Titles and Abstracts for Lectures

TORA XI - Lectures

Note: The abstracts for the Speed TORA and the Poster Session appears at the end.

Speaker: **Pramod Achar** (Louisiana State University)

Title: The Humphreys conjecture on cohomology of Frobenius kernels

Abstract: Let G be a reductive group over an algebraically closed field of characteristic $p > 0$, and let G_1 be its first Frobenius kernel. Results of Friedlander-Parshall and Andersen-Jantzen from the 1980s relate the group cohomology of G_1 to the geometry of nilpotent elements in the Lie algebra of G. I will explain these classical results, and how they fit into a modern context involving derived equivalences inspired by the geometric Langlands program. I'll then explain the recent proof of a conjecture of Humphreys on the cohomology of G_1 with coefficients in certain ("tilting") G-modules. This is based on joint work with W. Hardesty, and also partly with S. Riche.

Speaker: **Kwangho Choiy** (Southern Illinois University, Carbondale)

Title: On arithmetic aspects in discrete series of p-adic groups

Abstract: After a tour of several interesting phenomena and unsolved questions when representations of a p-adic group restricted to its closed subgroups with the same derived group, we shall focus on some arithmetic aspects in restriction of discrete series representations, including behavior of formal degrees, multiplicities, and R-groups. We also discuss their connections in the framework of local Langlands correspondences.

Speaker: **Tasho Kaletha** (University of Michigan)

Title: Characterization and construction of the local Langlands correspondence for supercuspidal parameters.

Abstract: We will formulate a list of properties that uniquely characterize the local Langlands correspondence for discrete Langlands parameters with trivial monodromy. Suitably interpreted, this characterization holds for any local field, but requires an assumption on p in the non-archimedean case. We will then discuss an explicit construction of this correspondence, as a realization of functorial transfer from double covers of elliptic maximal tori.

Speaker: **Kim Klinger-Logan** (Kansas State University / Rutgers University)

Title: Graviton scattering and automorphic forms

Abstract: Green, Russo, and Vanhove have shown that the scattering amplitude for gravitons (hypothetical particles of gravity represented by massless string states) is closely related to automorphic forms through differential equations. Specifically, the coefficients of the scattering amplitude of gravitons are determined given by eigenvalue problems involving the Laplace-Beltrami operator on different moduli spaces. A variety of methods have been used to compute these coefficients and we will examine some methods for solving the most complicated of these differential equations on $SL_2(\mathbb{Z})\backslash\mathfrak{H}$. We will present forthcoming work with S. Miller and D. Radchenko to improve

upon Miller's original method for solving this equation. Time permitting, we will also examine generalizations of these results and open problems left to consider.

Speaker: **Scott Larson** (University of Georgia)

Title: A Categorification of the Lusztig-Vogan Module

Abstract: Continuous actions of real reductive groups are often studied by first linearizing the action to spaces related to functions, then using algebra via Lie algebras and compact groups (cf. Gelfand, Harish-Chandra, Vogan). This paradigm essentially simplifies to the easier problem of studying a complex algebraic group K acting on flag varieties. K-orbit closures are important for representation theory, are generalizations of Schubert varieties, and certain properties are explicitly determined via equivariant resolutions of singularities. In joint work with Anna Romanov, we provide a geometric and algebraic categorification of the Lusztig-Vogan module using the equivariant derived category. Our methods allow us to compute cohomology of all fibers of resolutions constructed quite generally and generalize Soergel bimodule techniques from complex to real reductive algebraic groups.

Speaker: **Ayan Maiti** (Oklahoma State University)

Title: Weyl's Law for Cusp Forms of Arbitrary K_∞-type

Abstract: Let M be a compact Riemannian manifold. It was proved by Weyl that number of Laplacian eigenvalues less than T, is asymptotic to $C(M)T^{\dim(M)/2}$, where $C(M)$ is the product of the volume of M, volume of the unit ball and $(2\pi)^{-\dim(M)}$. Let Γ be an arithmetic subgroup of $SL_2(\mathbb{Z})$ and $\mathbb{H}^2$ be an upper-half plane. When $M = \Gamma\backslash\mathbb{H}^2$, Weyl's asymptotic holds true for the discrete spectrum of Laplacian. It was proved by Selberg, who used his celebrated trace formula.
Let G be a semisimple algebraic group of Adjoint and split type over $\mathbb{Q}$. Let $G(\mathbb{R})$ be the set of $\mathbb{R}$-points of G. For simplicity of this exposition let us assume that $\Gamma \subset G(\mathbb{R})$ be an torsion free arithmetic subgroup. Let K_∞ be the maximal compact subgroup. Let $L^2(\Gamma\backslash G(\mathbb{R}))$ be space of square integrable Γ invariant functions on $G(\mathbb{R})$. Let $L^2_{\text{cusp}}(\Gamma\backslash G(\mathbb{R}))$ be the cuspidal subspace. Let $M = \Gamma\backslash G(\mathbb{R})/K_\infty$ be a locally symmetric space. Suppose $d = \dim(\Gamma\backslash G/K_\infty)$. Then it was proved by Lindenstrauss and Venkatesh, that number of spherical, i.e. bi-K_∞ invariant cuspidal Laplacian eigenfunctions, whose eigenvalues are less than T is asymptotic to $C(M)T^{\dim(M)/2}$, where $C(M)$ is the same constant as above.
We are going to prove the same Weyl's asymptotic estimates for K_∞-finite cusp forms for the above space.

Speaker: **Anne Shepler** (University of North Texas)

Title: Invariant derivations and differential forms for reflection groups

Abstract: In the classical invariant theory of reflection groups, the invariants of a set often show the same algebraic structure as the original set. For example, Louis Solomon's celebrated 1963 theorem exhibits the space of invariant differential forms as an exterior algebra in its own right. We use tools of Gutkin and Opdam on characters to extend Solomon's Theorem to mixed differential derivations. This work correlates with conjectures on the cohomology of Lie groups and Lie algebras and results of Bazlov, Broer, Joseph, Reeder, and Stembridge, and also Deconcini, Papi, and Procesi. We also resolve some conjectures motivated by W-Catalan combinatorics and include complex reflections groups as well as Coxeter and Weyl groups.

Speaker: **Sug Woo Shin** (University of California, Berkeley)

Title: Points on Shimura varieties modulo primes

Abstract:

(Colloquium) After surveying the problem of computing the zeta function and ell-adic cohomology of Shimura varieties in the context of the Langlands program, I will report on joint work with Mark Kisin and Yihang Zhu to establish a stabilized trace formula computing the cohomology of abelian-type Shimura varieties at primes of good reduction, building upon earlier work by Kisin.

(Second Talk) After a review of the first talk, we discuss applications of the stabilized trace formula for Shimura varieties, focusing on the problem of describing the cohomology of Shimura varieties based on joint work with Kisin and Zhu. Attending the first talk would be helpful but not required.

TORA XI - SPEED TORA

Speaker: **Praneel Samanta** (University of Iowa)

Title: Double Square Moments and Bounds for Resonance Sums for Cusp Forms

Abstract: Let f and g be holomorphic cusp forms for the modular group $\mathrm{SL}(2, Z)$ of weight k_1 and k_2 with Fourier coefficients $\lambda_f(n)$ and $\lambda_g(n)$, respectively. For nonzero real numbers a and $0 < b < 1$, consider a smooth resonance sum $S_X(f, g, a, b)$ of $\lambda_f(n)\lambda_g(n)$ against $e(a * n^b)$ over $X < n < 2X$. Square moments of $S_X(f, g, a, b)$ are nontrivially bounded in both the f and g aspects as their weights tend to infinity together. By allowing both f and g to move, these double moments are indeed square moments for automorphic forms for GL(4). Their bounds reveal insights into the size and oscillation of the resonance sums and their potential resonance for GL(4) forms when k_1 and k_2 are large.

Speaker: **Dillon Hanson** (University of North Texas)

Title: Invariant theory of reflection groups containing transvections

Abstract: We consider the action of reflection groups on the set of differential derivations and provide an analogue of Saito's freeness criterion. We then produce a basis of the invariant differential derivations as a free exterior algebra when the group has maximal transvection root spaces, including special linear groups, general linear groups, and others.

Speaker: **Mee Seong Im** (United States Military Academy)

Title: One-dimensional topological theories with zero-dimensional defects and finite state automata

Abstract: Quantum groups are related to 3-dimensional topological quantum field theories. Downsizing from three dimensions to one and from a ground field to a semiring, I will explain a surprising relation between topological theories for one-dimensional manifolds with defects and values in the Boolean semiring and finite-state automata and their generalizations. This is joint with Mikhail Khovanov.

Speaker: **Matt Douglass** (National Science Foundation)

Title: Fast and Furious IV: Equivariant coherent sheaves on a point, Kazhdan-Lusztig bases, and the lowest two-sided cell

Abstract: In this talk I will discuss a refined version of a question of Ostrik that describes equivariant coherent sheaves on the nilpotent cone of a simple, complex Lie algebra that are supported on a point in terms of the Kazhdan-Lusztig basis of the extended, affine Hecke algebra and the lowest two-sided cell in the underlying extended affine Weyl group.

Speaker: **Andrew Alaniz** (University of Texas Rio Grande Valley)

Title: Minimizing the Irregularity Function of a Geometric Local Langlands Parameter

Abstract: Let G be a complex algebraic group. In the geometric Langlands program, the local Langlands parameters are formal flat G-bundles. In this talk I will describe a combinatorial problem which arises when trying to minimize the irregularity function of a formal flat G-bundle modified by an arbitrary representation of $\mathrm{Lie}(G)$. If G is simple, we can motivate a conjecture about the minimal value of the modified irregularity function, which involves the formal Frenkel-Gross connection, by analyzing some explicit examples.

TORA XI - POSTER SESSION

Presenter: **Faqruddin Ali Azam** (Oklahoma State University)

Title: On the Rational Generating function for intervals of Partitions

Abstract: A partition λ is a sequence $(\lambda_1, \lambda_2, \cdots, \lambda_k)$ of non-negative integers in descending order such that all but finitely many λ_i are zero. If $\sum_i \lambda = n$, then we say that λ is a partition of n. Moreover, if $\lambda_{k+1} = 0 < \lambda_k$, then we say that λ is a partition of n with exactly k parts. For two partitions λ and δ, we say that $\lambda \leq \delta$ whenever $\lambda_i \leq \delta_i$ for all i. By the interval $[\lambda, \delta]$, we mean the set of all partitions α such that $\lambda \leq \alpha \leq \delta$, and the number of all such α is called the size of $[\lambda, \delta]$. Suppose that $A_{k,n}$ is the average size of interval of partitions $[0, \lambda]$, where λ runs through the set of all partitions of n with exactly k parts. We showed that the sequence of $A_{k,n}$ has polynomial growth.

Presenter: **William Goode** (University of North Texas)

Title: Tensor Density Modules of Contact Vector Fields

Abstract: We define $\mathcal{K}$, the Lie superalgebra of contact polynomial vector fields on the superline and its maximal conformal subalgebra $\mathfrak{osp}(1|2)$. $\mathcal{K}$ comes with a natural action on the space $\mathbb{C}[x, \xi]$ where ξ is a symbol with the property that $\xi^2 = 0$. The tensor density modules of $\mathcal{K}$ are a 1-parameter family of deformations of this action, which we consider as modules of the universal enveloping algebra $\mathfrak{U}(K)$ of $\mathcal{K}$. Relevant to our discussion will be the Casimir operator of $\mathfrak{osp}(1|2)$ and its square root, often referred to as "Casimir's ghost". The poster concludes with some decompositions of the supersymmetric square and supersymmetric cube of $\mathcal{K}$, as well as a few conjectures about the annihilators of the action over $\mathfrak{U}(\mathcal{K})$.

Presenter: **Colin Lawson** (University of North Texas)

Title: Deformation Cohomology for Cyclic Group Actions

Abstract: The Hochschild cohomology of an algebra records information about the deformations of the algebra. We highlight the Hochschild cohomology governing the graded deformations of skew group algebras for cyclic groups acting on polynomial rings. To help find this information, we use chain maps to convert between resolutions giving theoretical information and resolutions giving practical information. As an example, we give an explicit description of the graded deformations of the skew group algebra for a cyclic group of prime order p acting on a two-dimensional vector space over a field of characteristic p.

Presenter: **Praneel Samanta** (University of Iowa)

Title: Double Square Moments and Bounds for Resonance Sums for Cusp Forms

Abstract: Let f and g be holomorphic cusp forms for the modular group $\mathrm{SL}(2, Z)$ of weight k_1 and k_2 with Fourier coefficients $\lambda_f(n)$ and $\lambda_g(n)$, respectively. For nonzero real numbers a and $0 < b < 1$, consider a smooth resonance sum $S_X(f, g, a, b)$ of $\lambda_f(n)\lambda_g(n)$ against $e(a * n^b)$ over $X < n < 2X$. Square moments of $S_X(f, g, a, b)$ are nontrivially bounded in both the f and g aspects as their weights tend to infinity together. By allowing both f and g to move, these double moments are indeed square moments for automorphic forms for GL(4). Their bounds reveal insights into the size and oscillation of the resonance sums and their potential resonance for GL(4) forms when k_1 and k_2 are large.

Presenter: **Mee Seong Im** (United States Naval Academy)

Title: Topological theories and automata

Abstract: Finite state automata are closely related to regular languages. To each pair of a regular language and a circular regular language, we associate a topological theory for one-dimensional manifolds with zero-dimensional defects labelled by letters of the language. Taking values in the Boolean semiring, universal construction of topological theories gives rise in this case to a monoidal category of Boolean semilinear combinations of one-dimensional cobordisms with defects modulo skein relations, which can be interpreted as a semilinear rigid monoidal closure of standard structures associated to a regular language. This is joint with Mikhail Khovanov.