

Introductory workshop, January 22-25, 2008

The soul of Combinatorial Representation Theory (CRT) lies in the interplay between combinatorics and various branches of mathematics. Combinatorial methods are applied to solve problems in representation theory, Lie theory, geometry, and mathematical physics and, in symbiosis, deep combinatorial problems also arise from these areas. The goal of the Introductory Workshop was to survey current and recent developments in the field, and set the stage for the focus of the program.

**Lecture series:**

There were three lecture series:

- • **Michel Broué**, *Complex reflection groups in representations of finite reflection groups*,
- • **Andrei Okounkov**, *Characters of symmetric groups*
- • **Arun Ram**, *Combinatorics of Lie type*

The lecture series of M. Broué provided a bridge between the RTF program and the CRT program. The lecture series of Broué, Okounkov and Ram were designed to provide the basic fundamentals of the fields and explain the role of these topics in current research. Broué introduced finite reflection groups, unipotent characters, Deligne-Lusztig induction and restriction, and Harish-Chandra theory.

The lectures of Arun Ram set out the fundamentals of the combinatorics of root systems and path models. In these lectures he gave definitions of Hecke algebras, double affine Hecke algebras, Macdonald polynomials, crystals, Chevalley groups, loop groups, flag varieties, loop Grassmannians and Mirkovic-Vilonen cycles. In total this formed a comprehensive overview of the combinatorics of Lie types. These lectures greatly inspired a project on Hecke group algebras completed at MSRI by Anne Schilling and Nicolas Thiery (preprint arXiv:0804.3781v1 [math.RT]).

Andrei Okounkov (a Fields medallist) started with a survey of the character theory of the symmetric group. He proceeded to relate this to the Fock space realization, Gromov-Witten theory, the Hurwitz problem and finally the amazing recent results by Okounkov and Pandharipande on the relationship between the quantum cohomology of the Hilbert scheme and the Gromov-Witten/Donaldson-Thomas correspondence for local curves.

**Research talks:**

To complement the lecture series the postdoctoral fellows of the program each gave an hour long presentation introducing their research area. The topics were

- • **Kevin Purbhoo**, *The Horn Inequalities and Their Generalizations*
- • **Syu Kato**, *Geometric representation theory of affine Hecke algebras*
- • **Lauren Williams**, *Total positivity for flag varieties: combinatorics, topology, and toric geometry*
- • **Ghislain Fourier**, *Finite dimensional modules for current and loop algebras*

• • **Sami Assaf**, *Applications of dual equivalence graphs*

These talks set the trend for the research activities pursued during the program. Sami Assaf gave a beautiful account on her recent work on dual equivalence graphs, which she used to give a combinatorial proof of the Macdonald-Kostka positivity, and related these graphs to crystal graphs. Ghislain Fourier presented the analysis of finite-dimensional modules for current and loop algebras. In particular he showed how to treat the twisted cases. This ties in with work of David Hernandez, another member of the program, on twisted  $q$ -characters for Kirillov-Reshetikhin modules for all types.

**5-minute presentations:**

In addition, there were multiple sessions of 5-minute presentations where the remaining participants were able to introduce themselves mathematically and gave a feel for their current research. These sessions were a great success (there were more volunteers than we could accommodate to speak)! The talks gave an overview of what our community is working on and enabled the participants of the program to make connections with each other. Arun Ram gave a sample 5 minute presentation about  $p$ -compact groups to stimulate the participation. Other highlights included Anne Schilling (affine Schubert calculus), David Hernandez (quantum affine algebras), Nat Thiem (supercharacters), Jason Bandlow (Macdonald polynomials), Brant Jones (Kazhdan-Lusztig polynomials), Monica Vazirani (crystals), Shona Yu (Brauer algebras), Mansaoru Koyama (discrete Fourier transform).

**Funding:** Andrei Okounkov, who was one of the mini course speakers, was funded. The other main speakers were in residence at the program. Our funding included support for 12 postgraduate participants and 13 graduate students to attend the workshop for a total budget of \$30,000. The total number of registered participants was 154, with participants from the USA, Portugal, UK, Korea, Brazil, Japan, Ireland, Spain, Israel, Germany, France, Nigeria, China, Australia, Uruguay, Mexico. Of these approximately 40 were women, 30 postdocs, and 50 graduate students.

# *Introductory Workshop on Combinatorial Representation Theory* **January 22-25, 2008**

Tuesday January 22, 2008		
9:00AM - 10:00AM	Arun Ram	Combinatorics of Lie type
10:00AM - 11:00AM	Morning Break	
11:00AM - 12:00PM	Michel Broué	Complex reflection groups in representations of finite reductive groups
12:00PM - 2:00PM	Lunch at MSRI	
2:00PM - 3:00PM	Andrei Okounkov	Characters of symmetric groups
3:00PM - 4:00PM	Afternoon Tea	
4:00PM - 5:00PM	5 Minute Presentations	
5:00PM - 6:00PM	Reception	
Wednesday January 23, 2008		
9:00AM - 10:00AM	Arun Ram	Combinatorics of Lie type
10:00AM - 11:00AM	Morning Break	
11:00AM - 12:00PM	Andrei Okounkov	Characters of symmetric groups
12:00PM - 2:00PM	Lunch at MSRI	
2:00PM - 3:00PM	Kevin Purbhoo	The Horn inequalities and their generalizations
3:00PM - 4:00PM	Afternoon Tea	
4:00PM - 5:00PM	Syu Kato	Geometric representation theory of affine Hecke algebras
Thursday January 24, 2008		
9:00AM - 10:00AM	Michel Broué	Complex reflection groups in representations of finite reflective groups
10:00AM - 11:00AM	Morning Break	
11:00AM - 12:00PM	5 Minute Presentations	
12:00PM - 2:00PM	Lunch at MSRI	
2:00PM - 3:00PM	Andrei Okounkov	Characters of symmetric groups
3:00PM - 4:00PM	Afternoon Tea	
4:00PM - 5:00PM	Lauren Williams	Total positivity for flag varieties: combinatorics, topology, and toric geometry
Friday January 25, 2008		
9:00AM - 10:00AM	Arun Ram	Combinatorics of Lie type
10:00AM - 11:00AM	Morning Break	
11:00AM - 12:00PM	Ghislain Fourier	Finite dimensional modules for current and loop algebras
12:00PM - 2:00PM	Lunch at MSRI	
2:00PM - 3:00PM	Sami Assaf	Applications of dual equivalence graphs
3:00PM - 4:00PM	Afternoon Tea	
4:00PM - 5:00PM	Michel Broué	Complex reflection groups in representations of finite reflective groups

## Currently Available Videos

- Arun Ram , Combinatorics of Lie type January 22,2008, 09:00 AM to 10:00 AM
- Michel Broué , Complex Reflection Groups in Representations of Finite Reductive Groups January 22,2008, 11:00 AM to 12:00 PM
- Andrei Okounkov , Characters of Symmetric Groups January 22,2008, 02:00 PM to 03:00 PM
- Arun Ram , Combinatorics of Lie Type January 23,2008, 09:00 AM to 10:00 AM
- Andrei Okounkov , Characters of Symmetric Groups January 23,2008, 11:00 AM to 12:00 PM
- Kevin Purbhoo , The Horn Inequalities and Their Generalizations January 23,2008, 02:00 PM to 03:00 PM
- Syu Kato , Geometric representation theory of affine Hecke algebras January 23,2008, 04:00 PM to 05:00 PM
- Michel Broué , Complex Reflection Groups in Representations of Finite Reductive Groups January 24,2008, 09:00 AM to 10:00 AM
- Andrei Okounkov , Characters of Symmetric Groups January 24,2008, 02:00 PM to 03:00 PM
- Lauren Williams , Total positivity for flag varieties: combinatorics, topology, and toric geometry January 24,2008, 04:00 PM to 05:00 PM
- Arun Ram , Combinatorics of Lie Type January 25,2008, 09:00 AM to 10:00 AM
- Ghislain Fourier , Finite dimensional modules for current and loop algebras January 25,2008, 11:00 AM to 12:00 PM
- Sami Assaf , Applications of dual equivalence graphs January 25,2008, 02:00 PM to 03:00 PM
- Michel Broué , Complex Reflection Groups in Representations of Finite Reductive Groups January 25,2008, 04:00 PM to 05:00 PM

## Participant List

Name	Role	Institution
Alghamdi, Ahmad M.	Speaker	Umm Alqura University
Amdeberhan, Tewodros	Participant	Massachusetts Institute of Technology
Andre, Carlos	Participant	University of Lisbon
Ardila, Federico	Participant	Microsoft Research
Arslan, Ogul	Participant	University of Florida
Assaf, Sami H	Participant	MIT
Bandlow, Jason	Participant	UC Davis
Barcelo, Hélène	Participant	MSRI - Mathematical Sciences Research Institute
Barry, Michael J.J.	Participant	Allegheny College
Beck, Matthias	Participant	San Francisco State University
Benkart, Georgia M.	Participant	University of Wisconsin
Berg, Chris	Participant	UC Davis
Berget, Andrew Schaffer	Participant	University of Minnesota
Beyene, Kumsa Abraham	Participant	Jimma university ,Ambo college

bidkhor, hoda	Participant	Massachusetts Institute of Technology
Boltje, Robert	Participant	University of California, Santa Cruz
Braun, Ben	Participant	Washington University in St. Louis
Brenti, Francesco	Participant	N/A
Brichard, Joelle	Participant	Columbia University
Broué, Michel	Participant	Institut Henri Poincaré
Chlouveraki, Maria	Participant	École Polytechnique Fédérale de Lausanne (EPFL)
Coskun, Olcay	Participant	Bilkent University
Crites, Andrew	Participant	University Of Washington
Croitoru, Dorian	Participant	Massachusetts Institute of Technology
Culbertson, Jared	Participant	Louisiana State University
Daugherty, Zaij	Participant	University of Wisconsin
Davis, James William	Participant	NC State University
Davis, Matt	Participant	University of Wisconsin
Denton, Tom	Participant	University of California
di Francesco, Philippe	Participant	Service de Physique Theorique
Diaconis, Persi	Organizer	Stanford University
Ding, Kequan	Participant	Chinese Academy of Sciences
Dobria, Eunice Voichita	Participant	Florida Atlantic University
Doker, Jeff	Participant	UC Berkeley
Dolbin, RJ	Participant	UC Riverside
Du, Ruoxia	Participant	MIT - Massachusetts Institute of Technology
Edwards, Robert	Participant	UCLA
Elias, Benjamin Seth	Participant	Columbia University
Elizalde, Sergi	Participant	Dartmouth College
Elliot, Jason Walter	Participant	University of Illinois
Eu, Sen-Peng	Participant	U of Minnesota
Ferreira, Jeff	Participant	UC Davis
Fong, Paul	Participant	University of Illinois, Chicago
Fourier, Ghislain	Participant	Universität zu Köln
Freedman, Michael H	Participant	Microsoft
Gao, Shanzhen	Participant	Florida Atlantic University
Garrousi, Mehdi	Participant	University of Western Ontario
Glessner, Adam Marc	Participant	N/A
Goodman, Frederick	Participant	University of Iowa
Graber, John	Participant	University of Iowa
Gramain, Jean-Baptiste B	Participant	EPFL
Grant, Joseph Steven	Participant	University of Bristol
Greene, Curtis	Participant	Haverford College
Haiman, Mark David	Participant	UCB - University of California, Berkeley
Hales, Alfred W.	Participant	Institute for Defense Analyses (CCR-LJ)
Halverson, Tom	Participant	Macalester University
Hansen, Mike	Participant	N/A
Hemmer, David J.	Participant	State University at Buffalo, SUNY
Hernandez, David	Participant	N/A
Hill, David Edward	Participant	University of California, Berkeley
Hodge, Terrell L.	Participant	Western Michigan University
Johnson, Paul	Participant	University of Michigan
Jones, Brant	Participant	University of California, Davis
Jung, Ji-Hye	Participant	Seoul National University
Juteau, Daniel Pierre	Participant	Jussieu University
Kang, Seok-Jin	Participant	Seoul National University
Kantor, William U.	Participant	University of Oregon
Kashuba, Iryna	Participant	University of Sao Paulo
Kato, Syu	Participant	Kyoto University
Kedem, Rinat	Participant	University of Illinois, Urbana-Champaign
Kedlaya, Kiran Sridhara	Participant	Massachusetts Institute of Technology
Kim, Jeong-Ah	Participant	University of Seoul
Kim, Myungho	Participant	Seoul National University

Konvalinka, Matjaz	Participant	MIT
Koyama, Masanori	Participant	University of Wisconsin Madison
Kujawa, Jonathan R	Participant	University of Oklahoma
Kumsa, Abraham Beyene	Participant	Jimma university ,Ambo college
Lin, Zongzhu	Participant	Kansas State University
Liu, Fu	Participant	University of California, Davis
Liu, Zhihua	Participant	Florida Atlantic University
Lyle, Sinead	Participant	University of East Anglia
MacQuarrie, John William	Participant	The University of Manchester
Maeno, Toshiaki	Participant	Kyoto University
Maisch, Filix Portocarrero	Participant	UCSC
Maroti, Attila	Participant	University of Southern California
Mathas, Andrew	Participant	University of Sydney
Mazza, Nadia	Participant	University of Aberdeen
Mbirika, Abukuse (Aba)	Participant	University of Iowa
Mihnea, Amalya	Participant	Florida Atlantic University
Miller, Michael Gatewood	Participant	UC Santa Cruz
Moci, Luca	Participant	Roma Tre
Mogel, Jennifer	Participant	University of California, Santa Cruz
Morales, Alejandro Henry	Participant	Massachusetts Institute of Technology
Morier-Genoud, Sophie	Participant	University of Michigan
Murray, John Cyril	Participant	National University of Ireland, Maynooth
Musiker, Gregg	Participant	Massachusetts Institute of Technology
Nash, David	Notetaker	University of Oregon
Nikolova-Popova, Daniela Borislavova	Participant	Florida Atlantic University
Noonan, John	Participant	Mount Vernon Nazarene University
Oh, SuHo	Participant	Massachusetts Institute of Technology
Okada, Soichi	Participant	Nagoya University
Okounkov, Andrei	Speaker	Princeton University
Orellana, Rosa	Participant	Dartmouth College
Orrison, Michael	Participant	Harvey Mudd College
Ovchinnikov, Sergei	Participant	San Francisco State University
Panova, Greta	Participant	Harvard University
Park, Euiyong	Participant	Seoul National University
Park, Euiyong	Participant	Seoul National University
Pereira, Mariana	Participant	Facultad de Ciencias, Universidad de la Republica
Pon, Steven	Participant	UC Davis
Poonen, Bjorn	Participant	UCB - University of California, Berkeley
Purbhoo, Kevin	Participant	University of Waterloo
Qing, Yulan	Participant	Massachusetts Institute of Technology
Ragnarsson, Kari	Participant	University of Illinois, Chicago
Rainbolt, Julianne Geering	Participant	St. Louis University
Ram, Arun	Organizer	University of Melbourne
Ridenour, Timothy Blake	Participant	University of California-Riverside Mathematics Department
Ruiz, Amanda	Participant	San Francisco State University
Sanus, Lucia	Participant	Universitat de Valencia
Schilling, Anne	Organizer	University of California, Davis
Serrano, Luis	Participant	University of Michigan
Shalile, Armin	Participant	Oxford University
Shin, Dong-Uy	Participant	Hanyang University
Skyner, Tony	Participant	Bristol University
Solomon, Louis	Participant	University of Wisconsin
Späth, Britta Kerstin	Participant	N/A
Srinivasan, Bhama	Participant	University of Illinois, Chicago
Suh, Uhi Rinn	Participant	Seoul National University
Sutherland, Andrew V.	Participant	MIT
Swenson, Daniel	Participant	University of Minnesota

Symonds, Peter	Participant	University of Manchester
Talaska, Kelli	Participant	University of Michigan
Tefera, Akalu	Participant	Grand Valley State University
Tenner, Bridget Eileen	Participant	DePaul University
tevin, lenny	Participant	yeshiva university
Thiem, Nat	Participant	University of Colorado
Thiéry, Nicolas M	Participant	Faculté d'Orsay, Université Paris Sud
Tiep, Pham Huu	Participant	University of Florida
Tijjani, Manir	Participant	Federal Airport Authority of Nigeria (FAAN)
Tingley, Peter	Participant	UC Berkeley
Vazirani, Monica Joy	Participant	University of California, Davis
Virk, Rahbar	Participant	University of Wisconsin
Vuletic, Mirjana	Participant	California Institute of Technology
Walter, Marty	Participant	University of Colorado
Webb, Peter	Participant	University of Minnesota
Williams, Lauren Kiyomi	Participant	Harvard University
Wilson, Benjamin John	Participant	University of Sydney
Wolff, Tom	Participant	Ohio University
Wong Kew, Rich	Participant	Postdoc Research Fellows
Xu, Zhe	Participant	ucsc
Yacobi, Oded	Participant	UCSD
Yang, Shih-Wei	Participant	Northeastern University
Yin, Jingbin	Participant	MIT
Yip, Martha	Participant	University of Wisconsin
Yoo, Meesue	Participant	University of Pennsylvania
Yu, Josephine T.	Participant	Massachusetts Institute of Technology
Yu, Shona Huimin	Participant	The University of Sydney
Zárate, Alma Leticia	Participant	CINVESTAV IPN