



# FIELDS INSTITUTE COMMUNICATIONS

THE FIELDS INSTITUTE FOR RESEARCH IN MATHEMATICAL SCIENCES

## Representations of Finite Dimensional Algebras and Related Topics in Lie Theory and Geometry

Vlastimil Dlab  
Claus Michael Ringel  
Editors



**American Mathematical Society**



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**American Mathematical Society**  
Providence, Rhode Island

## The Fields Institute for Research in Mathematical Sciences

The Fields Institute is named in honour of the Canadian mathematician John Charles Fields (1863–1932). Fields was a visionary who received many honours for his scientific work, including election to the Royal Society of Canada in 1909 and to the Royal Society of London in 1913. Among other accomplishments in the service of the international mathematics community, Fields was responsible for establishing the world's most prestigious prize for mathematics research—the Fields Medal.

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## Preface

The Tenth International Conference on Representations of Algebras and Related Topics (ICRA X) took place at The Fields Institute in Toronto, Canada from July 15 to August 10, 2002. Although this meeting adhered to the format of the previous conferences established over 20 years ago, the Organizing Committee (R. Bautista, S. Brenner, R.-O. Buchweitz (co-chairman), M. C. R. Butler, W. Crawley-Boevey, V. Dlab (co-chairman), Y. Drozd, E. Green, D. Happel, M. Kapranov, B. Keller, H. Lenzing, Shaoxue Liu, M.-P. Malliavin, H. Merklen, J. A. de la Peña, I. Reiten, C. M. Ringel, A. V. Roiter, L. L. Scott, S. O. Smalø, A. Skowronski and H. Tachikawa) decided this time to extend the scope of the meeting by a number of Specialized Workshops.

Thus, in addition to the traditional “Instructional” Workshop preceding the Conference proper, workshops on “Commutative Algebra, Algebraic Geometry and Representation Theory” (organized by R.-O. Buchweitz, W. Crawley-Boevey and Y. Drozd), on “Finite Dimensional Algebras, Algebraic Groups and Lie Theory” (organized by E. Neher and L. L. Scott) and on “Quantum Groups and Hall Algebras” (organized by S. Berman and C. M. Ringel) took place. These were to accommodate the latest developments and to reflect an increasing interest in areas that are closely related to the representation theory of finite dimensional associative algebras. Although these workshops have been organized separately, their topics emerged strongly related.

The workshop on Commutative Algebra, Algebraic Geometry and Representation Theory intended to survey various recently established connections, such as those pertaining to the classification of vector bundles or Cohen-Macaulay modules over noetherian rings, coherent sheaves on curves, or ideals in Weyl algebras. In addition, methods from algebraic geometry or commutative algebra relating to quiver representations and varieties of modules were presented.

The purpose of the workshop on Finite Dimensional Algebras, Algebraic Groups and Lie Theory was to survey developments in finite dimensional algebras and infinite dimensional Lie theory, especially as the two areas interact and might have future interactions. A further theme was the relationship with representations of finite groups of Lie type. It is remarkable that these themes include both infinite dimensional Kazhdan-Lusztig theories, as well as theories which are of interest in a very broad finite group theory context.

The workshop on Quantum Groups and Hall Algebras dealt with the different approaches of using the representation theory of quivers (and also species) in order to construct quantum groups, working either over finite fields or over the complex numbers. In particular, these Proceedings contain a quite detailed outline of the use of perverse sheaves in order to obtain canonical bases.

The program of the Instructional Workshop consisted of nine invited series of lectures; six of these, together with a related survey of Schocker, are included in these Proceedings. The Specialized Workshops included presentations of 27 invited speakers. Thirteen of these lectures or series of lectures appear in these Proceedings. In addition, a contribution of Reineke, who was unable to attend the meeting, also appears here. Some remaining contributions reported at the Workshops will appear in separate publications.

All contributions to these Proceedings have been carefully refereed. We would like to express our gratitude to the authors who submitted contributions, and to all referees for their assistance.

Finally, let us mention that contributed papers of the Conference will appear in a separate Proceedings, also in The Fields Institute Communication series.

We gratefully acknowledge the hospitality and financial support of The Fields Institute. We would also like to thank Miryam Ali, Alison Conway and Elena Kaufman and the staff of the Institute for their help with the running of the meeting, and Debbie Iscoe for the completion of the editorial work.

Vlastimil Dlab and Claus Michael Ringel  
Ottawa and Bielefeld, October 2003

## Schedule of Talks

### INSTRUCTIONAL WORKSHOP

July 15 - July 20, 2002

K. S. BROWN, Cornell University

*Semigroup and Ring Theoretical Methods in Probability*

T. BRUESTLE, University of Bielefeld

*Typical Examples of Tame Algebras*

W. CRAWLEY-BOEVEY, University of Leeds

*Weighted Projective Lines and Applications*

H. DERKSEN, University of Michigan

*Invariant Theory for Quivers*

O. IYAMA, Kyoto University

*Solomon zeta function and Representation dimension*

A. S. KLESHCHEV, University of Oregon

*Representations of Symmetric Groups and Affine Hecke Algebras*

S. KOENIG, University of Leicester

*Filtrations, Stratifications, and Applications*

M.S. PUTCHA, North Carolina State University

*Representations and Hecke-Iwahori Algebras of Reductive Monoids*

### SPECIALIZED WORKSHOPS

August 1 - August 10, 2002

**Thursday, August 2, 2002**

KONSTANZE RIETSCH, University of Oxford

*Introduction to Perverse Sheaves I*

SEOK-JIN KANG, Korea Institute for Advanced Study

*Quantum Affine Algebras and Combinatorics of Young Walls*

VYJAYANTHI CHARI, University of California, Riverside

*Weyl Modules and the Fusion Product for Representations of Affine Lie Algebras*



TOSHIYUKI TANISAKI, Osaka University  
*Character Formulas of Kazhdan-Lusztig Type I*

HENNING HAAHR ANDERSEN, Aarhus University  
*Tilting Modules for Algebraic and Quantum Groups*

YUN GAO, York University  
*A Primer to Extended Affine Lie Algebras (Extended Affine Lie Algebras: Classification)*

**Friday, August 2, 2002**

MIKHAIL KHOVANOV, University of California, Davis  
*How and Why Semisimple Representations become Grothendieck Groups*

YURI BEREST, Cornell University  
*Cherednik Algebras and Differential Operators on Quasi-Invariants  
Ideals of the Weyl Algebra*

GEORGIA BENKART, University of Wisconsin, Madison  
*Two-Parameter Quantum Groups - They are Doubly Good*

KONSTANZE RIETSCH  
*Introduction to Perverse Sheaves II  
Introduction to Perverse Sheaves III*

**Saturday, August 3, 2002**

TOSHIYUKI TANISAKI, Osaka University  
*Character Formulas of Kazhdan-Lusztig Type II*

YUN GAO, York University  
*A Primer to Extended Affine Lie Algebras (Extended Affine Lie Algebras: Representation)*

STEPHEN BERMAN, University of Saskatchewan  
*Covering Algebras of Kac-Moody Algebras and Extended Affine Lie Algebras*

YURIY DROZD, University of Kiev  
*Vector Bundles and Cohen-Macaulay Modules I  
Vector Bundles and Cohen-Macaulay Modules II*

**Tuesday, August 6, 2002**

SUSUMU ARIKI, Kyoto University  
*A Tame/Wild Problem for Hecke Algebras of Type B*

ZONGZHU LIN, Kansas State University  
*Hall Algebras and their Relations to Quantized Enveloping Algebras*

ARTURO PIANZOLA, University of Alberta  
*Torsors and Infinite Dimensional Lie Algebras*

BANGMING DENG, Beijing Normal University  
*Hall Algebra and their Relations to Quantized Enveloping Algebras I*

KONSTANZE RIETSCH

*Introduction to Perverse Sheaves IV*

*Introduction to Perverse Sheaves V*

YOSHIHISA SAITO, University of Tokyo

*Introduction to Perverse Sheaves and Canonical Bases I*

**Wednesday, August 7, 2002**

BANGMING DENG, Beijing Normal University

*Hall Algebra and their Relations to Quantized Enveloping Algebras II*

YOSHIHISA SAITO, University of Tokyo

*Introduction to Perverse Sheaves and Canonical Bases II*

*Introduction to Perverse Sheaves and Canonical Bases III*

OLIVIER SCHIFFMANN, Yale University

*Hall Algebra of the Cyclic Quiver*

*Elliptic Algebras and Weighted Projective Lines*

ZONGZHU LIN, Kansas State University

*Hall Algebra and their Relations to Quantized Enveloping Algebras*

J. E. HUMPHREYS, University of Massachusetts, Amherst

*Cells in Affine Weyl Groups and Reduced Enveloping Algebras*

**Thursday, August 8, 2002**

JAN SCHROER, University of Leeds

*Irreducible Components of Varieties of Modules*

IGOR BURBAN, Universitaet Kaiserslautern

*Derived Categories of Coherent Sheaves on Degenerations of Elliptic Curves*

YURIY DROZD, University of Kiev

*Vector Bundles and Cohen-Macaulay Modules III*

JIE DU, University of New South Wales

*Stratified Algebras and Representations of Finite Groups of Lie Type*

VOLODYMYR MAZORCHUK, Uppsala University

*Stratified Algebras Arising in Lie Theory*

MATTHEW DYER, University of Notre Dame

*Shellability and Highest Weight Representations*

**Friday, August 9, 2002**

KARIN ERDMANN, University of Oxford

*Tilting modules for Schur algebras*

ALEXANDER S. KLESHCHEV, University of Oregon

*Cartan Determinants and Shapovalov Forms*

PETER J. WEBB, University of Minnesota  
*Lie Theory in the Context of Finite Groups*

JIE DU, University of New South Wales  
*Ringel-Hall Algebras and the Geometric Setting of Quantum  $GL_n$*

BRIAN PARSHALL, University of Virginia  
*Cohomology in Non-Describing Characteristics*

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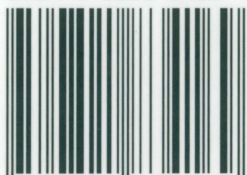
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