

# PATRICIA L. HERSH

North Carolina State University

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BORN: May 24, 1973, Michigan (US citizenship)

## EDUCATION

- Ph.D., **Massachusetts Institute of Technology** in Mathematics June 1999  
Thesis: *Decomposition and Enumeration in Partially Ordered Sets.*  
Advisor: Richard Stanley
- A.B., Magna cum laude, **Harvard University** in Mathematics/Computer Science June 1995  
Undergraduate Senior Thesis: *Approximate Counting of Contingency Tables Using Markov Chains.*  
Advisor: Persi Diaconis

## EXPERIENCE

- **North Carolina State University**, Department of Mathematics August 2008 - present  
Assistant Professor, 2008 - 2009  
Associate Professor, 2009 - present
- **Indiana University-Bloomington**, Department of Mathematics Fall 2004 - Summer 2009  
Assistant Professor (on leave Fall 2008 - Spring 2009); conferred tenure Spring 2009
- **Mathematical Sciences Research Institute** (MSRI), Berkeley, CA Fall 2004  
MSRI Postdoctoral Fellowship, Semester Program on Hyperplane Arrangements
- **University of Michigan**, Department of Mathematics Summer 2001 - Spring 2004  
NSF Math. Sciences Postdoctoral Research Fellow and Assistant Professor (postdoctoral position)
- **University of Washington**, Department of Mathematics Fall 1999 - Spring 2001  
Acting Assistant Professor
- **Institute for Defense Analysis** (IDA-CCR), Princeton, NJ Summers 1994, 1995 and 1998  
Summer Research Staff, Cryptology

## SELECTED GRANTS, FELLOWSHIPS AND AWARDS

- NSF Grants **DMS-0500638** (July 2005–June 2009) and **DMS-0757935** (August 2008–July 2011)
- NSF Mathematical Sciences Postdoctoral Research Fellowship Summer 2001–Spring 2004
- NSF-AWM Mentoring Travel Grant (awarded to collaborate with mentor Phil Hanlon) Summer 2000
- Hertz Foundation Graduate Fellowship Fall 1995–Spring 1999  
(One of about twenty awarded nationally each year in the applied physical sciences and mathematics)

- Awarded NSF Graduate Fellowship Spring 1995
- Elected to Phi Beta Kappa, Harvard-Radcliffe chapter (requiring A- or higher GPA) Spring 1995
- Alice T. Schafer Prize National Runner-up Spring 1994  
(Association for Women in Mathematics (AWM) national award for an undergraduate woman)

## RESEARCH INTERESTS

- Algebraic and topological combinatorics, especially interaction between combinatorics and such fields as topology, commutative algebra, representation theory and theoretical computer science.

## PUBLICATIONS

### REFEREED JOURNAL PUBLICATIONS

1. “On exact  $n$ -step domination.” *Discrete Mathematics*, **205** (1999), 235–239. Based on research done as an undergraduate at Joe Gallian’s REU at the University of Minnesota, Duluth.
2. “Deformation of chains via a local symmetric group action.” *Electronic J. Combinatorics*, **R27** (1999).
3. “Two generalizations of posets of shuffles.” *J. Combinatorial Theory, Ser. A*, **97** (2002), No. 1, 1–26.
4. (with Isabella Novik) “A short simplicial  $h$ -vector and the upper bound theorem.” *Discrete and Computational Geometry*, **28** (2002), No. 3, 283–289.
5. “Chain decomposition and the flag  $f$ -vector.” *J. Combinatorial Theory, Ser. A*, **103** (2003), No. 1, 27–52.
6. “Lexicographic shellability for balanced complexes.” *J. Algebraic Combinatorics*, **17** (2003), No. 3, 225–254.
7. “A partitioning and related properties for the quotient complex  $\Delta(B_{lm})/S_l \wr S_m$ .” *J. Pure and Applied Algebra*, **178** (2003), No. 3, 255–272. (With an appendix by Victor Reiner.)
8. (with Phil Hanlon) “Multiplicity of the trivial representation in rank-selected homology of the partition lattice.” *J. Algebra*, **266** (2003), no. 2, 521–538.
9. (with Phil Hanlon) “A Hodge decomposition for the complex of injective words.” *Pacific J. Math.*, **214** (2004), no. 1, 109–125.
10. “Connectivity of  $h$ -complexes.” *J. Combinatorial Theory, Ser. A*, **105** (2004), no. 1, 111–126.
11. (with Eric Babson) “Discrete Morse functions from lexicographic orders.” *Trans. Amer. Math. Soc.*, **357** (2005), 509–534.
12. “On optimizing discrete Morse functions.” *Advances in Applied Math.*, **35** (2005), 294–322.
13. (with Volkmar Welker) “Gröbner basis degree bounds on  $Tor_{\bullet}^{k[\Lambda]}(k, k)_{\bullet}$  and discrete Morse theory for posets”, Integer Points in Polyhedra–Geometry, Number Theory, Algebra, Optimization, 101–138, *Contemporary Mathematics*, **374**, Amer. Math. Soc., Providence, RI, 2005.
14. (with John Shareshian) “Chains of modular elements and lattice connectivity.” *Order*, **23** (2006), no. 4, 339–342.

15. (with Alexander Berglund and Jonah Blasiak) “Combinatorics of multigraded Poincaré series for monomial rings.” *J. Algebra*, **308** (2007), no. 1, 73–90.
16. (with Ed Swartz) “Coloring complexes and arrangements.” *J. Algebraic Combinatorics*, **27** (2008), no. 2, 205–214.
17. (with Robert Kleinberg) “A multiplicative deformation of the Möbius function for the poset of partitions of a multiset.” *Contemporary Mathematics*, **479** (2009), 113–119. (Special volume in honor of Joe Gallian’s 65th birthday.)
18. (with John Shareshian and Dennis Stanton) “The  $q = -1$  phenomenon for bounded (plane) partitions via homology concentration.” *Discrete Mathematics and Theoretical Computer Science* (special volume for FPSAC 2009), 471–484.
19. “Shelling Coxeter-like complexes and sorting on trees.” *Advances in Mathematics*, **221** (2009), no. 3, 812–829.
20. (with Sam Hsiao) “Random walks on quasisymmetric functions.” *Advances in Mathematics*, **222** (2009), no. 3, 782–808.

#### BOOK CHAPTER

21. (with Stephen Fienberg, Allesandro Rinaldo and Yi Zhou) “On maximum likelihood estimation in latent class models for contingency table data.” To appear as a chapter in the book “Algebraic and geometric methods in statistics”, Cambridge University Press.

## PREPRINTS

1. (with Drew Armstrong) “Sorting orders, subword complexes, Bruhat order and total positivity.” Submitted.
2. “Regular cell complexes in total positivity.” Submitted.
3. (with Cristian Lenart) “Combinatorial constructions of weight bases: the Gelfand-Tsetlin basis.” Submitted.
4. (with Phil Hanlon and John Shareshian) “A  $GL_n(q)$ -analogue of the partition lattice.” In preparation, available at <http://www4.ncsu.edu/~plhersh/papers.html>

## CONFERENCE PLENARY TALKS AND DEPARTMENTAL COLLOQUIA

- Upcoming: *UBC Math Departmental Colloquium*, March 19, 2010; *Combinatorics 2010: Advances, Trends and Speculations*, Lexington, KY (one hour plenary talk), March 26–28, 2010; *IDA-CCR Princeton Colloquium*, November 9, 2009.
- “Combinatorics and topology of regular cell complexes.” *Virginia Tech Math Departmental Colloquium*, April 2009.
- “Regular cell complexes in total positivity.” *CombinaTexas Conference*, El Paso, TX (one hour plenary talk), April 2008.
- “Connectivity bounds in combinatorics.” *University of Illinois, Urbana-Champaign Math Departmental Colloquium*, February 2007.
- “Combinatorics of multigraded Poincaré series for monomial rings.” *Conference on Trends in Topological Combinatorics*, KTH-Stockholm, Sweden (one hour plenary talk), February 2005.

- “A  $GL_n(q)$  analogue of the partition lattice and discrete Morse theory for posets.” *University of Virginia Math Departmental Colloquium*, March 2004; *Indiana University Math Departmental Colloquium*, February 2004; *LSU Math Departmental Colloquium*, December 2003; *Temple University Math Departmental Colloquium*, November 2003; *Western Michigan University Math Departmental Colloquium*, October 2003.
- “Discrete Morse functions on posets.” *Topological and Geometric Combinatorics Conference, Oberwolfach, Germany* (one hour plenary talk), April 2003.

## OTHER INVITED SEMINAR AND CONFERENCE TALKS

- Upcoming: *AMS central sectional meeting special session on Combinatorial Representation Theory*, Macalaster College, April 10-11, 2010.
- “Subword complexes, 0-Hecke algebras and a map to Bruhat order.” *UIUC Algebra, Geometry and Combinatorics Seminar*, October 2009.
- “The  $q = -1$  phenomenon for bounded (plane) partitions via homology concentration.” *FPSAC Conference, Linz, Austria*, July 2009.
- “Combinatorics and topology of regular CW complexes.” *Ulam Conference, Univ. of Florida*, March 2009; *Univ. Kentucky WILDCATS Seminar*, February 2009.
- “Regular cell complexes in total positivity.” *University of Minnesota Combinatorics Seminar*, November, 2008; *UNC-Chapel Hill Geometric Methods in Representation Theory Seminar*, October, 2008; *MIT Combinatorics Seminar*, February, 2008; *University of Michigan Combinatorics Seminar*, January 2008.
- “A homological obstruction to weak order on trees.” *65th birthday conference for Joe Gallian, Duluth, Minnesota*, July 2007; *University of Washington Algebra Seminar*, May 2007; *IMA Applications of Algebraic Geometry Seminar*, May 2007; *North Carolina State University Seminar*, March 2007.
- “Connectivity bounds in combinatorics.” *Georgia Tech Department Seminar*, February 2007; *UT Austin Algebra Seminar*, January 2007.
- “Coloring complexes and arrangements.” *University of Minnesota Combinatorics Seminar*, May 2007; *AMS eastern sectional meeting special session*, October 2006; *AMS central sectional meeting special session*, October 2006.
- “Shelling Coxeter-like complexes and sorting on trees.” *Oberwolfach (Germany), Geometric and Topological Combinatorics Conference*, February 2007; *UIUC Geometric Potpourri Seminar*, September 2006; *Joint meetings special session*, January 2006; *AMS eastern sectional meeting*, October 2005.
- “The  $q = -1$  phenomenon via homology concentration.” *UBC Joint Discrete Math, Topology and Algebra Seminar*, July 2006; *University of Washington Discrete Geometry and Combinatorics Seminar*, May 2006; *University of Wisconsin Combinatorics Seminar*, May 2006; *Ohio State University Combinatorics Seminar*, May 2006; *University of Michigan Combinatorics Seminar*, March 2006.
- “Combinatorics of multigraded Poincaré series for monomial rings.” *Philipps-Universität Marburg Combinatorics Seminar (Germany)*, June 2005; *Univ. of Kentucky Combinatorics Seminar*, April 2005; *Univ. of Minnesota Combinatorics Seminar*, March 2005.
- “Small resolutions over toric rings and discrete Morse theory for posets.” *Ohio State University Combinatorics Seminar*, March 2005.
- “Semi-group rings, resolutions and homology of monoids.” *University of Washington Combinatorics Seminar*, October 2004; *UC Davis Combinatorics Seminar*, October 2004.

- “Chains of modular elements.” *MSRI Workshop on Combinatorial Aspects of Arrangements*, November 2004; *60th Birthday Conference for Richard Stanley*, MIT, June 2004.
- “Chain decomposition and the flag  $f$ -vector” *Pomona College Algebra/Combinatorics Seminar*, May 2004.
- “A  $GL_n(q)$  analogue of the partition lattice and discrete Morse theory for posets.” *Stanford University Representation Theory Seminar*, Dec. 2004; *Cornell University Combinatorics Seminar*, Nov. 2004; *Park City Mathematics Institute, Program on Geometric Combinatorics*, July 2004; *North Carolina State University Algebra Seminar*, April 2004; *University of Wisconsin Special Combinatorics Seminar*, Nov. 2003; *AMS eastern sectional meeting*, Oct. 2003.
- “Semi-group rings and homology of monoids.” *AMS-IMS-SIAM Joint Summer Research Conference on Integer Points in Polyhedra* (Snowbird, Utah), July 2003.
- “Discrete Morse functions on posets.” *UC San Diego Special Combinatorics Seminar*, January 2003; *University of Pennsylvania Combinatorics Seminar*, January 2003.
- “A Hodge decomposition for the complex of injective words.” *Banff Recent Advances in Algebraic and Enumerative Combinatorics*, May 2003; *Philipps-Universität Marburg Combinatorics Seminar*, April 2003; *York Univ. Applied Algebra Seminar*, February 2003; *AMS southeastern sectional meeting*, November 2002.
- “Optimizing discrete Morse functions.” *Michigan State University Joint Topology/Combinatorics Seminar*, November 2002; *Univ. of Minnesota Combinatorics Seminar*, April 2002; *Univ. of Wisconsin Combinatorics Seminar*, April 2002.
- “Multiplicity of the trivial representation in rank-selected homology of the partition lattice.” *Univ. of Wisconsin Lie Algebras Seminar*, April 2002; *Univ. of Western Ontario Algebra Seminar*, March 2002; *AMS eastern sectional meeting*, October 2001.
- “Shellings and discrete Morse functions from lexicographic orders.” *Microsoft Research Combinatorics Seminar*, March 2001.
- “Discrete Morse functions from lexicographic orders.” *AMS central sectional meeting*, March 2001; *MIT Combinatorics Seminar*, March 2001.
- “Properties of the quotient complex  $\Delta(B_{kn})/S_k \wr S_n$ .” *University of Washington Algebra Seminar*, August 2001; *AMS western sectional meeting*, October 2000.
- “Flag  $h$ -vectors, quotient complexes and homology representations.” *University of Minnesota Combinatorics Seminar*, June 2000.
- “Lexicographic shellability for balanced complexes.” *UC Berkeley Combinatorics Seminar*, April 2000; *AMS eastern sectional meeting*, October 1999.
- “Flag  $f$ -vectors, symmetric functions and chain decomposition.” *University of Michigan Combinatorics Seminar*, January 1999; *Cornell University Combinatorics and Algebraic Geometry Seminar*, October 1998.
- “Shuffle posets of multisets.” *Conference on Formal Power Series and Algebraic Combinatorics (FPSAC)*, Fields Institute (Toronto), June 1998; *MIT Combinatorics Seminar*, April 1998.
- “Local  $S_n$ -action on lattices.” *University of Minnesota Combinatorics Seminar*, August 1997.

## TEACHING EXPERIENCE

- **North Carolina State University**, Raleigh, NC Fall 2008 – present  
*Instructor - Abstract Algebra* (introductory graduate class), *Combinatorics* (introductory graduate class)

- **Indiana University**, Bloomington, IN Spring 2005 – Spring 2008  
*Instructor - Linear Algebra with Applications, Brief Survey of Calculus II, Calculus III, Topological Combinatorics* (graduate topics class which had 15 students enrolled), *Calculus II, Linear Algebra for Undergrad.*
- **University of Michigan**, Ann Arbor, MI Spring 2004, Fall 2003, Fall 2002  
*Instructor - Applied Modern Algebra; Combinatorics and Graph Theory* (mixture of undergraduate and graduate students); *Linear Spaces and Matrix Theory* (joint math/electrical engineering course)
- **University of Washington**, Seattle, WA Fall 1999 – Spring 2001  
*Instructor - Calculus I, Calculus II* (160 students each); *Graduate Topics in Algebraic Combinatorics, Advanced Multivariable Calculus, Linear Algebra, Undergraduate Graph Theory, Undergraduate Combinatorics*
- **PROMYS Program - Boston University**, Boston, MA Summers 1991, 1992; Summer 1996  
*Counselor* (facilitated gifted high school students learning number theory); *Recitation Instructor*
- **Massachusetts Institute of Technology**, Cambridge, MA Spring 1998; Fall 1995  
*Teaching Assistant - Multivariable Calculus; Theory of Parallel and VLSI Computation*
- **Harvard University**, Cambridge, MA Fall 1992, Spring 1993, Fall 1993  
*Undergraduate Teaching Assistant - Multivariable Calculus, Linear Algebra, Abstract Algebra*

## SEMINARS AND SPECIAL SESSIONS ORGANIZED/CO-ORGANIZED

- **North Carolina State University**, Raleigh, NC Fall 2008–present  
*Algebra and Combinatorics Seminar*
- **SIAM Meeting on Discrete Mathematics**, Austin, TX June 2010  
*Mini-symposium on Topological Combinatorics*
- **Triangle Lectures in Combinatorics**, Raleigh, NC February 2010  
*Combinatorial workshop with four invited talks*
- **AMS Southeastern Sectional Meeting**, Raleigh, NC April 2009  
*Special Session on Rings, Algebras, and Varieties in Combinatorics*
- **AMS Central Sectional Meeting**, Bloomington, IN April 2008  
*Special Session on Combinatorial Representation Theory, Topological Combinatorics and their Interactions*
- **Indiana University**, Bloomington, IN Spring 2005–Spring 2008  
*Combinatorics Seminar*
- **Joint American/Austrian/German Math. Society Meeting**, Mainz, Germany June 2005  
*Special Session on Algebraic Combinatorics*
- **MSRI**, Berkeley, CA Fall 2004  
*MSRI Postdoc Seminar*
- **University of Michigan**, Ann Arbor, MI Fall 2003-Spring 2004  
*Combinatorics Seminar*
- **AMS Eastern Sectional Meeting**, Ann Arbor, MI March 2002  
*Special Session on Algebraic Combinatorics*
- **University of Washington**, Seattle, WA Fall 1999-Spring 2001  
*Discrete Geometry and Combinatorics Seminar*

## OTHER PROFESSIONAL ACTIVITIES RELATED TO RESEARCH

- **NSF Panel:** served on NSF combinatorics grant review panel multiple times.
- **NSA grant proposal review:** have reviewed several proposals
- **FPSAC Program Committee:** 19th annual conference on Formal Power Series and Algebraic Combinatorics. Handled refereeing of 8 extended abstract submissions for summer 2008 FPSAC conference held in Chile. FPSAC is quite possibly the largest annual combinatorics conference.
- **Refereeing and reviewing:** Advances in Mathematics, American Math Monthly, Bulletin London Math. Soc., Contributions to Algebra and Geometry, Discrete and Computational Geometry, Discrete Math, Electronic J. Combinatorics, Israel J. Math., J. Algebraic Combinatorics, J. Combinatorial Theory Ser. A, Math Reviews, Memoirs Amer. Math. Soc., Order, Pacific J. Math., Proc. Amer. Math. Soc., Rocky Mountain Math. J., SIAM J. on Discrete Math., Trans. Amer. Math. Soc. About half of these journals have asked me to referee for them repeatedly.
- **Book review:** for Math Reviews of “Algebraic combinatorics. Lectures from the Summer School held in Nordfjordeid, June 2003” by Peter Orlik and Volkmar Welker.
- **Member:** AMS, AWM

## OTHER TEACHING/MENTORING ACTIVITIES

- **Ph.D. student:** Rebecca Swanson (6th year graduate student at Indiana University; expected graduation date May 2010). Informally mentored others, most notably Daniel Jordan (Indiana University).
- **Introduced new graduate course:** (fall 2009-present, North Carolina State University) brainstormed with Nathan Reading, Carla Savage, Seth Sullivant and others on design for new year-long introductory graduate course in combinatorics leading to prelim exam in combinatorics. Teaching for first time in 2009-2010 with enumerative combinatorics in fall and geometric combinatorics in spring.
- **Proposed new undergrad course:** (fall 2007, Indiana University) coordinated brainstorming sessions regarding creation of undergrad combinatorics class and wrote proposal/course design (with Mihai Ciucu and Russell Lyons) for new course. This 300 level course was first taught in 2008-2009 and is now a regular annual course offering.
- **Math club faculty mentor:** (Spring 2005 – Fall 2005, Indiana University) helped students transform club from one that met a couple times a semester into one with weekly math talks by faculty and students.
- **Plenary lecturer at conference for undergraduates:** (July 2005, Indiana University) gave the plenary lecture for conference hosted by Indiana University for students participating in REU undergraduate research programs at various colleges and universities from across Indiana.
- **Dissertation Committees:** Shirley Law (2009, Masters thesis advisor: Nathan Reading, North Carolina State University, combinatorics); Daniel Jordan (summer 2006, Ph.D. advisor: Michael Larsen, Indiana University, computational algebra); Scott Kravitz (spring 2004, Ph.D. advisor: Phil Hanlon, University of Michigan, combinatorics); Jingui Ha (summer 2001, Masters thesis advisor: Neal Koblitz, University of Washington, cryptography).
- **University of Minnesota, Duluth REU alumni visitor/mentor:** Summers 1997, 1999, 2000, 2002, 2007. REU director Joe Gallian invites several alumni to visit his program each summer for approximately a week each to help current students by providing mathematical suggestions as well as general mentoring. Have also suggested a few possible projects for students, one of which led to a paper by Lauren Williams.

- **Initiated and organized Combinatorics Seminar “Pre-talks”:** (Fall 2002 – Spring 2004, University of Michigan) VIGRE activity in which selected speakers would give half-hour “pre-talks” prior to regular seminar talks, aimed at graduate students and post-docs, emphasizing background in the general area of the upcoming seminar talk from the point of view of an expert in the area to make seminar talks more accessible and help young mathematicians gain perspective on areas of current research.
- **Teaching Assistant, Park City Mathematics Institute’s Program on Geometric Combinatorics,** (July 2004) assisted with Michelle Wachs’ graduate course on “Poset topology: applications and tools”.

## OTHER SERVICE ACTIVITIES

- **Putnam exam committee member:** (Fall 2009, North Carolina State University math department). Leading 2 Putnam class sections on elementary number theory.
- **Women in science program (WISP) advisory board member:** (Spring 2008, Indiana University).
- **Undergrad support committee member:** (Fall 2006 – Spring 2008, Indiana University math department). Helped decide how to allocate scholarships to some exceptional undergrad math majors.
- **Web committee member:** (Fall 2005 – Spring 2006, Indiana University math department). Suggested and helped design new section for department web page with information for visitors. In the “research groups” portion of web site, created section on newly formed combinatorics group.
- **Departmental chair election committee member:** (Fall 2005, Indiana University math department) elected by math department to committee that conducted departmental chair election. Duties included discussing with numerous senior faculty members whether they would be willing to have their names on the ballot, in addition to conducting the actual election.
- **MIT Graduate Student Council executive committee, co-chair of two committees and math department representative:** (Fall 1996–Fall 1998) Co-chaired committee that redesigned institute-wide new graduate student orientation program, in response to request from MIT president that we greatly expand the program, and in particular find ways to increase interaction among departments; also co-chaired activities committee.
- **Harvard Undergraduate Math Club co-president:** (Fall 1992–Spring 1994) Co-organized undergraduate math table (with weekly math talks by faculty and students). Served as undergraduate member of department curriculum committee. Established annual newsletter in which students and alumni write articles about their experiences at various REU’s, grad schools and in math-related careers.