategies, illustrating the trade-off between the advantage of being an ideal free disperser and the setback caused by the weak Allee effect. Moreover, an integral criterion is given to determine the stability/instability of one of the semi-trivial steady states, which is always linearly neutrally stable.

Mayra Núñez López maynunlop@gmail.com

Title: Superinfection between influenza and RSV alternating patterns in San Luis Potosí State, México

The objective of this work is to explain through the ecological hypothesis superinfection and competitive interaction between two viral populations and niche(host) availability, the alternating patterns of Respiratory Syncytial Virus (RSV) and influenza observed in a regional hospital in San Luis Potosí State, México using a mathematical model as a methodological tool. The data analyzed consists of community-based and hospital-based Acute Respiratory Infections (ARI) consultations provided by health-care institutions reported to the State Health Service Epidemiology Department

Samares Pal samaresp@gmail.com , samaresp@yahoo.co.in

Title: Regime shifts in coral reefs under macroalgal toxicity and overfishing

Samares Pal and Joydeb Bhattacharyya, University of Kalyani

Macroalgae and corals compete for the available space in coral reef ecosystem. While herbivorous reef-fish play a beneficial role in decreasing the growth of macroalgae in coral reef ecosystem. Abundance of macroalgae changes the community structure towards macroalgae dominated reef ecosystem. We investigate coral-macroalgal phase shifts by means of a continuous time model in a food chain. It is observed that in presence of macroalgal toxicity and overfishing the system exhibits hysteresis through saddle-node bifurcation and transcritical bifurcation. We also examine the effects of time lags in the liberation of toxin by macroalgae and recovery of algal turf in response to grazing of herbivores on macroalgae.

Paul Rabinowitz rabinowi@math.wisc.edu

Title: Solution patterns for a phase transition model

Abstract: We will survey some recent joint work with J. Byeon on the existence and multiplicity of solutions for a family of Allen-Cahn model equations. In particular we focus on the rich structure of the patterns they form.

Tim Reluga treluga@math.psu.edu

Title: Being Discrete with Invasions

Invasions are one of the most easily identified spatial phenomena in ecology, and have inspired a rich variety of theories for naturalists' consideration. However, a number of arguments over the sensitivities of invasion rates to stochasticity, density-dependence, localization, and discreteness persist in the literature. This controversy inherits in part from tensions between Fisher's 87-year-old vision of invasions as smooth travelling waves and more recent approaches by Ellner and others that invasions are more like random walks where the discreteness of living organisms is fundamentally important. In this talk, I'll present an invasion model with discrete (atomic) individuals where reproduction and dispersal are independent to synthesize existing results. The results show that stochasticity both increases and decreases the speed of invasions. In particular, (1) dispersal stochasticity quickens invasions; (2) demographic stochasticity slows invasions, and (3) negative density-dependence slows invasions. The results are established using second-order stochastic dominance, a generalized Weierstrass Product Inequality, and a classic theorem on the evolution of clutch sizes.

Karen R Rios-Soto Karen_rs@math.uprm.edu

Title: The estimation of epidemiological parameters for seasonal dynamics of Dengue Fever in Puerto Rico under incidence data

Dengue fever is an infectious disease caused by one of four serotypes identified by DEN-1, DEN-2, DEN-3, and DEN-4. The disease is transmitted to humans through the bites of infected Aedes egypti (main vector of the disease) female mosquitoes. In Puerto Rico, dengue is considered endemic with some years classified as epidemics. It is therefore important to study the dynamics of dengue fever on the island. In our work, we construct a mathematical epidemiological model with seasonality of nonlinear ordinary differential equations to estimate epidemiological parameters from a time dependent transmission function. We use inverse problems theory with monthly incidence data of confirmed by laboratory dengue cases for the period of time between April 2011 and April 2013, where the 2012-2013 was a period classified as an epidemic. Among the estimated parameters are the average effective vector-human contact rate (β_0) and the amplitude of seasonality (η) of that rate on the island. For the estimation we implemented the method of least squares and a statistical model to measure the errors in the estimated values through residual plots. The available data was found to be a random sample from a population with constant variance where the estimates of the parameters of interest were β_0 = 0.79397 per month and η=0.54799, with 95% confidence intervals given by (0.78575, 0.80218) and (0.50476,0.59121) respectively.

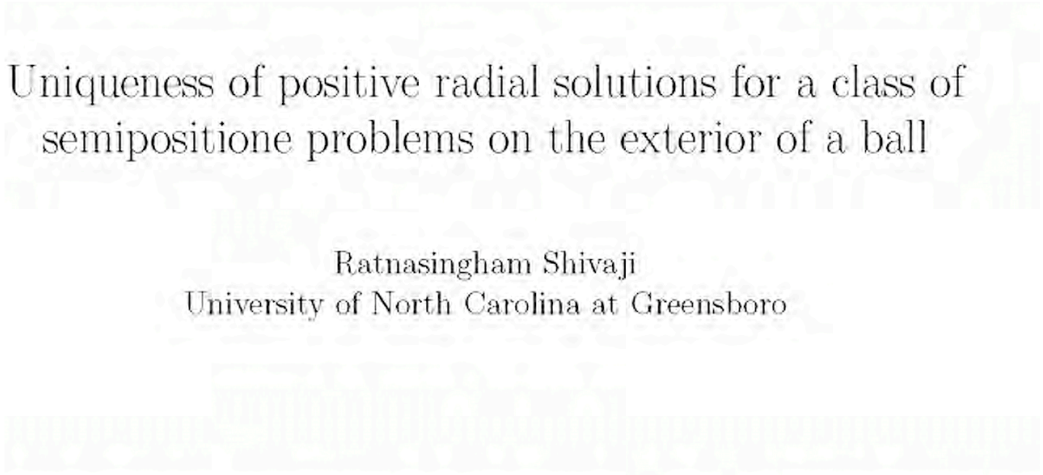
Junping Shi jxshix@wm.edu

Title: Dynamics of logistic population model with mixed instantaneous and delayed density dependence and dispersal

First a logistic population model with mixed instantaneous and multiple delayed density dependence is considered. When the delayed dependence is more dominant, the local asymptotic stability and stability switches of the positive equilibrium is derived by choosing the delay as the bifurcation parameter and analyzing the characteristic equation. Compared with the logistic model with the instantaneous term and a single delayed term, our finding here is that the incorporation of another delayed term can lead to the occurrence of multiple stability switches. Second we consider the diffusive logistic model with local or nonlocal delay effect, and related stability and Hopf bifurcation problems are discussed. The talk is based on joint work with Xiangping Yan, Shanshan Chen, Ying Su and Junjie Wei

Ratnasingham Shivaji r_shivaj@uncg.edu

Title: Uniqueness of positive radial solutions for a class of semipositione problems on the exterior of a ball


Uniqueness of positive radial solutions for a class of semipositione problems on the exterior of a ball

Ratnasingham Shivaji
University of North Carolina at Greensboro

Abstract: We study positive radial solutions to: $-\Delta u = \lambda K(|x|)f(u);\ x \in \Omega_e$, where $\lambda > 0$ is a parameter, $\Omega_e = \{x \in \mathbb{R}^N : |x| > r_0,\ r_0 > 0, N > 2\}$, Δ is the Laplacian operator, $K \in C((r_0, \infty), (0, \infty))$ satisfies $K(r) \leq \frac{1}{r^{N+\mu}}; \mu > 0$ for $r \gg 1$ and $f \in C^2([0, \infty), \mathbb{R})$ is a concave increasing function satisfying $\lim_{s\to\infty} \frac{f(s)}{s} = 0$ and $f(0) < 0$ (semipositone). We are interested in solutions u such that $u \to 0$ as $|x| \to \infty$ and satisfy the nonlinear boundary condition $\frac{\partial u}{\partial \eta} + \tilde{c}(u)u = 0$ if $|x| = r_0$ where $\frac{\partial}{\partial \eta}$ is the outward normal derivative and $\tilde{c} \in C([0, \infty), (0, \infty))$ is an increasing function. We will establish the uniqueness of positive radial solutions for large values of the parameter λ.

Hal Smith halsmith@asu.edu

Title: How nested infection networks in bacteria-virus communities come to be

This talk is essentially motivated by a series of recent papers from J. Weitz's group on phage-bacteria infection networks in natural ecosystems.
Their work showed that phage-bacteria infection networks in natural ecosystems, describing which phage infect which bacteria, often have a nested structure in which phage strains can be ordered according to the extent to which they are specialists or generalists at infecting bacterial strains and where bacterial strains infected by a more specialist phage are also infected by a more generalist phage.
In a recent paper, Weitz et al raised the question of whether a Lotka-Volterra-like model of a phage-bacteria community with nested infection network is permanent provided that bacterial strains that grow faster devote the least effort to defense

against infection and virus strains that are the most efficient at infecting host have the smallest host range.

Motivated by these works, grad student Dan Korytowski and I show that a mathematical model of a phage-bacteria community in which the bacterial strains compete for a single limiting nutrient in a chemostat setting and for which the infection network is perfectly nested is permanent, a.k.a. uniformly persistent, provided that bacteria strains that are superior competitors for nutrient devote the least effort to defence against infection and virus strains that are the most efficient at infecting host have the smallest host range. In addition, we answer the question in the title by showing that a permanent bacteria-phage community with an arbitrary number of bacteria and phage types for which the infection network is nested can arise through a succession of permanent sub-communities, each with a nested infection network, by the successive addition of one new population.

Necibe Tuncer ntuncer@fau.edu

Title: Identifiability Issues in an Immunological Model

I will present a mathematical model which links immunological and epidemiological models. This model allows us to understand dynamical interplay of infectious diseases at two different scales; immunological response of the host at individual scale and the disease dynamics at population scale. Once the host is infected, it triggers the immune response which produces anitgen-specific antibodies to clear the pathogen. The pathogen and antibody levels are often monitored in laboratory experiments. But how can we use the data generated in the laboratory experiments to estimate the parameters of the immunological model. Clearly, the parameters of the within-host immunological model have an effect of the epidemiological characteristics of disease such as reproduction number and prevalence. In this talk, I will present the identifiability issues in parameter estimation of the immunological model.

Rebecca C. Tyson rebecca.tyson@ubc.ca

Title: How seasonally varying predation behaviour and climate shifts affect predator-prey cycles

Rebecca C. Tyson and Frithjof Lutscher

While mathematical models have established that predator-prey interactions can drive population cycles, the assumption has always been that the functional response of the predator is an inherent property of that particular predator-prey interaction, and therefore does not vary substantially. There is evidence however, that some predators respond to strong seasonal environmental variation with a behavioral shift from generalist hunting, when many prey species

are available, to specialist hunting, when few species are present. This shift in prey availability is particularly pronounced at northern latitudes, where seasonal forcing is both very strong and experiencing dramatic shifts through climate change. We are then led to explore two questions: (1) How does a seasonal change in predation behaviour affect the dynamics of the prey and predator populations? and (2) How will these dynamics be affected by climate change? Motivated by experimental data on great horned owl *Bubo virginialis* behaviour from the boreal forest, we use a novel, periodic predator-prey model to address these questions.

Olga Vasilyeva olga.vasilyeva@cnu.edu

Title: Competition of multiple species in advective habitats

Aquatic organisms in advective habitats such as rivers, streams and coastlines are transported downstream by the water flow. We study the effect of changes in the flow speed on community composition in such environments. Our models describe competition of several species using reaction-diffusion-advection equations subject to Dankwerts boundary conditions. We use the dominant eigenvalue of the diffusion-advection operator to reduce the original models to systems of ordinary differential equations. We show that changes in flow speed can facilitate different types of coexistence among multiple species. More detailed treatment is provided in the cases of two and three competitors.

Jianhong Wu wujh@mathstat.yorku.ca

Title: Complex pathogen spread patterns induced by host range expansion

We consider a standard diffusive SIS model but conclude that the infection waves may have different wave speeds from the invasion speed of the entire (susceptible) population, and may exhibit different profiles from the normal wavefronts. This work also provides some answers to some open problems related to generalized eigenvalues of elliptic operators in unbounded domains.

Yanyu Xiao yanyuxiao@gmail.com

Title: How human activities impact the transmission of vector-borne diseases ?

Mosquito-borne diseases/zoonoses bring significant amount of deaths among human and other hosts, such as livestock and birds, and cause huge economic costs and losses. Human activities enormously contribute the outbreak and spread pattern of vector-borne diseases/zoonoses. I will present mathematical models to explore that how socioeconomic factors in conjunction with other well-known factors, i.e., disease latency and seasonality, will impact disease dynamics.

Xiaoxia "Jessica" Xie xzx0005@auburn.edu xxie12@iit.edu

Title: Two types of nonlocal diffusions and the convergence to the random/normal diffusion

This talk is concerned with the study of different types of diffusions: the random/normal diffusion and two types of nonlocal diffusions. The random/normal diffusion is the classical Laplace operator, while one type of nonlocal diffusions is an integral operator with a smooth kernel, and the other one is called the anomalous diffusion generated by the fractional Laplace operator. Regarding the nonlocal dispersal operator with a smooth kernel, we first study its principal spectral theory and asymptotic dynamics. Secondly, we consider its convergence to the random dispersal operator from three points of view. About the anomalous diffusion, we are interested in the Fokker-Plank equation, when the noise in the system is an α-stable Lévy motion. We investigate the existence, uniqueness, and regularity of solutions to the corresponding Fokker-Plank equation in two prototypical stochastic systems.

Rongsong Liu rongsong.liu@uwyo.edu

Title: An advection and age-structured approach to modeling bird migration and indirect transmission of avian influenza

We model indirect transmission, via contact with viruses, of avian influenza in migratory and non-migratory birds, taking into account age-structure. Migration is modeled via a reaction-advection equation on a closed loop parameterized by arc length (the migration flyway) that starts and ends at the location where birds breed in summer. Our modeling keeps the birds together as a flock, the position of which is implicitly determined and known for all future time. Births occur when the flock passes the breeding location and are modeled using ideas from impulsive differential equations. For a migratory species the model derivation starts from age structured reaction-advection equations with location-dependent parameters that describe local conditions. In the derivation of delay equations for the time-dependent variables representing numbers of juvenile and adult birds, these location-dependent parameters are evaluated at the flock's position, so that seasonal effects are captured indirectly but through rigorous modeling whereby we keep track of the flock's exact position and local conditions there. Sufficient conditions are obtained for the local stability of the disease-free equilibrium (for a non-migratory species) and for the disease-free periodic solution (for a migratory species). Two Types of Nonlocal Diffusions and the Convergence to the Random/Normal Diffusion

Abstract. This talk is concerned with the study of different types of diffusions: the random/normal diffusion and two types of nonlocal diffusions. The random/normal diffusion is the classical Laplace operator, while one type of nonlocal diffusions is an integral operator with a smooth kernel, and the other one is called the anomalous diffusion generated by the fractional Laplace operator. Regarding the nonlocal dispersal operator with a smooth kernel, we first study its principal spectral theory and asymptotic dynamics. Secondly, we consider its convergence to the random dispersal operator from three points of view. About the anomalous diffusion, we are interested in the Fokker-Plank equation, when the noise in the system is an α-stable Lévy motion. We investigate the existence, uniqueness, and regularity of solutions to the corresponding Fokker-Plank equation in two prototypical stochastic systems.

Fei Xu fxu.feixu@gmail.com A

Title: Spatial spread of an epidemic through public transportation systems with a hub

Fei Xu, C. Connell McCluskey, Ross Cressman

This article investigates an epidemic spreading among several locations through a transportation system, with a hub connecting these locations. Public transportation is not only a bridge through which infections travel from one location to another but also a place where infections occur since individuals are typically in close proximity to each other due to the limited space in these systems. A mathematical model is constructed to study the spread of an infectious disease through such systems. A variant of the next generation method is proposed and used to provide upper and lower bounds of the basic reproduction number for the model. Our investigation indicates that increasing transportation efficiency, and improving sanitation and ventilation of the public transportation system decrease the chance of an outbreak occurring. Moreover, discouraging unnecessary travel during an epidemic also decreases the chance of an outbreak. However, reducing travel by infectives while allowing susceptibles to travel may not be enough to avoid an outbreak.

Abdul-Aziz Yakubu ayakubu@howard.edu

Title: Infectious Fatal Disease and Demographic Allee Effect

In this talk, we will focus on biodiversity, a major problem for ecosystem resiliency. We will use extensions of the SI epidemic model of Hilker et al. to study how population persistence or extinction of a vulnerable species relates to habitat dependent Allee thresholds, fatal disease dynamics and migration rates in both discrete and continuum set of compartments. We will analyze the migration-linked models and establish verifiable conditions that guarantee host population persistence or extinction (This is joint work with Avner Friedman.)

Yuan Yuan yyuan@mun.ca

Title: Threshold dynamics in an SEIRS model with latency and temporary immunity

A disease transmission model of SEIRS type with distributed delays in latent and temporary immune periods is discussed. With general/particular probability distributions in both of these periods, we address the threshold property of the basic reproduction number R_0 and the dynamical properties of the disease-free/endemic equilibrium points present in the model. More specifically, we a). show the dependence of R_0 on the probability distribution in the latent period and the independence of R_0 from the distribution of the temporary immunity, b). prove that the disease free equilibrium is always globally asymptotically stable when $R_0<1$, and c).according to the choice of probability functions in the latent and temporary immune periods, establish that the disease always persists when $R_0>1$ and an endemic equilibrium exists with different stability properties. In particular,the endemic steady state is at least locally asymptotically stable if the probability distribution in the temporary immunity is a decreasing exponential function when the duration of the latency stage is fixed or exponentially decreasing.It may become oscillatory under certain conditions when there exists a constant delay in the temporary immunity period. Numerical simulations are given to verify the theoretical predictions.

Xiaoqiang Zhao zhao@mun.ca

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

Abstract: 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. We also extend this work to the time and space periodic case.

Huaiping Zhu huaiping@mathstat.yorku.ca

Title: Bifurcation of limit cycles in predator-prey models, canard cycles and Hilbert`s 16th problem

In this lecture, I will start with predator-prey system to present the limit cycles and

their bifurcations, including canard cycles and their cyclicity as well as fast-slow dynamics. I will then use the predator-prey system to introduce the two types of degenerate singularities and graphics in the predator-prey systems, and explain the mechanisms of fast-slow dynamics in mathematical biology. I will connect the finiteness part of Hilbert`s 16th problem, to explain the difficulties and progress in dealing with the finite cyclicity of degenerate graphics, the last challenge towards the proof of the finiteness part of Hilbert`s 16th problem for quadratic vector fields.

Lan Zou lanzou@163.com

Title: Modelling the transmission dynamics and control of Hepatitis B vrus in China

Hepatitis B is a potentially life-threatening liver infection caused by the hepatitis B virus (HBV) and is a major global health problem. HBV is the most common serious viral infection and a leading cause of death in mainland China. The comparisons between the incidence data of HBV and sexually transmitted diseases (including AIDS, HIV, syphilis, gonorrhea) demonstrate that sexual transmission is an important route of spread of HBV in China. We propose a compartmental model to study the effect of sexual transmission of the spread and prevalence of HBV in China. Our study shows that effective hepatitis B control measures in China include enhancing public education and awareness about hepatitis B virus, in particular about the fact that hepatitis B is a sexual transmitted disease, and increasing the immunization rate of both under-aged children and adults, especially certain high risk groups.

Xingfu Zou xf2zou@gmail.com

Title: On a R-D system for the sterile insect release method in a bounded domain

In this paper, I will present some recent results on a reaction diffusion system in a bounded domain which describes the interaction of fertile and stile insects. Two releasing strategies for the sterile species will be discussed, one is domain-wise release and the other is release on boundary only. By analyzing the models, we obtain some conditions that ensure the success of the sterile insect release method in eradicating the insects.