

Curriculum Vitæ

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Research

My interests span a number of subtly related areas of mathematics. The focus of my work since my Ph.D has been the development of a collection of tools from higher category theory and homotopical algebra and the application of these tools to the study of K -theory and partial differential equations in sundry algebro-geometric contexts.

- Higher categories** The technical cornerstone of my work is the homotopical algebra of weakly enriched \mathbf{M} -categories for internal model categories \mathbf{M} . I have shown that the collection of all such entities forms a model category with excellent formal properties; thus the homotopy theory of weakly enriched \mathbf{M} -categories is rich and, more importantly, computable. I have also shown that virtually all of the “classical” results of ordinary category theory have suitable analogues in this context. Via suitable choices of \mathbf{M} , the theory of weakly enriched \mathbf{M} -categories includes the theory of (weak) (m, n) -categories and (m, n) -stacks (i.e., sheaves of (m, n) -categories) for any $0 \leq m \leq \infty$ and $0 \leq n \leq m$.
- Operator categories** A new theme in my work has been the study of homotopy coherent algebra via combinatorial gadgets I call operator categories. In effect, the objects of an operator category are indexing sets for multiplication laws. These can be used to describe E_n and A_n structures in great generality in a purely combinatorial fashion. This new technology has allowed me, for example, to demonstrate that the $(\infty, 1)$ -category of modules over an E_n -ring spectrum is E_{n-1} -monoidal. From this one can deduce, using the homotopical algebra of higher categories mentioned above, that the THH of an E_n -ring spectrum is an E_{n-1} ring spectrum. It has also allowed me to prove a generalization of the Breen-Baez-Dolan Stabilization Hypothesis. Finally, it may provide a promising approach to determining whether various A_∞ ring spectra — such as BP — have an E_∞ -structure.
- K -theory** An example of M. Schlichting demonstrates that there is no hope to recover the K -theory of a ring from its derived category alone; however, as observed by B. Toën and G. Vezzosi, K -theory is an invariant of the $(\infty, 1)$ -category. I have advanced this point of view in two ways: first, K -theory can be characterized as the universally additive functor from the category of “Waldhausen” $(\infty, 1)$ -categories to a suitable category of spectra. Second, I have also given a direct construction of the K -theory of such $(\infty, 1)$ -categories, extending work of Waldhausen. This more functorial point of view on K -theory has allowed to prove a number of new theorems — among them the assertion that the K -theory of an E_n -ring spectrum is an E_{n-1} -ring spectrum in a canonical fashion.
- \mathcal{D} -crystals** The $(\infty, 1)$ -category of \mathcal{D} -crystals is a surrogate for the $(\infty, 1)$ -category of complexes of D -modules (i.e., modules over the ring of differential operators) that is well-behaved for arbitrary varieties, irrespective of characteristic or smoothness assumptions. There is an $(\infty, 1)$ -category of \mathcal{D} -crystals on stacks and higher stacks as well, and \mathcal{D} -crystals may be twisted by ∞ -gerbes. The morphism spectra of this and related $(\infty, 1)$ -categories are cohomology theories of de Rham and Beilinson-Deligne type. I have been able to show that the K -theory of these categories coincides with the G -theory of the variety or stack itself; this provides a new perspective on the Beilinson regulator. Perhaps most interestingly, many of these $(\infty, 1)$ -categories have well-behaved symmetric monoidal structures, and the geometry of the commutative (or E_∞ -) algebras in these categories is closely linked with a kind of microlocal analysis.

Employment History

- 2007–08 Institute for Advanced Study. Visitor, Term I; Member, Term II. *New connections of representation theory to algebraic geometry and physics*. Project leader: R. Bezrukavnikov.
- 2006–08 Matematisk Institutt, Universitetet i Oslo. YFF (Yngre fremragende forskere) Postdoctoral fellow. *Geometry and arithmetic of structured ring spectra*. Project leader: J. Rognes.
- 2005–06 Mathematisches Institut Göttingen. DFG (Deutsche Forschungsgemeinschaft) Postdoctoral fellow. *Homotopical algebraic geometry*. Project leader: Yu. Tschinkel.

Education

- 2001–05 University of Pennsylvania. Ph.D in Mathematics. Thesis title: $(\infty, n)\mathbf{Cat}$ as a Closed Model Category. Adviser: T. Pansev.
- 1997–2001 University of North Carolina at Chapel Hill. B.Sc in Mathematics, with Highest Honors. Adviser: J. Stasheff.

Honors and Memberships

- Member, 2007– American Mathematical Society.
- Member, 2006– Société Mathématique de France.
- 2001–05 Eugenio Calabi Scholar. University of Pennsylvania.
- 2001 Archibald Henderson Prize in Mathematics, University of North Carolina.

Selected Invited Presentations

- March 2008 Workshop on New Topological Contexts for Galois Theory and Algebraic Geometry at the Banff International Research Station for Mathematical Innovation and Discovery: TBA.
- February 2008 Thirty-five minute lecture at the Special Session on Algebraic Topology at the Joint European Math Society/Danish Mathematical Society Meeting in Copenhagen: TBA.
- December 2007 One-hour lecture at the Max Planck Institut in Bonn: TBA.
- October 2007 One-hour lecture at the Massachusetts Institute of Technology: *Operator Categories and Strictification of Homotopy Coherent Algebraic Structures*.
- June 2007 One-hour lecture at the Matematisk Institutt Universitetet i Bergen: *Operator Categories, Multicategories, and K-Theory*.
- March 2007 One-hour lecture at the Fields Institute in Toronto: *Differential Calculus in Spectral Algebraic Geometry*.
- November 2006 One-hour lecture in Essen: *A New Perspective on Grothendieck-Verdier Duality*.
- September 2006 One hour lecture at the Matematisk Institutt Universitetet i Oslo: *Crystals and \mathcal{D} -Crystals in Spectral Algebraic Geometry*.
- July 2006 Forty-five minute lecture at Oberwolfach: *\mathcal{D} -Crystals*.
- June 2006 Two hour lecture at the Mathematischen Institut Göttingen: *Toward a Theory of Higher-Dimensional Chiral Algebras*.
- May 2006 Two hour lecture at the Université de Nice – Sophia Antipolis: *Divided Power Structures and the Crystalline Topos in Spectral Algebraic Geometry*.
- May 2006 Extemporaneous two-hour lecture at the Université de Nice – Sophia Antipolis: *Rezk Multi- (∞, n) -Categories*.
- March 2005 Two hour lecture at the University of Chicago: *(∞, n) -Stacks and Algebraic Geometry over Structured Ring Spectra*.
- December 2004 Five hour lecture series at the Mathematischen Institut Göttingen: *∞ -Groupoids, Stacks, and Segal Categories*.

- December 2003 One hour lecture at the University of Pennsylvania: *On the Chiral Algebras of Beilinson and Drinfeld*.
- November 2003 Three hour lecture series at the University of Pennsylvania: *Tannakian Fundamental Groups and the Deligne–Ihara Conjecture*.
- July–August 2003 Three hour lecture series at the University of Pennsylvania: *Analytic Continuation via Coleman Integration and Furusho’s p -adic Multiple Zeta Values*.
- May–June 2003 Two hour lecture series at the University of Pennsylvania: *Soulé’s Approach to Varieties over \mathbf{F}_1* .
- February 2003 Two hour lecture series at the University of Pennsylvania: *Fundamental Groups via Fibre Functors*.
- October 2001 Two hour lecture series at the University of Pennsylvania: *Model Categories and Simplicial Objects*.

Selected Conferences

- June 2007 *Norwegian Topology Symposium*, organized by M. Brun, B. I. Dundas, and C. Schlichtkrull, at the Matematisk Institutt Universitetet i Bergen.
- March 2007 *Thematic Program on Geometric Applications of Homotopy Theory*, organized by G. Carlsson, D. Christensen, and J. F. Jardine, at the Fields Institute, Toronto.
- September 2006 *Topological Algebraic Geometry*, organized by J. Rognes, at the Matematisk Institutt, Universitetet i Oslo.
- July 2006 *Algebraic K-Theory*, organized by D. Grayson, A. Huber-Klawitter, U. Jannssen, and M. Levine, at Oberwolfach.
- May 2006 *Higher Stacks in Algebraic Geometry*, organized by C. Simpson and B. Toën, at the Université de Nice — Sophia Antipolis.
- July 2005 *Algebraic Groups*, organized by Yu. Tschinkel at the Mathematischen Institut Göttingen.
- June 2004 *Workshop on Higher Categories and Nonabelian Hodge Theory*, organized by B. Toën, at the Laboratoire Émile Picard at the Université Paul Sabatier in Toulouse.
- April 2004 *Workshop on Motives, Homotopy Theory of Varieties, and Dessins d’Enfants*, organized by G. Carlsson and R. Jardine, at the American Institute of Mathematics in Palo Alto.
- May 2003 *RIMS 2*, organized by M. Fried, at the University of California in Irvine.
- January 2002 *Introductory Workshop on Algebraic Stacks, Intersection Theory, and Nonabelian Hodge Theory*, organized by T. Pantev, L. Katzarkov, and B. Toën, at the Mathematical Sciences Research Institute in Berkeley.

Works Completed

- “On Reedy Model Structures.” Preprint, arXiv:0708.2832.
- “On the Dreaded Right Bousfield Localization.” Preprint, arXiv:0708.3435. Submitted to the *Journal of Topology*
- “On (Enriched) Left Bousfield Localizations of Model Categories.” Preprint, arXiv:0708.2067. Submitted to the *Journal of Topology*

Works In Progress

- Weakly Enriched \mathbf{M} -Categories I* (Monograph).
- Weakly Enriched \mathbf{M} -Categories II* (Monograph).
- “On the Homotopy Theory of Divided Power Algebras.”
- “On Additive Functors of Waldhausen ∞ -Categories.”
- “On the Geometry of \mathcal{D} -Crystals.”
- (with J. Rognes) *Crystals and Logarithms in Spectral Algebraic Geometry*.
- (with M. Spitzweck) “On Multi- ∞ -categories.”

“On Higher-Dimensional Chiral Algebras”

(with P. A. Østvær) *Spectral Motives*.

Notes

“Operator Categories, Multicategories, and Homotopy Coherent Algebra.” Preprint.

“ \mathcal{D} -Crystals.” In *Algebraic K-Theory*. Mathematisches Forschungsinstitut Oberwolfach Report No. 32/2006.

“ ∞ -Groupoids, Stacks, and Segal Categories.” In *Mathematisches Institut Georg-August-Universität Göttingen Seminars Wintersemester 2004–05*.

Mentoring

P. Arndt Doctoral student, joint with M. Spitzweck. Tentative thesis title: *Descent for Grothendieck–Verdier Duality*. Expected date of Ph.D: 2008.

Teaching

2006–08 Matematisk Institutt, Universitetet i Oslo. *Infinity categories for Fun and Profit*. Mini-course on the theory of higher categories and their applications.

Summer 2006 Mathematisches Institut Göttingen. *Topics in Algebraic Geometry II*. The homotopy theory of (∞, n) -categories and (∞, n) -stacks.

Winter 2005–06 Mathematisches Institut Göttingen. *Topics in Algebraic Geometry*. Homotopical algebra, sites and topoi, schematization of homotopy types, algebraic K -theory, Grothendieck–Verdier duality.

Spring 2005 University of Pennsylvania. *Mathematics 104*. Calculus I: integrals, transcendental functions, methods of integration, series, Taylor’s Theorem (under M. Pimsner).

Summer 2004 University of Pennsylvania. *Mathematics 170*. Ideas in mathematics: Mathematics in politics; logic, language, and voting (self-designed).

Spring 2004 University of Pennsylvania. *Mathematics 104*. Calculus I: integrals, transcendental functions, methods of integration, series, Taylor’s Theorem (under D. DeTurck).

Fall 2003 University of Pennsylvania. *Mathematics 502*. Master’s-level algebra I: groups, rings, and modules (under C.-L. Chai).

Summer 2003 University of Pennsylvania. *Mathematics 170*. Ideas in mathematics: A naïve view of rings and varieties (self-designed).

Spring 2003 University of Pennsylvania. *Mathematics 503*. Master’s-level algebra II: rings, modules, fields, categories (under T. Chinburg).

Fall 2002 University of Pennsylvania. *Mathematics 104*. Calculus I: integrals, transcendental functions, methods of integration, series, Taylor’s Theorem (under E. Crotty).

Summer 2002 University of Pennsylvania. *Mathematics 240*. Calculus III: linear algebra, calculus in \mathbf{R}^n , “baby” manifold theory (self-designed).