

## Justin Noel

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### Research Interests

- **Algebraic Topology**
  - Equivariant homotopy theory.
  - Derived algebraic and differentiable geometry.
  - $H_\infty$  and  $E_\infty$  ring spectra.
  - The interplay between unstable and stable homotopy theory, (especially after  $K(n)$ -localization).

### Education

- **University of Chicago** Chicago, IL  
*Ph.D. in Mathematics* August 2009
  - Advisor: Peter May
  - Thesis: Some Applications of the Theory of Formal Groups to Algebraic Topology*M.S. in Mathematics* June 2005
- **University of California, Santa Cruz** Santa Cruz, CA  
*B.A. in Mathematics with Highest Honors* June 2003
  - Advisors: Chongying Dong and Richard Montgomery
  - Thesis: The Endomorphism Algebra of a Vertex Operator Algebra.*B.S. in Computer Science with Highest Honors* June 2003

### Academic Experience

- **Mathematisches Institut der Universität Bonn / Max-Planck-Institut für Mathematik** Bonn, Germany  
*Postdoctoral Researcher* October 2010-September 2013
  - Worked with Stefan Schwede.
  - Worked with doctoral students from the University of Bonn.
  - Organized a working seminar on the non-existence of elements of Kervaire invariant one.
  - Organized a working seminar on Goodwillie calculus.
- **Institut de Recherche Mathématique Avancée** Strasbourg, France  
*Postdoctoral Researcher* September 2009-August 2010
  - Independently researched topics of interest to the HGRT research group (New links between homotopy theory, group theory, and representation theory).
- **University of Chicago** Chicago, IL  
*College Lecturer* September 2005-June 2009 (8 quarters)
  - Taught first and second year courses in calculus that targeted biology, chemistry and economics majors.
  - Wrote syllabi, homeworks, exams and oversaw 3 course assistants.
  - Designed independent study projects in mathematics for 4 advanced undergraduate students and guided them through one-on-one meetings.
  - Served on graduate student committee.
- **Massachusetts Institute of Technology** Cambridge, MA  
*Research Affiliate* March 2007-June 2007
  - Visiting scholar under the sponsorship of Mark Behrens.
- **University of Chicago** Chicago, IL  
*REU Asst. Coordinator* June 2005-August 2007 (3 Summers)
  - Managed a group of 5 graduate students who were responsible for mentoring 2-3 undergraduates a piece and typing lecture notes for courses.
  - Designed independent study projects in mathematics for 9 students.

- **University of Chicago**  
College Fellow  
– Teaching Assistant for real analysis.  
– Led problem sessions and graded homework.

Chicago, IL  
September 2004-June 2005

### Additional Research Experience

- **Susquehanna Investment Group** Bala Cynwyd, PA  
Quantitative Researcher Intern May 2008 - August 2008  
– Improved convergence of Black-Scholes algorithm in order to more accurately calculate the 'Greeks' in vanilla options.  
– Isolated and eliminated several convergence problems in Black-Scholes computations.
- **Learning and Experimental Economics Projects** Santa Cruz, CA  
Student Programmer April 2002 - June 2003  
– Wrote "Double Market," a Java based client/server application for simulating dishonest markets.
- **Research Experience For Undergraduates** State College, PA  
Mentor: Svetlana Katok June 2002 - August 2002  
– Studied arithmetic and geometric coding of modular flows.

### Awards

HGRT Postdoctoral Research Support, Strasbourg, France	September 2009-June 2010
3 Midwest Topology Network NSF Grants	March 2009-June 2009
NSF/VIGRE Grants	Spr. 2006,2007, Win.-Spr. 2008, Spr. 2009
Summer Research Grants	2004-2008
NSF Graduate Research Fellowship Honorable Mention	2005
Stevenson College Honors	2003
UC Regents Scholar (Full Tuition Scholarship)	1999-2003
Colin C. Belin Fellowship in Computer Science (\$1000)	1999

### Publications

- **For Complex Orientations Preserving Power Operations,  $p$ -typicality is Atypical**  
with Niles Johnson <http://arxiv.org/abs/0910.3187>  
*Topology and its applications* doi:10.1016/j.topol.2010.06.007  
We show, for primes  $p \leq 13$ , that a number of well-known  $MU_{(p)}$ -rings do not admit the structure of commutative  $MU_{(p)}$ -algebras. These spectra have complex orientations that factor through the Brown-Peterson spectrum and correspond to  $p$ -typical formal group laws. We provide computations showing that such a factorization is incompatible with the power operations on complex cobordism. This implies, for example, that if  $E$  is a Landweber exact  $MU_{(p)}$ -ring whose associated formal group law is  $p$ -typical of positive height, then the canonical map  $MU_{(p)} \rightarrow E$  is not a map of  $H_\infty$  ring spectra. It immediately follows that the standard  $p$ -typical orientations on  $BP$ ,  $E(n)$ , and  $E_n$  do not rigidify to maps of  $E_\infty$  ring spectra. We conjecture that similar results hold for all primes.

### Preprints

- **Derived smooth manifolds: A simplicial approach**  
with Dennis Borisov Preprint: <http://arxiv.org/abs/1112.0033>  
Derived differential manifolds are constructed using the usual homotopy theory of simplicial rings of smooth functions. They are proved to be equivalent to derived differential manifolds of finite type, constructed using homotopy sheaves of homotopy rings (D.Spivak), thus preserving the classical cobordism ring. This reduction to the usual algebraic homotopy can potentially lead to virtual fundamental classes beyond obstruction theory.
- **$H_\infty \neq E_\infty$**  Preprint: <http://arxiv.org/abs/0910.3566>  
We provide an example of a spectrum with an  $H_\infty$  structure which does not rigidify to an  $E_3$  structure. It follows that not every  $H_\infty$  ring spectrum comes from an underlying  $E_\infty$  ring spectrum. After comparing definitions, we obtain this example by applying  $\Sigma_+^\infty$  to the counterexample to the transfer conjecture constructed by Kraines and Lada.

- **Generalized Witt Schemes in Algebraic Topology**

Preprint: <http://nullplug.org/publications/generalized-witt-schemes.pdf>

We analyze the even-periodic cohomology of the space  $BU$  and some of its relatives using the language of formal schemes as developed by Strickland. In particular, we connect  $E^0(BU)$  to the theory of Witt vectors and  $\lambda$ -rings. We use these connections to study the the coproduct arising from the tensor product in terms of  $E$ -theory Chern classes. We then exploit this connection to simultaneously construct Husemoller's splitting of  $H\mathbb{Z}_{(p)}^*(BU)$  and Quillen's splitting of  $MU_{(p)}$ .

<b>Papers in Progress</b>
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- **Lifting homotopy  $T$ -algebra maps to strict maps**

with Niles Johnson

Draft: <http://nullplug.org/publications/obstruction-theory.pdf>

Many categories of interest to homotopy theorists such as simplicial groups, simplicial rings,  $A_\infty$  spaces,  $E_\infty$  ring spectra, etc., are each equivalent to the category of algebras over some monad  $T$ . In such cases,  $T$  is acting on a nice simplicial model category in such a way that the  $T$  descends to a monad on the homotopy category and defines a category of *homotopy*  $T$ -algebras. In such cases there is a forgetful functor from the homotopy category of  $T$ -algebras to the category of homotopy  $T$ -algebras.

Under suitable hypotheses we provide an obstruction theory, in the form of a Bousfield-Kan spectral sequence, for lifting a homotopy  $T$ -algebra map to a strict map of  $T$ -algebras. Once we have a map of  $T$ -algebras to serve as a basepoint, the spectral sequence computes the homotopy groups of the space of  $T$ -algebra maps and the edge homomorphism on  $\pi_0$  is the aforementioned forgetful functor. We also discuss under what conditions the required hypotheses are satisfied.

When  $T$  is the monad whose algebras are  $E_\infty$  ring spectra, the forgetful functor takes values in  $H_\infty$  ring spectra. We provide examples arising from unstable rational homotopy theory to show that this functor is generally neither full nor faithful.

- **$K$ -theory as a universal Picard  $\infty$ -groupoid**

with Masoud Kamgarpour

In Progress

Building on ideas from Jacob Lurie's work on the Baez-Dolan cobordism hypothesis and classical results about  $n$ -fold loop spaces we construct a universal Picard  $\infty$ -groupoid from a  $k$ -monoidal  $(\infty, n)$ -category. Picard  $\infty$ -groupoids correspond to connective spectra and when we apply this construction to a symmetric monoidal topological groupoid  $\mathcal{C}$  we obtain the algebraic  $K$ -theory spectrum associated to  $\mathcal{C}$ . Via this construction we can realize algebraic  $K$ -theory as the categorified analog of Grothendieck's  $K$ -construction which formally adds inverses to a commutative monoid to obtain an abelian group in a universal way.

By applying our more general construction to bordism categories of framed manifolds we can recover a form of the cobordism hypothesis namely that any field theory on such a category taking values in a Picard  $\infty$ -groupoid is determined by its value on a point. We then study an explicit field theory landing in the Brauer Picard groupoid of super central simple algebras over  $\mathbb{C}$  which detects the first two stable homotopy groups of spheres.

- **Spectral Sequences in Rational Homotopy Theory**

In Progress

We show that a special case of the spectral sequence constructed by Johnson and Noel can be identified with the rational unstable Adams spectral sequence, which is identified with a special case of the Goerss-Hopkins spectral sequence, which is, in turn, identified with a dual form of the spectral sequence of Halperin and Stasheff. As a consequence the edge homomorphisms which, *a priori*, detect different phenomena can be identified. These spectral sequences can be embedded in the Eilenberg-Moore spectral sequence, their differentials are determined by Massey products, and Whitehead products lift filtration.

- $\pi_\star^G H\mathbb{Z}$

In Progress

We make a number of computations in the  $RO(G)$  graded ordinary integral cohomology theory  $H\mathbb{Z}$ , where  $\mathbb{Z}$  is the unique Mackey functor taking values only at  $\mathbb{Z}$  and with all restriction homomorphisms the identity map. These include computations for  $G = C_{p^n}, D_n, Q_n, A_4$ , and  $\Sigma_4$ . In the cyclic case we describe the multiplicative structure. The key tool for these computations is an Atiyah-Hirzebruch spectral sequence for  $RO(G)$ -graded cohomology theories.

- **The Morava  $K$ -theory of Coker  $J$  And Higher Chromatic Analogues**

with Nick Kuhn

In Progress

We show that the  $K(2)$ -homology of the infinite loop space  $\text{Coker } J$  is isomorphic to the free Morava  $K$ -theory Dyer-Lashof algebra on a single generator. Corollaries of this computation include a description of the  $E$ -cohomology of  $\text{Coker } J$ , where  $E$  is either  $K(2)$ ,  $E_2$ ,  $tmf$ , or  $E_2^{hG}$ , where  $G$  is a subgroup of the second Morava stabilizer group. We then define higher chromatic analogues of  $\text{Coker } J$  to obtain analogous results.

This extends the work of Hodgkin and Snaith on the  $K$ -theory of the infinite loop spaces  $J$  and  $\text{Coker } J$ .

## Lectures

- **Conference Lectures**

- November 11th, 2011 - NRW Conference: Böchum, Germany - From  $H_\infty$  to  $E_\infty$ .
- August 31st, 2011 - GDR Conference: Topologie Algèbrique et Applications, Nantes, France - Rational Homotopy Theory and  $H_\infty$  Maps.
- Fall 2009 - GDR Conference: Topologie Algèbrique et Applications, Strasbourg, France - For Complex Orientations Preserving Power Operations,  $p$ -Typicality is Atypical.
- Spring 2009 - Conference on Algebraic Topology, Group Theory and Representation Theory, Isle of Skye, Scotland -  $H_\infty$  Orientations which are  $p$ -Typical are Atypical.
- Spring 2009 - Graduate Student Topology Conference, Madison, Wisconsin -  $H_\infty$  Orientations which are  $p$ -Typical are Atypical.
- Fall 2008 - Algebraic Topology Conference, Buenos Aires, Argentina - A New Perspective on Old Splittings.
- Fall 2008 - AMS Regional Conference, Kalamazoo, MI - Witt Schemes in Algebraic Topology.
- Fall 2008 - AMS Regional Conference, Vancouver, BC - Witt Schemes in Algebraic Topology.
- Winter 2008 - Graduate Student Topology Conference, University of Illinois, Urbana-Champaign - The Yoneda Lemma, Hopf Algebras, and Algebraic Topology.

- **Senior Colloquia**

- April 17th, 2012 - University of Hamburg - Goodwillie Calculus.

- **Seminar Lectures**

- February 20th, 2012 - University of Copenhagen, Geometry seminar - Maps of Homotopy  $T$ -algebras.
- January 9th, 2012 - University of Osnabrück, Seminar on combinatorial structures in algebra and topology - Map of Homotopy  $T$ -algebras.
- October 27th, 2011 - University of Texas, Austin, Geometry Seminar - An Alternative Model for Derived Manifolds.
- October 24th, 2011 - University of Georgia, Athens, Algebra/Topology Seminar - Equivariant cohomology of representation spheres.
- October 11th, 2011 - University of Chicago, Topology Seminar - Rational Homotopy Theory and  $H_\infty$  Maps.
- October 10th, 2011 - Northwestern University, Topology Seminar - Rational Homotopy Theory and  $H_\infty$  Maps.
- April 12th, 2011 - University of Bonn, Topology Seminar - Some Elementary Computations in Bredon Cohomology.
- March 14th, 2011 - Max Planck Institute for Mathematics, Topology Seminar - Some Elementary Computations in Bredon Cohomology.
- January 17th, 2011 - University of Münster, Topology Seminar - Some Elementary Computations in Bredon Cohomology.
- February 18th, 2011 - Northwestern University, Topology Seminar - When  $H_\infty = E_\infty$ .
- May 4th, 2010 - Ruhr-University of Böchum, Topology Seminar - For Complex Orientations Preserving Power Operations,  $p$ -Typicality is Atypical.
- February 11th, 2010 - University of Georgia, Topology Seminar - For Complex Orientations Preserving Power Operations,  $p$ -Typicality is Atypical.
- February 6th, 2010 - University of Glasgow, Algebra Seminar - For Complex Orientations Preserving Power Operations,  $p$ -Typicality is Atypical.
- February 2nd, 2010 - University of Sheffield, Transpennine Topology Circle - For Complex Orientations Preserving Power Operations,  $p$ -Typicality is Atypical.
- January 14th, 2010 - University of Paris XIII, Topology Seminar - For Complex Orientations Preserving Power Operations,  $p$ -Typicality is Atypical.
- December 15th, 2009 - University of Bonn, Topology Seminar - When  $H_\infty = E_\infty$ .
- December 4th, 2009 - University of Lille, Topology Seminar - When  $H_\infty = E_\infty$ .

- Fall 2009 - University of Strasbourg, Topology Seminar -  $H_\infty$  Orientations and  $p$ -typicality (2 lectures).
- Summer 2009 - University of Chicago, Topology Seminar - Some Applications of the Theory of Formal Groups to Algebraic Topology.
- Spring 2009 - Northwestern University, Topology Seminar -  $H_\infty$  Orientations on  $BP$ .
- Winter 2009 - University of Chicago, Topology Seminar - The Morava  $K$ -theory of Coker  $J$  and Higher Chromatic Analogues.
- **Junior Colloquia**
  - October 26th, 2011 - University of Texas, Austin, Informal Topology Seminar - Some elementary computations in Bredon cohomology.
  - October 18th, 2011 - University of Georgia, Athens, Graduate Student Seminar - Equivariant cohomology.
  - February 10th, 2010 - University of Georgia, Athens Graduate Student Seminar - On the Hopf Invariant One Problem.
  - Fall 2008 - University of Chicago, Graduate Student Seminar - What Is K-Theory?
  - Fall 2007 - University of Chicago, Graduate Student Seminar - Computing Homotopy Groups of Spheres.
  - Winter 2007 - University of Chicago, Graduate Student Seminar - Beating Deep Blue: How Machines Play Games.
- **Reading Seminar Lectures**
  - Spring 2012 - University of Bonn, Arbeitsgemeinschaft: Goodwillie Calculus
    - \* Introduction to Goodwillie calculus and overview of program.
  - Fall 2011 - University of Bonn, Arbeitsgemeinschaft: Infinity categories and higher algebra
    - \* The universal additive invariant and categories of non-commutative motives.
  - Summer 2011 - Max-Planck-Intitut für Mathematik, Arbeitsgemeinschaft: Derived manifolds
    - \* Spivak's derived manifolds.
    - \* Homotopy sheaves an alternative model for derived manifolds.
  - Winter 2011 - University of Bonn, Arbeitsgemeinschaft: Kervaire invariant
    - \* On the non-existence of elements of Kervaire invariant one: an overview.
    - \* Computations in the slice spectral sequence.
    - \* The slice theorem.
  - March 26th, 2010 - University of Paris XIII, Groupe de Travaile - Equivariant Stable Homotopy Theory.
  - Spring 2007 - Massachusetts Institute of Technology, JuviTop Seminar - Power Operations and  $H_\infty$  Ring Spectra.
  - Fall 2004-Spring 2009 - University of Chicago, Topology Proseminar:
    - \* The Nilpotence and Periodicity Theorems (Two-part series).
    - \* Generalized Witt schemes in Algebraic Topology (Three-part series).
    - \* The  $EHP$ -sequence.
    - \* The Hopkins-Miller Theorem.
    - \* Equivariant K-Theory (Two-part series).
    - \* Étale Homotopy Theory, Galois Symmetry and the Adams Conjecture.
    - \* Stacks and Stable Homotopy Theory (Four-part series).
    - \* Fundamental Theorems in Algebraic K-Theory.
    - \* Clifford Algebras and Bott Periodicity.
    - \* Computing  $\pi_* tmf$ .
    - \* Elliptic Cohomology Theories.
    - \* The Algebraic  $K$ -theory of Spaces.
    - \* The Image of  $J$ .
    - \* Topological K-Theory.
    - \* Spectral Sequences.

<b>Additional Information</b>
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- U.S. citizen.
- Languages: English (native speaker), German (B2), French (B1), and Spanish(A1)<sup>1</sup>.
- Experienced with computer programming and administration, including experience with Linux, Mathematica, Python, C, C++, and Java.
- Outside Interests: Cycling, jogging, travel, language, and games.

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<sup>1</sup>Language levels are only self-estimates relative to the [CEFR](#) standards.