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ABSTRACTS

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Grothendieck Classes of Quiver Cycles as Iterated Residues

In the case of Dynkin quivers we establish a formula for the Grothendieck class of a quiver cycle as the iterated residue of a certain rational function, for which we provide an explicit combinatorial construction. Moreover, we utilize a new definition of the double stable Grothendieck polynomials due to Rimányi and Szenes in terms of iterated residues to exhibit that the computation of quiver coefficients can be reduced to computing the coefficients in a combinatorially prescribed Laurent expansion of the aforementioned rational function. For more details, please se the recent preprint at arxiv.org/abs/1310.3548.

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A Mixed Finite Element Method for a Cahn-Hilliard-Darcy-Stokes System

We devise and analyze a mixed finite element method for a modified Cahn-Hilliard equation coupled with a non-steady Darcy-Stokes flow that models phase separation and coupled fluid flow. Applications for my model include applications to immiscible binary fluids, such as oil and water, and diblock copolymer melts. The time discretization is based on a convex splitting of the energy of the equation. We prove that our scheme is unconditionally energy stable with respect to a spatially discrete analogue of the continuous free energy of the system, unconditionally uniquely solvable, and convergent with optimal rates in both two and three space dimensions.

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Parametic Equations Go to the Circus: Trochoids in Poi Flower Patterns

Poi spinning is a performance art, related to juggling, involving two weights on the ends of short chains, which are swung around making visually interesting patterns. We will consider a certain class of technical moves for poi, where the patterns created are centered trochoids, which are closely related to the cycloid. Like all curves in the cycloid family, they are best expressed using parametric equations. Based on the calculus of the curves, we can easily determine that there are

just a few places in these patterns where one pattern can be smoothly transformed into another. We will also consider how many two handed variations there are for this class of patterns using combinatorics.

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Proof and Reasoning in an Inquiry-oriented lass: The Impact of Classroom Discourse

Over the past decade, mathematics educators and researchers have become increasingly aware of the impact of social interactions on students' learning (NCTM, 2000; Bowers and Nickerson, 2001; Forman, 2003). Current research indicates that the classroom environment, including the activities and discussions that take place, can have a significant effect on the ways students make sense of mathematical concepts (Yackel, et al., 2001). Understanding mathematics involves knowing how to make sense of key concepts through the processes of reasoning and justification. Educators and researchers agree on the importance of providing students with opportunities in class to explore, conjecture, and prove in order to promote mathematical understanding beyond procedural knowledge (Lakatos, 1976; Rasmussen and Marrongelle, 2006).

Although there are a number of studies that investigate many different aspects of classroom discourse and students' learning, there remains a need for more understanding (Franke, Kazemi and Battey, 2007). This study is aimed at investigating the nature and impact of social interactions, both teacher-student and student-student, in classroom discourse. In particular, the study seeks to gain understanding of how interactions influence students' engagement in proof and reasoning activities. In addition, the study analyzes students' argumentation schemes as they occurred in classroom discussions and during student group work.

This study contributes to the existing research by highlighting certain types of interactions that resulted in students contributing to proof construction and collective reasoning.

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Combinatorics of Link Diagrams and Volume

An interesting goal in knot theory is to discover how much information about a link can be carried by a projection diagram of that link. For certain A- adequate links, we present a result that bounds the hyperbolic volume of the link complement above and below in terms of two diagrammatic quantities: the twist number and the number of special tangles in an A-adequate diagram. We then restrict our attention to plat closures of certain braids, a rich family of links whose volumes can be bounded in terms of the twist number alone. Furthermore, in the absence of special tangles, the above volume bounds can be expressed in terms of a single coefficient of the colored Jones polynomial. By relating these geometric and quantum link invariants to each other, we provide a new collection of links that are now known to satisfy a Coarse Volume Conjecture.

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Expected Values of the Conformal Radius

In this presentation we examine problems on how randomness affects values involving the conformal radius. First, we look at two points contained in non-overlapping domains. When the points are distributed randomly in a known way, we seek to find an upper bound for the expected value of the product of the conformal radii without any knowledge of the domains themselves. Some of the situations that will be presented are when the points are distributed **(a)** uniformly along a line segment; **(b)** uniformly in the unit disk; **(c)** with the real parts and imaginary parts being independently and normally distributed. Second, we look at situations where the domain is known, the location of the point within the domain is not known, but it is distributed randomly in a known way. We seek to find exactly the expected value of the conformal radius. Of all domains with a fixed area we believe the disk maximizes this expected value. To that end, we develop results on how this expected value changes under conformal mappings and use these results on parameterized families of domains to provide evidence that supports this conjecture.

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Combinatorial Heegaard Floer Homology and Branched Spines

A 3-dimensional closed manifold Y represented by its branched spine has a canonical Heegaard decomposition. We present this decomposition graphically in the form of a Strip Diagram. We show that strip diagrams have nice properties which greatly simplify the calculation of Heegaard Floer homology for "most" manifolds. Motivated by this work, we present a combinatorial definition of a chain complex which we expect to be homotopically equivalent to the Heegaard Floer one, yet significantly smaller. Finally, we consider the presentation of a branched spine by its O-graph and show how to reformulate our definition in these terms.

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Transmission Eigenvalues and Non-destructive Testing Of Anisotropic Magnetic Materials with Voids

The transmission eigenvalue problem is a new class of eigenvalue problems that have appeared in inverse scattering theory for inhomogeneous media. These are non self-adjoint and nonlinear eigenvalue problems, which makes its mathematical investigation interesting and challenging. we will present some results on the interior transmission eigenvalue problem for an anisotropic material with voids. In particular, we prove the existence of real transmission eigenvalues and show that the first transmission eigenvalue can be used to determining material properties and provide qualitative information about the size of the void(s). In addition, we show that the real transmission eigenvalues can be determined from the scattering data. Some numerical examples are given to demonstrate the feasibility of our theoretical results.

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A Scheme for Modeling and Analyzing the Dynamics of Logical Circuits

It is shown how logical circuits can be modeled by discrete dynamical systems that preserve the qualitative behavior observed in physical realizations. While continuous dynamical systems provide quite accurate mechanistic models, they can become extremely computationally expensive to simulate. In contrast, simulating a discrete dynamical system is relatively inexpensive. A model for the RS flip-flop circuit, made with chaotic NOR gates, is found in an ad-hoc manner. This is shown to replicate the qualitative features of the physical realization. Next, a systematic - algorithmic - first principles based approach is developed in order for such dynamical models to more accurately reflect observed behavior and facilitate further investigation. Also, it is demonstrated how this fundamental algorithmic approach can, with similar ease, be used to obtain discrete dynamical models of other more complicated logical circuits.

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Time-Delayed PDEs with Stochastic Boundary in Mathematical Modeling of Kidney

We consider nonlinear time-delayed transport equations with stochastic boundary to study the stability of feedback systems in the kidney. We prove the existence and uniqueness of the steady- state solution for deterministic and stochastic boundary cases with small delay, based on the contraction mapping theorem. Model results revealed that the system admits the stationary solution for small delay despite stochastic influences, whereas it exhibits oscillatory solutions for large delay, resembling irregular oscillations in spontaneously hypertensive rats.

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Arithmetic Mirror Symmetry and Multiple Mirrors

Arithmetic mirror symmetry predicts that the zeta functions of mirror pairs of varieties should be closely related. We use Greene-Plesser-Roan and Berglund-Huebsch-Krawitz mirror symmetry to describe the structure of the congruent zeta function for a set of pencils of quartic K3 surfaces which admit discrete group symmetries.

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Classification of Finite Planar Nontrivial Ideal-based Zero-divisor for Commutative Rings with nonzero Identity

My research has focused on a generalization of the zero-divisor graph called the *ideal-based zero-divisor graph*. In 2001, S. P. Redmond gave the following definition: Let R be a commutative ring with nonzero identity and I an ideal of R. Define $\Gamma_I(R)$ to be the graph on vertices $\{x \in R \backslash I \mid xy \in I$ for some $y \in R \setminus I\}$ where distinct vertices x and y are adjacent if and only if $xy \in I$. This is called the *ideal-based zero-divisor graph* of R with respect to the ideal I. Among other things, my research has classified, up to isomorphism, all finite commutative rings R with nonzero identity which contain a proper, non-prime ideal I such that $\Gamma_I(R)$ is planar. A graph Γ is *planar* if it can be drawn in the plane in such a way that no two edges cross. The focus of the poster presentation would be on this classification. We begin by considering what constraints planarity forces on the cardinality of the ideal I and the girth of $\Gamma(R/I)$. The girth of a graph is the length of a shortest cycle in the graph provided one exists; and infinity if no cycles exist. Using the latter properties, we can then classify all finite commutative rings with nonzero identity, up to isomorphism, which admit a planar ideal-based zero-divisor graph.

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On the Infinitude of Prime Elements

Let R be an infinite unique factorization domain with at most finitely many units. We discuss certain properties involving the infinitude of prime elements in R when R satisfies the following property: if f and g are polynomials with coefficients in R such that $f(r)$ divides $g(r)$ for all $r \in R$ with $f(r) \neq 0$, then either $g = 0$ or $\deg f \leq \deg g$.

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Results Concerning Huppert's Conjecture

In the late 1990s, Bertram Huppert conjectured that if G is a finite group and H a finite nonabelian simple group such that the sets of character degrees of G and H are the same, then $G \cong H \times A$, where A is an abelian group.

Huppert verified the conjecture for many nonabelian simple groups, including many of the sporadic simple groups. His method of proof relies upon a five step procedure which ultimately requires properties of the character degrees and maximal subgroups of the simple group in question. We will present progress in the verification of Huppert's Conjecture for the simple groups of Lie type of rank two, some of the simple groups of exceptional Lie type, the remaining sporadic groups, and progress on groups of Lie type of higher rank.

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Domain Decomposition Methods for High Contrast Problems

We will introduce a non-overlapping domain decomposition methods for high contrast elliptic problems. We apply the approximation for Dirichlet to Neumann maps in high contrast media to the domain decomposition methods as a preconditioner. The preconditioned system will not depends on either the high contrast coefficients or the smallness of the mesh size.

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Mathematical Modeling of Cardiovascular Dynamics During Head-up Tilt

Short-term cardiovascular responses during head-up tilt (HUT) involve complex regulation in order to maintain blood pressure at homeostatic levels. Patient specific pulsatile and non-pulsatile models that use heart rate as an input to predict dynamic changes in arterial blood pressure during HUT are presented in this work. The models are rendered patient specific via the use of parameter

estimation techniques. This process involves sensitivity analysis, prediction of a subset of identifiable parameters, and nonlinear optimization. The approach proposed here was applied to the analysis of carotid blood pressure (carotid and aortic for the pulsatile model) and heart rate HUT data from healthy young subjects. Results showed that it is possible to develop mathematical models that can predict changes in cardiac contractility and vascular resistance, quantities that cannot be measured invasively, but which are useful to assess the state of the cardiovascular system during HUT. It is also shown that a simpler non-pulsatile model can be used in conjunction with other physiological models; yet still portray the same dynamics as the pulsatile model. We also show that an optimal control approach is useful for controlling cardiac contractility and vascular resistance during HUT in comparison to numerical optimization with piece-wise linear splines. Moreover, the model estimates physiologically reasonable values for arterial and venous blood pressures, blood volumes, and cardiac output for which data are not available.