SPECIAL SUMMER MATHEMATICS COLLOQUIUM SERIES

2019 NSF REU MATHEMATICS PROGRAM

Scott Alexander Atkinson
Assistant Professor of Mathematics
Department of Mathematics
Vanderbilt University

Unitary Dilation

Friday, July 12, 2019, EMCS Rm. 422, 2:00–3:00 pm

Abstract. The subject of unitary dilation addresses the following type of problem. Given operators on a Hilbert space H (complete inner-product space), can we find unitary operators (unitary = Hilbert space isomorphism) on a larger Hilbert space K containing H having algebraic properties similar to the original operators (e.g., commuting relations, moment conditions, etc.), such that their restrictions to H recover the original operators? Unitary dilation has many benefits in operator theory. For instance, the Sz.-Nagy Dilation Theorem provides a concise proof of von Neumann's inequality. In this talk we will discuss many aspects of unitary dilation including classical and recent results, counterexamples, applications, and open questions. We will begin with a brief summary of Hilbert space operators. No prior knowledge of Hilbert spaces will be assumed.

This talk is intended to be accessible to advanced undergraduate and beginning graduate mathematics majors.

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We thank the National Science Foundation Division of Mathematical Sciences for its generous support.

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Fernando Xuancheng Shao
Assistant Professor of Mathematics
Department of Mathematics
University of Kentucky

The Hardy–Littlewood Circle Method and Applications

Monday, July 15, 2019, EMCS Rm. 422, 2:00–3:00 pm

Abstract. The Hardy–Littlewood circle method, also known as the exponential sum method, is a central tool in analytic number theory. I will describe what this classical and important method is, and how it applies to various problems in additive number theory, including Vinogradov's three primes theorem (the ternary version of the Goldbach conjecture) and Roth's theorem in combinatorics. I will also discuss the limitation of the circle method, and the modern development in the past decade to overcome this.

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Judy D. Day
Associate Professor of Mathematics
Department of Mathematics
Department of Electrical Engineering and Computer Science
The University of Tennessee, Knoxville

Working @ the Interface: the Challenges and Opportunities of Mathematical Biology

Friday, July 19, 2019, EMCS Rm. 422, 2:00–3:00 pm

Abstract. The questions that drive Mathematical Biology research and the quest for their answers make working at the interface of mathematics and biology interesting and exciting. However, it is also a place of great challenge and struggle where two very different fields are being melded together to synergistically create something greater than the sum of the parts. The amount of time that must be spent in the great "in-between" of the interface is often taken for granted; yet, it is here where skill, logical thinking, and creativity (not to mention patience!) are greatly required. Using examples from immunology, I will illustrate some of the challenges and opportunities that may be encountered when working at the interface.

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Eleni Panagiotou
Assistant Professor of Mathematics
Department of Mathematics
The University of Tennessee at Chattanooga

Introduction to Applied Knot Theory

Monday, July 22, 2019, EMCS Rm. 422, 2:00–3:00 pm

Abstract. Mathematical knots are simple closed curves in space and can be classified using topological invariants. In the last decades, more and more knots are found in physical systems with important implications. For example, knots in proteins and DNA are related to disease and entanglement in polymer melts determines their viscoelastic properties with many industrial applications. Physical knots usually do not satisfy the strict mathematical definitions of knottedness, giving rise to a new area of study, Applied Knot Theory. In this talk we will have a short introduction to applied knot theory and see how it can be applied in practice to measure entanglement in polymers.

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Carmeliza Navasca
Associate Professor of Mathematics
Department of Mathematics
University of Alabama at Birmingham

Sparse Optimization for Tensors

Friday, July 26, 2019, EMCS Rm. 422, 2:00–3:00 pm

Abstract. The popularity of sparse ell one norm optimization problem was due to Emmanuel Candes and Terrence Tao via compressed sensing. I will start by introducing the little ell one norm. Then, I will describe how and why these sparse ell one norm optimization problems are useful in solving today's challenging problems in data science and machine learning. In particular, I will discuss their applications to tensor decomposition. I will also include numerical examples in surveillance video analysis and matrix and tensor completion. In this talk, one can observe the interplay of (multi)linear algebra, optimization and numerical analysis with applications in computer science.

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SPECIAL SUMMER MATHEMATICS COLLOQUIUM SERIES

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Doron Lubinsky
Associate Professor of Mathematics
Department of Mathematics
Georgia Institute of Technology

Continuing the Fraction

Monday, July 29, 2019, EMCS Rm. 422, 2:00–3:00 pm

Abstract. Continued fractions play a key role in number theory, especially in understanding how well we can approximate irrational numbers by rational numbers. They also play an important role in function theory, in understanding how well we can approximate analytic functions by irrational functions. We discuss a few of the main achievements of the theory.

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Emily Eckels, Emory University
Steven Jin, University of Maryland, College Park
Brian Tobin, Harvard University

Lower Bounds for the L^1 Norm of Exponential Sums

Thursday, August 1, 2019, EMCS Rm. 422, 10:00–10:30 am

Abstract. We employ the method of Balog and Ruzsa and the large sieve to investigate the behaviour of the L^1 norm of a wide class of exponential sums over the square-free integers and the primes. Moreover, we provide a new proof of a lower bound due to Vaughan for the L^1 norm of an exponential sum with the von Mangoldt Λ function over the primes.

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Margaret Brown, University of Maryland, College Park
Miko Jiang, Mount Holyoke College

Modeling Cholera Transmission with Disease Control

Thursday, August 1, 2019, EMCS Rm. 422, 10:40–11:10 am

Abstract. We construct a new mathematical model to investigate the transmission dynamics of cholera under the impact of disease control measures, particularly with awareness programs and water sanitation. The model incorporates the impact of awareness programs into the disease transmission rates, and that of water sanitation into the description of the environmental pathogen evolution. We conduct a careful mathematical analysis to the model and establish the local and global stabilities, characterized by the basic reproduction number, for the disease-free and endemic equilibria. In addition, an optimal control study is in progress to explore effective prevention and intervention strategies for cholera epidemics.

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S. Blake Allan, Baylor University
Justin Kim, Vanderbilt University
Gregory Michajlyszyn, University of Rochester
Donald Rung, Sewanee: The University of the South

Explicit Krein Resolvent Identities for Singular Sturm–Liouville Operators with Applications to Bessel Operators

Thursday, August 1, 2019, EMCS Rm. 422, 11:20–11:50 am

Abstract. We derive explicit Krein resolvent identities for generally singular Sturm–Liouville operators in terms of boundary condition bases and the Lagrange bracket. As an application of the resolvent identities obtained, we compute the trace of the resolvent difference of a pair of self-adjoint realizations of the Bessel differential expression. The resulting trace formula is then used to determine the spectral shift function for the pair.

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Nafisa Tabassum, York College, City University of New York
Carolyn Valenti, Bucknell University

A Multi-Scale Model for Cholera Dynamics

Thursday, August 1, 2019, EMCS Rm. 422, 12:00–12:30 pm

Abstract. A multi-scale mathematical model for cholera dynamics is developed and analyzed. The model links the within-host and between-host disease dynamics and their interaction with the pathogen in the aquatic environment. The within-host, between-host and environmental sub-systems are on the fast, intermediate, and slow time scales, respectively. A study based on separation of scales is first performed for each of the three sub-systems. Properties of the trivial and non-trivial equilibria are thoroughly investigated and threshold-type results are established. The analysis is then extended to the full system coupling the three time scales.

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