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CURRENT POSITION

Associate Professor — **University of Massachusetts**
Department of Mathematics — Fall 2009–present
Boston, MA, USA

EDUCATION

Ph.D., Mathematics — May 2003
Yale University, New Haven, CT, USA

M.Phil., Mathematics — May 2001
Yale University, New Haven, CT, USA

M.S., Mathematics — May 2000
Yale University, New Haven, CT, USA

B.S., Mathematics, with distinction — August 1995
Pennsylvania State University, University Park, PA, USA

HONORS

Award for Outstanding Overall Achievement, UMB College of Science and Mathematics, 2006–2007.

Award for Outstanding Achievement in Research and Scholarship, UMB College of Science and Mathematics, 2004–2005.

Dolciani-Halloran **National Project NExT Fellow**, 2003–2004.

Visiting Scholar, **National University of Singapore**, January 2006.

Invited Participant, **PMET working group**, Park City, UT, July 2008.

RESEARCH INTERESTS

Invariant theory, representation theory, mathematical physics, integrable systems.

Dissertation: **Standard Monomial Theory for Reductive Dual Pairs**. A construction of monomial bases for infinite-dimensional modules arising in the Howe correspondence analogous to "standard monomial" bases constructed by Lakshmibai and Seshadri for finite-dimensional modules.

PUBLICATIONS

Creating entanglement using integrals of motion, with Maxim Olchanii, Thibault Scoquart, Dmitry Yampolsky, and Vanja Dunjko, **Physical Review A 97 (2018) 013630**. Integrability and evolution of quantum entanglement in Galilean cannons associated with reflection groups of type A.

Integrable Families of Hard-Core Particles with Unequal Masses in a One-Dimensional Harmonic Trap, with Nathan Harshman, Maxim Olchanii, A .S. Dehkharghani, A. G. Volosniev, and N. T. Zinner, **Physical Review X 7 (2017) 041001**. New integrable systems of harmonically trapped particles associated with finite reflection groups.

On the kernel of the maximal flat Radon transform on symmetric spaces of compact type, with Eric Grinberg, **Journal of Lie Theory 27 (2017), pp. 623-636**. A uniform representation-theoretic proof of Grinberg's 1994 conjecture that the maximal flat Radon transform on a Riemannian globally symmetric space M of compact type is injective if and only if M coincides with its adjoint space.

Exactly solvable quantum few-body systems associated with the symmetries of the three-dimensional and four-dimensional icosahedra, with Thibault Scoquart, Joseph Seaward, and Maxim Olchanii, **SciPost Physics 1, 005 (2016)**. Particle systems associated with the non-crystallographic root systems H_3 and H_4.

An exactly solvable quantum four-body problem associated with symmetries of an octacube, with Maxim Olchanii, **New Journal of Physics 17 (2015) 105005**. A particle realization of the Girardeau-Gutkin system associated with the reflection group F_4.

A short note on nilpotent orbits associated to Coxeter cells, with Alfred Noël, **ACM Communications in Computer Algebra 43 (2009), pp. 52–53**. A short announcement of the central results of *Tau signatures and characters of Weyl groups*.

A new approach to computing generators for $\mathcal{U}(\mathfrak{g})^K$, with Alfred Noël, **Journal of Algebra 322 (2009), pp. 2607–2620**. An algorithm for computing generators for the centralizer of a maximal compact subgroup in the universal enveloping algebra of a reductive Lie algebra.

Toric degenerations of branching algebras, with Roger Howe, Eng-Chye Tan, Soo-Teck Lee, and Jeb Willenbring, **Advances in Mathematics 220 (2009), pp. 1809–1841**. Flat degeneration of varieties associated with branching rules for symmetric pairs to affine toric varieties.

Prehomogeneous spaces associated with nilpotent orbits in simple real Lie algebras $E_{6(6)}$ and $E_{6(-26)}$ and their relative invariants, with A. Noël, **Experimental Mathematics 15 (2006), pp. 455–469**. Determination of fundamental characters in exceptional symmetric pairs of non-inner type.

Prehomogeneous spaces associated with real nilpotent orbits, with A. Noël, **Journal of Algebra 305 (2006), pp. 194–269**. An extension of our calculation of isotypic decompositions and relative invariants to prehomogeneous spaces arising via the Kostant-Sekiguchi correspondence from nilpotent orbits in real reductive Lie algebras.

Polarizable theta-stable parabolic subalgebras and $K_{\mathbb{C}}$-saturation in the non-compact real forms of G_2 and F_4, with A. Noël, **Lecture Notes in Computer Science 3992 (2006), pp. 422–429**. Algorithms to find representatives of $K_{\mathbb{C}}$-conjugacy classes of theta-stable parabolics and compute the $K_{\mathbb{C}}$-saturations of their nilradicals.

A LiE subroutine for computing prehomogeneous spaces associated with real nilpotent orbits, with A. Noël, **Lecture Notes in Computer Science 3482 (2005), pp. 512–521**. An algorithm for determination of highest weights in prehomogeneous spaces arising via the Kostant-Sekiguchi correspondence from nilpotent orbits in simple real Lie algebras of inner type.

A LiE subroutine for computing prehomogeneous spaces associated with

complex nilpotent orbits, with A. Noël, **Lecture Notes in Computer Science 3516 (2005), pp. 611–618**. An algorithm for determination of highest weights in prehomogeneous spaces of Dynkin-Kostant type, implemented in the computer algebra system LiE.

Prehomogeneous spaces associated with complex nilpotent orbits, with A. Noël, **Journal of Algebra 289 (2005), pp. 515–557**. A computation of isotypic decompositions and relative invariants of prehomogeneous spaces of Dynkin-Kostant type arising from conjugacy classes of nilpotent elements in complex reductive Lie algebras.

PAPERS SUBMITTED FOR PUBLICATION

Tau signatures and characters of Weyl groups, with Alfred Noël, Todor Milev, and Thomas Folz-Donahue, submitted to **Representation Theory, October 2018**. An algorithm to identify irreducible representations of classical Weyl groups from their τ-signatures (i.e. the sets of parabolic subgroups admitting sign characters in the restriction). For cell representations (and hence for their special irreducible components) the τ-signature can be read off immediately from the W-graph; in particular, in the context of the *Atlas of Lie Groups and Representations* project this gives a simple algorithm for computing the associated variety of the annihilator of an irreducible Harish-Chandra module.

Incidence geometry in a Weyl chamber I: GL_n, with Mboyo Esole, Ravi Jagadeesan, and Alfred Noël, submitted to **Advances in Applied Mathematics, June 2018**. We study the central hyperplane arrangement whose hyperplanes are the vanishing loci of the weights of the first and the second fundamental representations of $\mathfrak{gl}_n$ restricted to the dual fundamental Weyl chamber. We obtain generating functions that count flats and faces of a given dimension. This counting is interpreted in physics as the enumeration of the phases of the Coulomb and mixed Coulomb-Higgs branches of a five dimensional gauge theory with 8 supercharges in presence of hypermultiplets transforming in the fundamental and antisymmetric representation of a U(n) gauge group as described by the Intriligator-Morrison-Seiberg superpotential.

Incidence geometry in a Weyl chamber II: SL_n, with Mboyo Esole, Ravi Jagadeesan, and Alfred Noël, submitted to **Advances in Applied Mathematics, June 2018**. We study the polyhedral geometry of the hyperplanes orthogonal to the weights of the first and the second fundamental representations of $\mathfrak{sl}_n$ inside the dual fundamental Weyl chamber. We obtain generating functions that enumerate the flats and the faces of a fixed dimension. In addition, we describe the extreme rays of the incidence geometry and classify simplicial faces. From the perspective of supersymmetric gauge theories with 8 supercharges in five dimensional spacetime, the poset of flats is isomorphic to the network of mixed Coulomb-Higgs branches. On the other hand, the poset of faces is conjectured to be isomorphic to the network of crepant partial resolutions of an elliptic fibration with gauge algebra $\mathfrak{sl}_n$ and "matter representation" given by the sum of the first two fundamental representations.

PREPRINTS

Two-ball billiard predicts digits of π in non-integer numerical bases, with X. M. Aretxabaleta, M. Gonchenko, N. L. Harshman, M. Olshanii, and G. E. Astrakharchik, **arXiv:1712.06698 (2017)**.

The center of the small quantum group $u_q(\mathfrak{sl}_3)$ for $l = 5$: a numerical computation, with Anna Lachowska, **arXiv:1611.08872 (2016)**. A computation of the dimension of the center of the small quantum group $u_q(\mathfrak{sl}_3)$ at the fifth root of unity.

Work in Progress

Tempered states of Girardeau-Gutkin systems associated with finite reflection groups. Classification of bound and scattering states of a free particle interacting with finite delta-potentials supported on the reflection hyperplanes of a finite reflection group.

Invariant theory of the enveloping algebra. A description of primary and secondary K-invariants in the enveloping algebra of a symmetric pair.

Orbit structure of Dynkin-Kostant spaces, with A. Noël. Full orbit decompositions and closure orderings for Dynkin-Kostant spaces arising from $\mathbb{Z}$-graded complex reductive Lie algebras.

Limited-depth Littlewood-Richardson cones and toric degeneration of the centralizer of a maximal compact in $SU(p,q)$, with Sangjib Kim. A study of the centralizer of a maximal compact subgroup in the universal enveloping algebra of $\mathfrak{su}(p,q)$, showing, in particular, that this algebra admits a SAGBI degeneration to the toric algebra associated with a polyhedral cone constructed in a straightforward manner from limited-depth Littlewood-Richardson cones, and utilizing a simplicial decomposition of the depth three LR cone to give explicit generators for $\mathcal{U}(\mathfrak{g})^K$ in the cases $\mathfrak{g} = \mathfrak{su}(p,2)$ and $\mathfrak{su}(p,3)$.

Conormality of nilpotent orbits in classical Lie Algebras, with Hervé Sabourin. Classification of nilpotent elements whose centralizers admit complementary subalgebras.

Conormality of nilpotent orbits in exceptional Lie Algebras, with Alfred Noël. Computer algebra project to find subalgebras complementary to the centralizers of nilpotent elements in exceptional algebras.

K-spherical flag varieties and multiplicity-free branching rules. An explicit determination of covariant algebras for certain affine spherical cones, leading to combinatorial (positive-sum) branching rules for the corresponding symmetric pairs.

A `Macaulay2` package for computation of invariants of reductive group actions. An implementation of Derksen's algorithm for (infinite) reductive algebraic groups.

Talks

Mathematics of X-ray crystallography, UMass Boston Mathematics Department Colloquium, March 7, 2018.

Kaleidoscopes and integrable systems, UMass Boston Mathematics Club Colloquium, February 28, 2018.

Kaleidoscopic symmetry, UMass Boston Mathematics Club Colloquium, November 29, 2017.

Lectures on the coordinate Bethe ansatz, Center for Quantum Nonequilibrium and Integrable Systems, UMass Boston, weekly throughout spring 2017.

Sign signatures and characters of Weyl groups, AMS Fall Eastern Section Meeting, Brunswick, ME, September 24, 2016.

An exactly solvable quantum four-body problem associated with symmetries of the octacube, XXXV Workshop on Geometric Methods in Physics, Bialowieza,

Poland, July 2, 2016.

Invariant theory: a gentle introduction via $\mathcal{U}(\mathfrak{g})^K$, New Mexico State University Mathematics Seminar, February 5, 2009.

A generating function for K-invariants in the universal enveloping algebra, MIT Lie Groups Seminar, May 7, 2008.

A Molien series for the centralizer of a maximal compact subgroup, Cornell Lie Groups Seminar, April 25, 2008.

Decomposing cell representations, Meeting of the Atlas of Lie Groups and Representations Project, College Park, MD, March 18, 2008.

Computing generators for the centralizer of a maximal compact subgroup in the universal enveloping algebra, UMass Boston Mathematics Seminar Series, April 30, 2007.

Polarizable theta-stable parabolic subalgebras and $K_{\mathbb{C}}$-stauration, International Conference on Computational Science, Reading, UK, May 30, 2006.

Prehomogeneous spaces associated with real nilpotent orbits and their relative invariants, AMS Special Session on Algebraic Groups, Durham, NH, April 23, 2006.

A LiE subroutine for computing prehomogeneous spaces associated with complex nilpotent orbits, International Conference on Computational Science, Workshop on Computer Algebra Systems and Applications, Atlanta, May 25, 2005.

Relative invariants of graded Lie algebras, Yale Algebra and Lie Groups Seminar, April 20, 2005.

Prehomogeneous spaces associated with complex nilpotent orbits, UMASS Boston Mathematics Seminar Series, October 4, 2004.

Coordinate systems and canonical forms, UMASS Boston College of Science and Mathematics Fall Faculty Reception, September 20, 2004.

Scalars, vectors and spinors: symmetry and representation theory in physics, Haitian Scientific Society, June 26, 2004.

Nullcone deformations and depth one tensor products, UMASS Boston Mathematics Seminar Series, April 26, 2004.

Gröbner bases and constructive representation theory, University of Southern Maine Mathematics Seminar, March 7, 2003.

Service

MTEL Objective Review Committee, Massachusetts Department of Elementary and Secondary Education, fall 2007. Reviewed and set objectives for the new mathematics subtest of the Massachusetts Test for Educational Licensure (MTEL) General Curriculum Test, the primary qualifying examination taken by prospective elementary and secondary teachers in Massachusetts.

MTEL Item Review Committee, Massachusetts Department of Elementary and

Secondary Education, spring 2008. Evaluated proposed MTEL test items for fairness, alignment to test objectives, and mathematical accuracy.

MTEL Marker Response Committee, Massachusetts Department of Elementary and Secondary Education, fall 2008. Selected sample responses to anchor the scoring system for the MTEL open-response section.

MTEL Qualifying Score Committee, Massachusetts Department of Elementary and Secondary Education, spring 2009. **Massachusetts Curriculum Frameworks Review Committee**, Massachusetts Department of Elementary and Secondary Education, spring 2008–present. Reviewed and revised the Massachusetts Curriculum Frameworks in Mathematics.

STEM Summit Panel on Cross-Disciplinary Cooperation in Mathematics Education, Massachusetts STEM Initiative, fall 2007. Panel discussion on communication and trust-building between mathematics educators and research mathematicians.

McNair Program Advisor, fall 2007–spring 2009. Supervised advanced reading and honors research of a Fellow of the Ronald McNair Post-Baccalaureate Achievement Program, which seeks to provide research opportunities for undergraduates from underrepresented groups.

Intel Mathematics Initiative Content Advisory Panel, spring 2008–spring 2009. Advised the Intel Foundation on curriculum development issues related to the Intel Mathematics Initiative.

Curriculum Committee, Department of Mathematics, AY 2004–2005, 2007–2008, 2012–2015, and 2018–2019.

Wrote final proposals for **six graduate courses** in connection with Graduate College of Education's M.Ed. in secondary mathematics program (spring 2005) and for advanced undergraduate courses in **General Topology** (spring 2008) and **Computational Algebraic Geometry** (fall 2012).

Personnel Committee, Department of Mathematics, AY 2005–2006, 2006–2007, and 2007–2008. Participated in annual faculty evaluations and a Periodic Multi-Year Review.

Recruitment Committee, Department of Mathematics. Chaired a successful national search for a faculty position (AY 2005–2006) and participated in searches for two staff positions (AY 2006–2007).

College Personnel Committee, College of Science and Mathematics, 2014–2016.

Faculty Senate, College of Science and Mathematics, AY 2005–2006, 2006–2007, and 2007–2008, and 2008–2009.

Moderated **Project NExT** session, MAA MathFest, Providence, RI, summer 2004.

Implemented **tutor training** program, UMB Mathematics Resource Center, fall 2004.

Organized student trips and coached student presentations for the **Hudson River Undergraduate Mathematics Conference**, spring 2006, spring 2007, and spring

2009.

Faculty advisor to the **Mathematics Club**, AY 2006–2007, 2007–2008, 2008–2009, and 2017–2018. Helped organize and publicize club events and off-campus trips; helped raise travel funds for five students attending the **Joint Mathematics Meetings** in January 2007; assisted with budget requests and website implementation.

Graded **Writing Proficiency Exams**, 2003–2005. Assisted with implementation of **online placement tests**, AY 2005–2006.

Reviewer for *Mathematical Reviews*.

Teaching Experience

Visiting Associate Professor — **Department of Mathematics**
Yale University — Spring 2011
New Haven, CT, USA

Organized departmental teaching seminar for new graduate instructors.

Senior Trainer — **Intel Foundation**
Intel Mathematics Initiative — Summer 2007
Boston, MA, USA

One of two Massachusetts Mathematics Partnership instructors leading a train-the-trainers scale-up of MMP-type courses in Massachusetts and California. Continuing service as a consultant on curriculum development.

Lead Instructor — **Lesley University**
Center for Mathematics Achievement — Summer 2004–Summer 2007
Cambridge, MA, USA
Headed instructional team in mathematics content workshops for K-8 teachers seeking Massachusetts professional licensure.

Courses taught:
Mathematics as a Second Language
Functions and Algebra
Trigonometry and Quadratic Functions
Number Theory
Calculus for Elementary Teachers

Assistant Professor — **University of Massachusetts**
Department of Mathematics — Fall 2003–Spring 2009
Boston, MA, USA

Courses taught:
Math 140 (Calculus I), Fall 2003, Spring 2004, Summer 2004, Fall 2007
Math 141 (Calculus II), Fall 2003, Fall 2004, Spring 2009
Math 240 (Calculus III), Spring 2004
Math 260 (Linear Algebra), Fall 2004, Fall 2006, Fall 2007, Fall 2008
Math 360 (Abstract Algebra I), Fall 2005, Fall 2006, Fall 2008
Math 361 (Abstract Algebra II), Spring 2006, Spring 2007, Spring 2009
Math 480 (Special Topics: Differentiable Manifolds and Lie Groups), Spring 2007
Math 480 (Special Topics: Computational Algebraic Geometry), Fall 2007
Math 480 (Special Topics: General Topology), Spring 2008

Instructor **Yale University**
Department of Mathematics Fall 1998–Fall 2002
New Haven, CT, USA
Lectured and moderated student discussions and group work sessions. Designed and scored examinations and homework assignments, with others. Revised departmental syllabus and established departmental assessment guidelines (with M. Frame). Supervised undergraduate research.

Courses taught:
Math 112 (Calculus I), Fall 2000, Fall 2001
Math 115 (Calculus II), Fall 1999, Fall 2002
Math 230 (Honors Vector Calculus and Linear Algebra), course assistant, Fall 1998.

Related Work Experience

Professional Tutor **University of New Haven**
Center for Learning Resources Fall 1998–Spring 2003
West Haven, CT, USA
Individual and small-group tutoring in undergraduate math and physics. Tutored courses ranging from developmental and pre-calculus mathematics through abstract algebra and real analysis.

Professional Tutor **East Stroudsburg University**
Department of Academic Enrichment Fall 1995–Summer 1997
East Stroudsburg, PA, USA
Drop-in and appointment-based tutoring, as above, with emphasis on students with disabilities and other special needs.

Instructor's Assistant **East Stroudsburg University**
Summer Intensive Study Program Summer 1996
East Stroudsburg, PA, USA
Provided individual tutoring and assessment services in a basic skills remediation program for economically and academically disadvantaged students.

Training

Departmental teaching seminar **Yale University**
Department of Mathematics Fall 1998–Spring 2000
New Haven, CT, USA
Weekly seminar on issues in the teaching of undergraduate mathematics. Topics included basic teaching skills, testing and grading, student grievances, cultural diversity, and technology in the classroom.

Tutor training **East Stroudsburg University**
Department of Academic Enrichment Fall 1995
East Stroudsburg, PA, USA
Topics included learning styles, awareness of student disabilities and other special needs, communication and listening skills, and collaborative learning.

Memberships

- Center for Quantum Nonequilibrium and Integrable Systems
- Atlas of Lie Groups and Representations Project
- American Mathematical Society
- Phi Beta Kappa