ABSTRACTS

Plenary Speakers

Trachette Jackson - *Turning cancer discoveries into effective treatments with the aid of mathematical modeling*

Tumor growth and progression is critically dependent on the establishment of a vascular support system. This is often accomplished via the expression of pro-angiogenic growth factors, including members of the vascular endothelial growth factor (VEGF) family of ligands. VEGF ligands are overexpressed in a wide variety of solid tumors, and therefore have inspired optimism that inhibition of the different axes of the VEGF pathway, alone or in combination, would represent powerful anti-angiogenic therapies for most cancer types. When considering treatments that target VEGF and its receptors it difficult to tease out the differential anti-angiogenic and anti-tumor effects of all combinations experimentally because tumor cells and vascular endothelial cells are engaged in a dynamic crosstalk that impacts key aspects of tumorigenesis, independently of angiogenesis. Here we develop a mathematical model that connects intracellular signaling responsible for both endothelial and tumor cell proliferation and death to population level cancer growth and angiogenesis. We use this model investigate the effect of bidirectional communication between endothelial cells and tumor cells on treatments targeting VEGF and its receptors in vitro and in vivo. Our results underscore the fact that in vitro therapeutic outcomes do not always translate to the in vivo situation. For example, our model predicts that certain therapeutic combinations result in antagonism in vivo that is not observed in vitro. Mathematical modeling in this direction can shed light on the mechanisms behind experimental observations that manipulating VEGF and its receptors is successful in some cases but disappointing in others. Though we have concentrated on the downstream effects of VEGF, more generally, this modeling approach could provide a useful framework for enhancing the understanding of the dynamics of a variety of mediators of tumor growth and progression with the ultimate goal of predicting the effectiveness of novel treatment strategies, and optimizing targeted molecular therapeutics.

Susan Tolman – *Symplectic circle actions*

Let the circle act on a closed manifold $\boldsymbol{M}$, preserving a symplectic form ω. We say that the action is Hamiltonian if there exists a moment map, that is, a map Ψ: $M \rightarrow R$ such that $\iota_\xi\omega = -d\Psi$, where ξ is the vector field that generates the action. In this case, a great deal of information about the manifold is determined by the fixed set. Therefore, it is very important to determine when symplectic actions are Hamiltonian. There has been a great deal of research on this question, but it left the following question, usually called the “McDuff conjecture”: Does there exists a non-Hamiltonian symplectic circle action with isolated fixed points on a closed, connected symplectic manifold? I will answer this question by constructing such an example.

Satellite Colloquium (Friday)

Emmy Murphy - *Planar graphs and Legendrian surfaces*

Associated to any planar cubic graph, there is a closed surface in R_5, as defined by Treumann and Zaslow. R_5 has a canonical geometry, called a contact structure, and this surface is Legendrian with respect to this contact structure. Up to smooth isotopy these surfaces have no interesting information, but the Legendrian isotopy type recovers the chromatic data of the graph, by studying sheaves with singular support on the Legendrian. This Legendrian also defines a differential graded algebra, called the contact homology, which is a pseudo-holomorphic symplectic field theory. By following the conjectural equivalence of constructable sheaves and augmentations of contact homology, we obtain a new definition of an n-coloring of a planar graph, which is interesting in part because the definition is much more nonlinear compared to other known definitions. We discuss how to compute the contact homology combinatorially from the graph, and also the combinatorics of other TQFT structures corresponding to cobordisms, fillings, and connect sums, and relationships with loose Legendrians. This is joint work with Roger Casals and Kevin Sackel.

Invited Speakers

Adriana Dawes - *Antagonistic motor protein dynamics in contractile cellular structures*

Contractile structures play important roles in biological processes including wound healing and cell division. Many contractile structures rely on motor proteins called myosins for constriction. Using ring channels as our model system, contractile ring structures in the nematode worm *C. elegans* that do not completely close, we investigate force generation by the Type II myosins NMY-1 and NMY-2. By exploiting the ring channel's circular geometry, we derive a second order ODE to describe the radius of the ring channel. By comparing our model predictions to experimental depletion of NMY-1 and NMY-2, we show that these myosins act antagonistically to each other, with NMY-1 exerting force orthogonally and NMY-2 exerting force tangentially to the ring channel opening.

Marisa Eisenberg - *Identifiability and Parameter Estimation in Modeling Disease Dynamics*

Connecting dynamic models with data to yield predictive results often requires a variety of parameter estimation, identifiability, and uncertainty quantification techniques. These approaches can help to determine what is possible to estimate from a given model and data set, and help guide new data collection. Here, we examine how parameter estimation and disease forecasting are affected when examining disease transmission via multiple types or pathways of transmission. Using examples taken from cholera outbreaks, the West Africa Ebola epidemic, and HPV, we illustrate some of the potential difficulties in estimating the relative contributions of different transmission pathways, and show how alternative data collection may help resolve this unidentifiability. We also illustrate how even in the presence of large uncertainties in the data and model parameters, it may still be possible to successfully forecast disease dynamics.

Tanya Firsova - *Hedgehogs in holomorphic dynamics*

One of the fundamental questions in holomorphic dynamics is to understand the dynamics in a neighborhood of a fixed point. The local dynamics becomes interesting and highly mysterious if a germ is not linearizable. For one-dimensional maps, Perez-Marco constructed totally invariant non-trivial sets in a neighborhood of a non-linearizable fixed point (Cremer point) that he called 'hedgehogs'. We will outline his approach. And discuss the topological construction of 'hedgehogs' for two-dimensional semi-Cremer germs. This is a joint work with M. Lyubich, R. Roeder, R. Tanase.

Alexandra Jilkine - *Characterizing noise in a mathematical model of the adipogenic transcriptional network*

Adipogenesis is the process by which precursor cells develop into mature adipocytes, or fat-storing cells. From a 2012 study by Park et al., we expanded a deterministic model of the transcriptional network of adipogenesis to include a module for adiponectin (AdipoQ) production, an insulin-sensitizing hormone secreted by adipocytes. We analyzed two possible implementations for the adiponectin module to determine if variability within the system parameters alone is sufficient to explain the adipocyte heterogeneity observed in a study by Loo et al. For each model, we first characterized overall susceptibility to noise by calculating the relative local sensitivity of AdipoQ and fat to various parameters. We then simulated the experiment done by Loo et al. with 30% added noise to determine if our system could replicate their data. Our results show that only the model where fat increases the degradation of adiponectin fits the trends observed in the Loo study, indicating that it is more likely than the model where fat decreases the synthesis of adiponectin.

Keiko Kawamuro - *On quasipositive and strongly quasipositive links*

Quasipositive (QP) and strongly quasipositive (SQP) links are very important classes of knots and links in the 3-sphere. These concepts were introduced by Rudolph and have been intensively studied in knot concordance, contact/symplectic geometry and Heegaard Floer homology theory.

In this talk, I will describe QP links from mapping class group theory point of view. I will also generalize SQP to links in general 3-manifolds then discuss how to detect SQP links. This is joint work with Tetsuya Ito.

Laura Schaposnik - *On the geometry of branes in the moduli space of Higgs bundles*

After giving a gentle introduction to Higgs bundles, their moduli space and the associated Hitchin fibration, I shall describe how actions both on groups and on surfaces (anti-holomorphic or of finite groups) lead to families of interesting subspaces of the moduli space of Higgs bundles (the so-called branes). Finally, we shall look at correspondences between these branes that arise from Langlands duality, as well as from other relations between Lie groups.

Wanda Strychalski - *Mathematical Modeling of Cellular Blebbing Dynamics*

Blebs are pressure-driven protrusions that play an important role in cell migration, particularly in 3D environments. A bleb is initiated when the cytoskeleton detaches from the cell membrane, resulting in the pressure-driven flow of cytosol towards the area of detachment and local expansion of the cell membrane. Recent experiments involving blebbing cells have led to conflicting hypotheses regarding intracellular pressure dynamics. A dynamic computational model of the cell in both two and three dimensions is presented to simulate these experiments, and results show that complex rheology of cytoplasm is essential to explain experimental observations. The model is also used to quantify intracellular pressure dynamics during different mechanisms of bleb initiation. Extensions of the modeling and simulation framework for modeling amoeboid cell migration and osteocyte mechanotransduction are discussed.

Ioana Suvaina - *ALE Kahler manifolds*

The study of asymptotically locally Euclidean Kahler manifolds had a tremendous development in the last few years. This talk presents a survey of the main results and the open problems in this area. When the manifolds support an ALE Ricci flat Kahler metric the complex surfaces and their metric structures are well understood. The remaining case to be studied is that of ALE scalar flat Kahler manifolds. In this direction, the underlying complex manifold is described.

Anush Tserunyan - *Edge-sliding and ergodic actions*

A countable Borel equivalence relation E

on a probability space can always be generated in two ways: as the orbit equivalence relation of a Borel action of a countable group and as the connectedness relation of a locally countable Borel graph, called a *graphing* of E. Assuming that E is measure-preserving, graphings provide a numerical invariant called *cost*, whose theory has been largely developed and used by Gaboriau and others in establishing rigidity results. A well-known theorem of Hjorth states that when E is ergodic, treeable (admits an acyclic graphing), and has integer or infinite cost $n \leq \infty$, then it is generated by an a.e. free measure-preserving action of the free group $\mathbf{F}_n$ on n generators. We give a simpler proof of this theorem and the technique of our proof, combined with two other new tools, yields a significant strengthening of Hjorth's theorem: the action of $\mathbf{F}_n$ can be arranged so that each of the n generators acts ergodically. This is joint work with Benjamin Miller.

Liz Vivas - *Local holomorphic dynamics around a parabolic fixed point*

We will present the theory known for parabolic fixed points focusing on the discrete dynamics of a holomorphic map around it. As time permits we will also give results on parametrization of 'repelling petals and basins' of skew parabolic maps.