8th Annual Davis Math Conference

Schedule and Abstracts

Organizers: Kirill Paramonov and Jingyang Shu

January 11th 2018

1 Schedule

Breakfast	9:00 AM	
Introductory Remarks	9:25 AM	Jordan Snyder
Partial Differential Equations	9:30 AM	Joseph Biello
Mathematical Physics	10:05 AM	John Murray
Algebra	10:30 AM	Erik Carlsson
Topology	11:05 AM	Kevin Lamb
Number Theory	11:30 AM	Elena Fuchs
Optimization	12:05 PM	William Wright
Lunch	12:30 PM	
Computational Mathematics	1:30 PM	Thomas Strohmer
Machine Learning	2:05 PM	Kirill Paramonov
Mathematical Biology	2:30 PM	Robert Guy
Combinatorics	3:05 PM	Chaim Even Zohar
Department Tea	3:30 PM	

2 Abstracts

2.1 Partial Differential Equations

Joseph Biello
Title: The Non-linear PDEs of atmospheric fluid dynamics

Abstract: The PDEs of ideal fluids describe atmosphere and ocean dynamics. Open problems include the development of singularities and the effect of interaction across scales. I will discuss a few problems which are motivated by shear flows and organized waves in the tropical atmosphere. The PDEs I will describe (and show solutions to) are derived from the ideal fluid equations using systematic asymptotic analysis. Some of this work is joint with J. Hunter.

2.2 Mathematical Physics

John Murray
Title: Higher Algebra and Quantum Field Theory

Abstract: Though the experimental predictions of quantum field theories are astoundingly accurate, we are far from having a complete mathematical description of these theories. We will explore a formalism using new ideas from higher algebra to advance us toward that goal. In particular, we will describe how one deformation quantizes functions on the simplices of a derived stack. From a physical perspective, this process defines perturbation theory about classical field configurations including those that model tunneling between vacua.

2.3 Algebra

Erik Carlsson
Title: Double Coinvariants and Cohomology

Abstract: I'll explain what the double coinvariant algebra is, and how it relates to some interesting topics in algebraic geometry and combinatorics, including the (co)homology of something called the affine Springer fiber.

2.4 Topology

Kevin Lamb

Title: Circular Distance for Knots in the 3-Sphere

Abstract: Knots can often be studied via their complements in the 3-manifolds in which they sit. In turn, one of the main areas of study in 3-manifold theory is their classification. One of the primary tools we use to classify 3-manifolds is a decomposition into two handlebodies; that is, a Heegaard splitting of the 3-manifold. In 2001, Hempel showed that these splittings can be studied via Harding's curve complex. For any Heegaard splitting of a 3-manifold, we can define a combinatorial invariant for that splitting called its distance. It was then shown in 2002 by K. Hartshorn that if a 3-manifold contains an incompressible surface of genus g, then the distance of any Heegaard splitting is bounded by 2g.

The aim of this talk is to show recent results that provide a notion of distance (the circular distance) for a class of Heegaard splittings (circular Heegaard splittings) of knot complements in the 3-sphere. In particular, we show that Hartshorn's result extends to this setting; that is, if the knot's complement in the 3-sphere contains an incompressible surface of genus g, then the circular distance of any circular Heegaard splitting of that complement is bounded by 2g. We also state results for uniqueness of minimal genus Seifert surfaces and for circular thin position.

2.5 Number Theory

Elena Fuchs

Title: Sieves and Expanders

Abstract: A problem that arises frequently in number theory is that of counting prime numbers given an interesting set of integers. Sieves are number-theoretic machines that have been used for centuries to estimate the number of primes in problems like these. In this talk, I will discuss how a seemingly unrelated object ? families of expander graphs ? feed into sieves in certain situations, and how this has led to some interesting number theoretic discoveries in the past few years.

2.6 Optimization

William Wright

Title: An Eigenvalue Optimization Method for Phase Retrieval

Abstract: Phase retrieval is the process of recovering the phase of an unknown signal using only the magnitudes of some signal observations. Some common applications are X-ray crystallography, electron microscopy, speech processing, and astronomical imaging. A wide variety of methods exist for retrieving phase, yet most do not allow for much noise in the observations. A phase retrieval method was recently developed [Friedlander, 2016] which handles noise, leading to an eigenvalue optimization problem. This underlying eigenvalue problem has a unique structure which we exploit using modern eigenvalue methods to increase the efficiency of the phase retrieval process.

2.7 Computational Mathematics

Thomas Strohmer

Title: Mathematics of Data Science

Abstract: I will talk about some recent research my collaborators and I have conducted in the field of data science. Topics include blind deconvolution, convex and nonconvex optimization, data clustering, and deep learning.

2.8 Machine Learning

Kirill Paramonov

Title: Graphlet enumeration in large graphs

Abstract: Graphlets are connected induced subgraphs of small size. Counting the number of graphlets of a certain type yields an important statistic for analyzing many social graphs. During the talk, I introduce the problem and talk about different issues that may arise while solving it. In particular, I?ll introduce the Markov Chain Monte Carlo approach for estimation of the graphlet count statistic.

2.9 Mathematical Biology

Robert Guy

Title: Flagellar swimming in viscoelastic fluids: Role of fluid elastic stress revealed by simulations based on experimental data

Abstract: Many important biological functions depend on microorganisms' ability to move in viscoelastic fluids such as mucus and wet soil. The effects of fluid elasticity on motility remain poorly understood, partly because, the swimmer strokes depend on the properties of the fluid medium, which obfuscates the mechanisms responsible for observed behavioral changes. In this study, we use experimental data on the gaits of Chlamydomonas reinhardtii swimming in Newtonian and viscoelastic fluids as inputs to numerical simulations that decouple the swimmer gait and fluid type in order to isolate the effect of fluid elasticity on swimming. In viscoelastic fluids, cells employing the Newtonian gait swim faster but generate larger stresses and use more power, and as a result the viscoelastic gait is more efficient. Furthermore, we show that fundamental principles of swimming based on viscous fluid theory miss important flow dynamics: fluid elasticity provides an elastic memory effect which increases both the forward and backward speeds, and (unlike purely viscous fluids) larger fluid stress accumulates around flagella moving tangent to the swimming direction, compared to the normal direction.

2.10 Combinatorics

Chaim Even Zohar

Title: Patterns in Random Permutations

Abstract: Every k entries in a permutation of order n can have one of $k!$ different relative orders, called *patterns*. How many times does each pattern occur in a large random permutation? We analyze the distribution of pattern densities, using representations of the symmetric group.