

# 2015 Modern Math Workshop

## Speakers at the Math Institute Presentations I & II

October 28, 1-4 pm & October 29, 9:00-10:25 am (Wednesday-Thursday)

### AIM

#### Dr. Naomi Cameron

Naomi Cameron was born in Washington, DC and raised in Providence, RI. She received her BS (1995) and PhD (2002) in mathematics from Howard University. Her PhD thesis in combinatorics was titled: “Random Walks, Trees and Extensions of Riordan Group Techniques.” Currently, she is an Associate Professor of Mathematics at Lewis & Clark College, where she has been since 2006. Her research interests fall into areas of enumerative and algebraic combinatorics and number theory, including the theory of the Riordan group, lattice path enumeration, combinatorial identities, permutation patterns and statistics, and the theory of dessins.

*“Belyi Maps for Trees of a Given Passport”*

**Abstract:** *Dessin* is short for *dessin d’enfant*, which is French for “child’s drawing.” Introduced in the late 1990s by A. Grothendieck, a dessin can be described as a connected bicolored graph where the edges around every vertex are cyclically ordered. Grothendieck proposed that dessins can be realized by Belyi maps, which are meromorphic functions from a Riemann surface to the extended complex plane having at most three critical values. In this talk, I will discuss the origins, outcomes, and future of a research project that was designed to determine Belyi maps that realize certain classes of bicolored trees embedded on the complex sphere.

### IAS/PCMI

#### Dr. Michael Mahoney

Michael Mahoney is at the University of California at Berkeley in the Department of Statistics and at the International Computer Science Institute (ICSI). He works on algorithmic and statistical aspects of modern large-scale data analysis. Much of his recent research has focused on large-scale machine learning, including randomized matrix algorithms and randomized numerical linear algebra, geometric network analysis tools for structure extraction in large informatics graphs, scalable implicit regularization methods, and applications in genetics, astronomy, medical imaging, social network analysis, and internet data analysis. He received his PhD from Yale University with a dissertation in computational statistical mechanics, and he has worked and taught at Yale University in the mathematics department, at Yahoo Research, and at Stanford University in the mathematics department. Among other things, he is on the national advisory committee of the Statistical and Applied Mathematical Sciences Institute (SAMSI), he was on the National Research Council’s Committee on the Analysis of Massive Data, he runs the biennial MMDS Workshops on Algorithms for Modern Massive Data Sets, and he spent fall 2013 at UC Berkeley co-organizing the Simons Foundation’s program on the Theoretical Foundations of Big Data Analysis.

*“Mathematics and Modern Massive Data Set Analysis”*

**Abstract:** The ability to generate enormous quantities of data provides important challenges and opportunities in the natural and social sciences, in economics, finance, and electronic

commerce, and in social media, public policy, and many other areas important to our society and world. It also provides important challenges and opportunities for mathematics, including areas of applied mathematics such as theoretical computer science and theoretical statistics. This talk will provide an overview of some mathematical challenges associated with modern large-scale data analysis, including a discussion of some of the topics that will appear in the 2016 Park City Math Institute's program on the "Mathematics of Data."

## ICERM

### Dr. Edray Goins

#### Professor of Mathematics, Purdue University

Edray Herber Goins grew up in South Los Angeles, California. The product of the Los Angeles Unified (LAUSD) public school system, he attended the California Institute of Technology, where he majored in mathematics and physics, and earned his doctorate in mathematics from Stanford University. He is currently an Associate Professor of Mathematics at Purdue University in West Lafayette, Indiana. He works in the field of number theory, as it pertains to the intersection of representation theory and algebraic geometry.

*"Fuchsian Differential Equations with Prescribed Monodromy: An Introduction to Solving a Quintic Without Using Radicals"*

**Abstract:** We all learn at an early age how to find the roots of a quadratic polynomial using square roots via the Quadratic Formula. In the 1540's, Gerolamo Cardano published a method of finding the roots of both cubic and quartic polynomials using both square roots and cube roots. In 1823, Niels Henrik Abel gave a proof which showed that the roots of quintic polynomials cannot be expressed in terms of radicals. But in 1858, Charles Hermite showed that such roots can be expressed in terms of hypergeometric functions!

In this talk, we explain how to express such roots in terms of these functions by reducing the problem to inverting rational functions by using solutions to certain differential equations. This is a report on work done as part of the Research Experiences for Undergraduate Faculty (REUF) with Torina Lewis (Clark Atlanta University), Katie Quertermous (James Madison University), Chris Seaton (Rhodes College), and Alfredo Villanueva (Savannah State University).

## IMA

### Dr. Romeo Awi, IMA Postdoctoral Fellow

Starting from Fall 2015, Romeo Awi will be a postdoctoral fellow at the Institute for Mathematics and its Applications (IMA). After a Bachelor's degree in Electrical and Computer Engineering, a Bachelor's degree in Mathematics and a Master's degree in Mathematics at the University of Abomey-Calavy (Benin Republic), he got his PhD in Mathematics from Georgia Institute of Technology in 2015. His current research interests are Calculus of Variations, Partial Differential Equations and Numerical Analysis.

*"Minimization Problems and Polyconvexity"*

**Abstract:** We will consider minimization problems in the calculus of variations. The existence of minimizers of integral problems is closely related to the properties of the functional to minimize. We will introduce the important concepts of quasiconvexity and polyconvexity. Inspired by finite element methods from Numerical Analysis, we introduce a perturbed problem which has some interesting uniqueness properties.

## IPAM

### Dr. Isabel Meirelles

Isabel Meirelles is a designer and educator whose intellectual curiosity lies in the relationships between visual thinking and visual representation. She is a Professor in the Faculty of Design and a researcher in the Visual Analytics Lab at the Ontario College of Art and Design (OCAD) University, Toronto, Canada. Isabel's research focuses on the theoretical and experimental examination of the fundamentals underlying how information is structured, represented, and communicated in different media. Meirelles is the author of "Design for Information: An introduction to the histories, theories, and best practices behind effective information visualizations" (Rockport Publishers, 2013).

*"Visualization of cultural phenomena: An overview"*

**Abstract:** The talk will present an overview of analytical and visual/spatial methods of reasoning about cultural phenomena. I will start by presenting a few historical examples that will help situate present efforts. The focus will be on recent visualization trends involving computational and mathematical techniques for the analysis of large sets of cultural data that are available digitally, ranging from written language to sonic experiences, from static to moving images.

## MBI

### Dr. Talitha Washington

Dr. Talitha Washington is an Associate Professor of Mathematics at Howard University. She has been an Assistant Professor of Mathematics at the University of Evansville and The College of New Rochelle, and a VIGRE Research Associate in the Department of Mathematics at Duke University. She earned her master's and doctoral degrees in mathematics from the University of Connecticut, and completed her undergraduate studies in mathematics at Spelman College. Dr. Washington's current fields of interest include applying ordinary and partial differential equations to problems in biology and engineering.

*"Workshops, Conferences, and REUs Oh My! My Experiences at MBI"*

**Abstract:** The Mathematical Biosciences Institute (MBI) has a plethora of activities for both students and faculty alike. In this talk, I will give a tour of the various programs in which I have participated.

## MSRI

### Dr. Talia Fernós

Originally from Puerto Rico, Talia Fernós is excited to be up for tenure at the University of NC, at Greensboro. She studied math and physics at the Evergreen State College where she received thoughtful evaluations in place of grades. Her love of math brought her to UIC in Chicago and finished a PhD on Relative Property (T) in 2006. She loves the safari that is the study of infinite groups; this wild ride visits geometry, analysis, and of course algebra. Currently, she is focused on  $CAT(0)$  cube complexes.

*"Playing Ping Pong with Free Groups"*

**Abstract:** The question of determining when two groups are isomorphic is undecidable in general. Fortunately, the Ping Pong Lemma offers an elegant and handy way to recognize when a group is free (i.e. elements satisfy only the trivial relations required to make it a group). Only basic group theory will be required to understand this elementary talk where we will discuss and prove this wonderful lemma.

## NIMBioS

### Dr. Suzanne O'Regan, NIMBioS Postdoctoral Fellow

Suzanne O'Regan received her PhD in Applied Mathematics from University College Cork, Ireland, 2011. She was a postdoctoral researcher in the Odum School of Ecology at the University of Georgia prior to beginning a NIMBioS postdoctoral fellowship in January 2015. At NIMBioS, she is developing mathematical tools to anticipate emergence and elimination of infectious diseases.

*“Anticipating critical transitions in infectious diseases”*

**Abstract:** Predicting abrupt shifts in state (“critical transitions”) of complex systems is a key research topic in a variety of scientific domains. Small smooth changes in underlying drivers leading to a sudden change in system behavior, mathematically described as a bifurcation, is a mechanism for critical transitions that is of considerable interest. Bifurcations may be detectable because prior to reaching the dynamical threshold, the system may exhibit “critical slowing down.” Statistical signatures of critical slowing down have been detected from temporal and spatial data in biological systems ranging from the global climate system, ecosystems, experimental microcosms and physiological systems. Anticipating infectious disease emergence and documenting progress in disease elimination are important applications for the theory of critical transitions. Non-parametric approaches that are independent of model-fitting would advance infectious disease forecasting significantly. In this talk, I consider compartmental epidemiological SIS and SIR models that are slowly forced through a critical transition. I develop expressions for the behavior of several candidate indicators during the approach to emergence or elimination. I show that moving-window estimates of the candidate indicators may be used for anticipating critical transitions in infectious disease systems. Although leading indicators of elimination were highly predictive, I found the approach to emergence to be much more difficult to detect. It is hoped that these results, which show the anticipation of critical transitions in infectious disease systems to be theoretically possible, may be used to guide the construction of online algorithms for processing surveillance data.

## SAMSI

### Dr. Christopher Strickland, SAMSI Postdoctoral Fellow

Christopher Strickland is a Postdoctoral Fellow at SAMSI and the University of North Carolina, Chapel Hill. He received his PhD in mathematics at Colorado State University in December 2013, under the joint supervision of Dr. Gerhard Dangelmayr and Dr. Patrick Shipman.

Currently, he conducts research modeling, analyzing, and optimizing systems in ecology as part of SAMSI's Program on Mathematical and Statistical Ecology. His background is in applied mathematics, including mathematical modeling, dynamical systems theory, and mathematical biology, and some of his current projects include modeling water resource dynamics in Australian savanna, exploring the dynamics of ecological invasive spread on networks, and modeling the wind-borne dispersal of tiny insects for biocontrol.

*“A Stochastically Driven Model for Savanna Water Resource Dynamics”*

**Abstract:** Modeling has become an essential part of understanding ecosystem dynamics, and within the savanna ecology community, models are used as a key tool to advance theories about the determinants of savanna as an ecological state between forest and grassland. However, many models have paid little attention to intra-annual water resource availability by adopting mean annual precipitation (MAP) as the primary variable for water resources, despite the fact that savannas typically persist in locations with strong rainfall seasonality.

In this talk, I will introduce a new analytic model that explores the relationship between savanna stand structure, seasonal water resource availability, and fire disturbance in Australia. The model demonstrates how variation in dry season length, rather than mean annual precipitation, can determine savanna stability as an underlying woody total basal area equilibrium. This equilibrium may then be estimated numerically using the daily rainfall record, with fire disturbance acting as a perturbation away from this state. Finally, I will describe the specific woody population dynamics predicted by the model, including the effect of various regimes and stochastic fire disturbances.

[This is a joint work with Adam C. Liedloff (CSIRO, Australia), Gerhard Dangelmayr (Colorado State Univ.) and Patrick D. Shipman (Colorado State Univ.)]