# Banff International Research Station

**for Mathematical Innovation and Discovery**

## Applications of Macdonald Polynomialsp
## September 9-14, 2007

### MEALS

*Breakfast (Buffet): 7:00–9:00 am, Vistas (4th floor Sally Borden Bldg.), Monday–Friday
*Lunch (Buffet): 11:30 am–1:30 pm, Vistas (4th floor Sally Borden Bldg.), Monday–Friday
*Dinner (Buffet): 5:30–7:30 pm, Vistas (4th floor Sally Borden Bldg.), Sunday–Thursday
Coffee Breaks: As per daily schedule, 2nd floor lounge, Corbett Hall
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

### MEETING ROOMS

**All lectures will be held in Max Bell 159 (Max Bell Building accessible by bridge on 2nd floor of Corbett Hall). Hours: 6 am–12 midnight. LCD projector, overhead projectors and blackboards are available for presentations.** *Please note that the meeting space designated for BIRS is the lower level of Max Bell, Rooms 155–159. Please respect that all other space has been contracted to other Banff Centre guests, including any Food and Beverage in those areas.*

### SCHEDULE

*You are welcome to schedule lectures as you see fit, as long as you adhere to the meal times (noted above), coffee break start and end times (noted below) and take into account the "welcome" on Monday morning, the Banff Centre tour on Monday afternoon and group photo on Tuesday morning.*

*When your schedule is finalized, please e-mail it to the BIRS Station Manager birsmgr@birs.ca by 12 noon on the Thursday before your arrival. You are also encouraged to e-mail the schedule to all of your participants at: <birs event id>-par@lists.pims.math.ca*

**Sunday**

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| **16:00** | Check-in begins (Front Desk - Professional Development Centre - open 24 hours) |
| | Lecture rooms available after 16:00 (if desired) |
| **17:30–19:30** | Buffet Dinner, Vistas (4th floor Sally Borden Bldg.) |
| **20:00** | Informal gathering in 2nd floor lounge, Corbett Hall (if desired) |
| | Beverages and small assortment of snacks available on a cash honour-system. |

**Monday**

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| **7:00–9:00** | Breakfast |
| **9:15–9:30** | Introduction and Welcome to BIRS by BIRS Station Manager, Max Bell 159 |
| **9:30-10:20** | Lecture 1 - Nick Loehr |
| **10:30-11:20** | Lecture 2 - Jim Haglund |
| **11:30–13:00** | Lunch |
| **13:00–14:00** | Guided Tour of The Banff Centre;(meet in the 2nd floor lounge, Corbett Hall |
| **14:00** | Group Photo; meet on the front steps of Corbett Hall |
| **14:10-15:00** | Lecture 3- Sami Assaf |
| **15:00-16:00** | Coffee Break, 2nd floor lounge, Corbett Hall - to END no later than 4 pm. |
| **17:30–19:30** | Dinner |

**Tuesday**

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| **7:00–9:00** | Breakfast |
| **10:00-10:50** | Lecture 1 - Jennifer Morse |
| **11:00-11:50** | Lecture 2 - Thomas Lam |
| **12:00–13:30** | Lunch |
| **14:00-14:50** | Lecture 3 - John Stembridge |
| **15:00-15:30** | Coffee Break, 2nd floor lounge, Corbett Hall |
| **15:30-17:00** | Poster Session |
| **17:30–19:30** | Dinner |

**Wednesday**

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|---|---|
| **7:00–9:00** | Breakfast |
| **9:30- 10:20** | Lecture 1 - Iain Gordon |
| **10:30-11:00** | Coffee Break, 2nd floor lounge, Corbett Hall |
| **11:00- 11:50** | Lecture 2 - Bogdan Ion |
| **12:00- 12:30** | Lecture 3 - Sarah Mason |
| **12:30–13:30** | Lunch |
| | Free Afternoon |
| **17:30–19:30** | Dinner |

**Thursday**

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|---|---|
| **7:00–9:00** | Breakfast |
| **10:00-10:50** | Lecture 1 - Adriano Garsia |
| **11:00-11:50** | Lecture 2 - Mike Zabrocki |
| **12:00–13:30** | Lunch |
| **14:00-14:50** | Lecture 3 - Nantel Bergeron |
| **15:00-15:50** | Lecture 4 - Tom Koornwinder |
| **17:30–19:30** | Dinner |

**Friday**

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|---|---|
| **7:00–9:00** | Breakfast |
| **10:00-11:30** | Coffee Break, 2nd floor lounge, Corbett Hall |
| **11:30–13:30** | Lunch |

**Checkout by 12 noon.**

** 5-day workshops are welcome to use the BIRS facilities (2nd Floor Lounge, Max Bell Meeting Rooms, Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **



# Applications of Macdonald Polynomials
# September 9-14, 2007

## ABSTRACTS FOR TALKS

Speaker: **Nick Loehr** (Virginia Tech, USA) (talk describes joint work with Jim Haglund and Mark Haiman)
Title: *Symmetric and Non-symmetric Macdonald Polynomials*
Abstract: Macdonald polynomials have played a central role in symmetric function theory ever since their introduction by Ian Macdonald in 1988. The original algebraic definitions of these polynomials are very non-explicit and difficult to work with. Haglund conjectured an explicit combinatorial formula for the Macdonald polynomials. This was later extended to a combinatorial formula for non-symmetric Macdonald polynomials in type A. This talk will discuss the algebraic and combinatorial definitions of both symmetric and non-symmetric Macdonald polynomials. We also sketch the main ideas in the proofs that the algebraic and combinatorial constructions are equal.

Speaker: **Jim Haglund** (Univ. of Pennsylvania, USA) will deliver a talk prepared by **Greg Warrington** (Wake Forest, USA) who had to cancel his trip
Title: *Combinatorical structures associated to the nabla operator*
Abstract: Over the past ten years, there has been a rich interplay among the modified Macdonald polynomials, the diagonal harmonics modules, the nabla operator, and the combinatorics of q,t-weighted lattice paths. In this talk, we review these connections, paying particular attention to the q,t-Catalan numbers. We finish with recent joint work of N. Loehr and G. Warrington which gives a conjectured nested-lattice-path interpretation for nabla applied to arbitrary Schur functions.

Speaker: **Sami Assaf** (Univ. of Pennsylvania, USA)
Title: *A combinatorial proof of Macdonald positivity*
Abstract: Taking Haglund's formula for the transformed Macdonald polynomials expressed in terms of monomials as the definition, we present a self-contained, combinatorial proof of symmetry and Schur positivity of Macdonald polynomials, and give a combinatorial interpretation of the Schur coefficients. The method of the proof uses the theory of dual equivalence graphs and a new generalization of them called D graphs.

Speaker: **Jennifer Morse** (Drexel Univ., USA)
Title: *An update on the $k$-Schur approach to statistics problems*
Abstract: We will review the $k$-Schur role in the theory of Macdonald polynomials and talk about some related open problems and new conjectures.

Speaker:**Thomas Lam** (Harvard Univ., USA)
Title:*$k$-Schur functions and the homology of the affine Grassmannian*
Abstract: I will explain the relationship between Lapointe, Lascoux and Morse's $k$-Schur functions and the Schubert basis of the homology $H_*(Gr)$ of the affine Grassmannian of $SL(n)$. I will state some general facts about $H_*(Gr)$ then describe Peterson's work on affine Schubert calculus. Peterson's work can be

connected to $k$-Schur functions via the Fomin-Stanley subalgebra and the theory of Stanley symmetric functions.

Speaker: **John Stembridge** (Univ. of Michigan, USA)
Title: *Kostka-Foulkes polynomials of general type and their variations*
Abstract: In this talk we plan to discuss the general features of Kostka-Foulkes polynomials for finite root systems. We will pose several problems or conjectures aimed at developing a general framework for explaining the nonnegativity of their coefficients in a combinatorial way.

If there is time, we will also discuss some additional families of univariate polynomials that also occur in representation theoretic contexts and have the same combinatorial flavor– one related to the Blattner multiplicity formula, and another related to Demazure modules.

Speaker: **Iain Gordon** (University of Edinburgh, United Kingdom)
Title: *Rational Cherednik algebras, diagonal coinvariants, and other animals*
Abstract: I will explain how the representation theory of rational Cherednik algebras is used to get a handle on diagonal coinvariants for Weyl groups. This is quite well understood, but may only be part of a broad scheme. Beyond diagonal invariants there is a dream that the representation theory could shed new light on the n! theorem and its conjectural generalisations to wreath products.

Speaker: **Bogdon Ion** (Univ. of Pittsburgh, USA)
Title: *Nonsymmetric Macdonald polynomials and applications*
Abstract: I will give a quick survey of nonsymmetric Macdonald polynomials and their properties and I will also describe some of their applications (geometric formulas for weight multiplicities and random walks on buildings).

Speaker: **Sarah Mason** (Davidson College, USA)
Title: *A specialization of nonsymmetric Macdonald polynomials*
Abstract: The nonsymmetric Macdonald polynomials can be specialized to polynomials which decompose the Schur functions. We describe several combinatorial properties of these polynomials and their connections to Demazure characters. We discuss a related family of polynomials called "key polynomials" and two new methods for constructing key polynomials.

Speaker: **Adriano Garsia** (Univ. California at San Diego, USA)
Title: *Constant terms and Kostka-Foulkes Polynomials*
Abstract: A problem that arose in Gauge Theory led us to the evaluation of a constant term with a variety of ramifications into several areas from Invariant Theory, Representation Theory, the Theory of SymmetricFunctions and Combinatorics. A significant by-product of our evaluation is the construction of a trigraded Cohen Macaulay basis for the Invariants under an action of $SL_n(\mathbb{C})$ on a space of $2n + n^2$ variables.

Speaker: **Mike Zabrocki** (York University, Canada)
Title: *TBA*

Speaker: **Nantel Bergeron** (York University, Canada)
Title: $\nabla\, k\, \Lambda$
Abstract: We present a series of problems related to $\nabla$ applied to symmetric functions. We show that the analogue results are true for non-commutative symmetric functions.

Speaker: **Tom Koornwinder** (University of Amsterdam, Netherlands)
Title: *The relationship between Zhedanov's algebra AW(3) and DAHA for Askey-Wilson*
Abstract: Zhedanov's algebra $AW(3)$ will be considered with explicit structure constants such that, in

the basic representation, the first generator becomes the second order q-difference operator for the Askey-Wilson polynomials. This representation is faithful for a certain quotient of $AW(3)$ such that the Casimir operator is equal to a special constant. A central extension of this quotient of $AW(3)$ can be embedded in the double affine Hecke algebra (DAHA) by means of the faithful basic representations of both algebras. Next I will discuss the relationship between $AW(3)$ and the spherical subalgebra of the DAHA for Askey-Wilson. This one-variable exercise should be a stepping stone for exploring analogues of $AW(3)$ in higher rank.

## ABSTRACTS FOR POSTERS

Presenter(s): **J. Haglund (Univ. of Pennsylvania) and L. Stevens (UC San Diego)**
Title: *An extension of the Foata map to standard Young tableaux*
Abstract: We define an inversion statistic on standard Yooung tableaux. We prove that this statistic has the same distribution over $SYT(\lambda)$ as the major index statistic by exhibiting a bijection on $SYT(\lambda)$ in the spirit of the Foata map on permutations.

Presenter(s): **L. Tevlin (Yeshiva Univ.)**
Title: *Noncommutative Hall-Littlewood Polynomials and q-Cauchy Identity*
iAbstract: This poster will contain a proposal for a noncommutative version of Hall-Littlewood (H-L) polynomials. These seem to be natural analogs of classical objects as ribbon H-L polynomials interpolate between ribbon Schur functions and noncommutative monomial symmetric functions, while fundamental H-L polynomials interpolate between noncommutative fundamental and monomial symmetric functions.

Presenter(s): **Alex Woo (UC Davis)**
Title: *Garnir modules, Springer fibers, and Ellingsrud-Stromme cells on the Hilbert scheme*
Abstract: We calculate defining ideals for certain $S_n$ invariant subspace arrangements of the braid arrangement and relate them (in part using duality) to the cohomology rings of Springer fibers as studied by Garsia and Procesi. This allows us to calculate their graded characters to be particular sums of Hall-Littlewood polynomials. We also relate these subspace arrangements to closed unions of cells on the Hilbert scheme.

This is joint work with Mark Haiman.