Inaugural Conference of the Institute of the Mathematical Sciences of the Americas

September 6, 7 & 8, 2019

Titles and Abstracts

Dr. Jørgen Andersen –
Geometric Recursion
We shall review the geometric recursion and its relation to topological recursion. In particular, we shall consider the target theory of continuous functions on Teichmüller spaces and we shall exhibit a number of classes of mapping class group invariant functions, which satisfies the geometric recursion. Many of these classes of functions are integrable over moduli spaces and we prove that these averages over moduli spaces satisfies topological recursion. The talk will end with some future perspectives of applications of geometric recursion. The construction of geometric recursion and the results relating it to topological recursion is joint work with Borot and Orantin.

Dr. Denis Auroux –
An Invitation to Homological Mirror Symmetry
We will give a gentle introduction to Kontsevich's homological mirror symmetry conjecture, first formulated in 1994 and subsequently extended beyond the Calabi-Yau setting. We will use simple examples to illustrate key concepts such as the Fukaya category, and the extension of HMS beyond the Calabi-Yau setting. Specifically, we will focus on two one-dimensional examples, the cylinder and the pair of pants, to give a flavor of the geometric concepts involved in a general formulation of homological mirror symmetry.

Dr. Ingrid Daubechies –
Teeth, Bones and Manifolds

Dr. Simon Donaldson –
Branched Harmonic Functions and Some Related Developments in Differential Geometry
The focus of the talk will be on branched, or multivalued, harmonic functions on a Riemannian manifold. The branch set is a codimension 2 submanifold and we consider the problem of deforming this branch set to remove the leading term in the asymptotic expansion of the solution. This is analogous to a free boundary problem, in the case of codimension 1. We will explain how this problem is related to a variety of other topical developments in gauge theory, calibrated geometry and special holonomy.

Dr. Phillip Griffiths –
Hodge Theory and Moduli
Both Hodge theory and birational geometry/moduli are highly developed subjects in their own right. The theme of this talk will be on the uses of Hodge theory to study an interesting geometric question and to illustrate how this works in one particular non-classical example of an algebraic surface.

Dr. Alan Hastings –

Transient Dynamics in Ecology

Analyses of both models and data in ecology are still focused on equilibrium or long-term dynamics, with some notable exceptions. Although recent work on tipping points does include approaches based both on underlying changing environments and dynamics on different time scales, the possible situations where dynamics on different time scales are important are much more general. Using new mathematical ideas one can address questions of dynamics on ecological time scales, rather than longer times, and include other kinds of underlying environmental change. The importance of this way of analyzing ecological systems is clear in consideration of changing environments due to anthropogenic influences.

The analyses demonstrate that there are wide ranges of ecological situations where standard analyses based on assuming asymptotic behavior are misleading. Additional cases where explicit time dependence is included in dynamics shows further complications. Different kinds of situations where long transient behavior is expected can be identified. In particular, adding space, which essentially makes systems very high dimensional, is often likely to lead to long transient dynamics. This work also, unfortunately, points out challenges in trying to identify systems where future sudden shifts in system state due to transients are going to occur, since transient behavior of a system with long transients will be asymptotic or long-term behavior of a corresponding system without transients. Examples of ecological systems illustrating the conclusions, including coral-algal-grazer systems will be discussed in light of the general theoretical results.

Dr. Maxim Kontsevich –

Arithmetic Hall Algebras

In theory of representations of finite quivers there are two types of Hall algebras. The classical version has a basis consisting of isomorphism classes of representations over a given finite field, with the structure constants counting extensions with given isomorphism class of subrepresentation and of the quotient. Cohomological upgrade of Hall algebra replaces counting by Borel-Moore homology of representation stacks. I will talk about analogs of both types of Hall algebras in arithmetic, where quiver representations are replaced by "Arakelov bundles", i.e. lattices in Euclidean space.

Dr. Ernesto Lupercio –

Self Organized Criticality in Algebraic Geometry

In this talk for the general public I will explain our study of self-organized criticality in algebraic geometry. Self-organized critical systems are complex systems in which through simple local rules, remarkably complex global behavior arises. I will explain with vivid graphical examples this relation.

Dr. John Morgan –

Mirror Symmetry, Integral Lattices, and a Conjecture of Morrison's

The paradigm of mirror symmetry suggests non-trivial statements for the integral monodromy representation about a maximal unipotent boundary point of the moduli space of complex structures on Calabi-Yau varieties. These arise by analogy from results about Quantum cohomology. We shall examine some of these predictions, especially for Calabi-Yau three folds arising as hypersurfaces and complete intersections in toxic varieties.

Dr. James Simons –

Remarks on Science Philanthropy

Dr. Richard Stanley –

A Survey of Lattice Polytopes

Let P be a polygon in the plane with integer vertices. Suppose that the area of P is A and that P has I interior lattice points and B lattice points on the boundary. Alexander Pick showed that $A=(2I+B-2)/2$. What happens in higher dimensions? This question gave rise to a beautiful theory of *lattice polytopes. We will survey some of the highlights of this theory, which is based on the Ehrhart polynomial of a lattice polytope and Ehrhart-Macdonald reciprocity. Several combinatorial applications will be given, as well as connections with commutative algebra.*

Dr. Mina Teicher –
How Does the Brain Work?
Some insight into the algorithm of brain activity (using singularities and statistics) and some application to neuro medicine epilepsy and sleep disorders).

Dr. Yuri Tschinkel –
Rational Points, Rational Curves, and Rational Varieties
I will discuss some recent results and constructions in the study of rationality of higher-dimensional algebraic varieties.

Dr. Marcelo Viana –
Two Issues in Partially Hyperbolic Dynamics
Partial hyperbolicity is a spin-off of the classical notion of uniform hyperbolicity introduced by Smale (Anosov, Sinai, ...) in the 1960s, and it has been at the heart of dynamical systems for over two decades. I will discuss recent progress in dealing with couple of outstanding issues: metric behavior of center foliations, and prevalence of non-vanishing Lyapunov exponents.

Dr. Michelle Wachs –
From Eulerian Polynomials and Chromatic Polynomials to Hessenberg Varieties
The Eulerian polynomials, which were introduced by Euler over 200 years ago,are pervasive throughout discrete mathematics and have arisen in a variety of surprising ways. The chromatic polynomials were introduced by Birkhoff in 1912 as a means of attacking the four color problem. Over the years, generalizations possessing fundamental properties of these polynomials have been introduced. I will discuss some of these generalizations and describe some intriguing connections with symmetric function theory,representation theory, and algebraic geometry.