

David I. Spivak

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Education

Ph.D. Mathematics, University of California, Berkeley, 2007

Advisor: Peter Teichner

Thesis title: Quasi-smooth Derived Manifolds

B.S. Mathematics, University of Maryland, College Park, 2000

Employment

Massachusetts Institute of Technology

2013 – Present: Research Scientist, Department of Mathematics

2010 – 2013: Postdoctoral Associate, Department of Mathematics

Categorical Informatics Incorporated

2016 – Present: Chief Mathematician

University of Oregon

2007 – 2010: Paul Olum Visiting Assistant Professor, Department of Mathematics

2008: Guest Instructor, Department of Computer and Information Sciences

University of California, Berkeley

2001 – 2007: Graduate Student Instructor/Researcher, Department of Mathematics

University of Maryland, College Park

1999 – 2000: Strauss Teaching Assistant, Department of Mathematics

Grants

As Principal Investigator (totaling \$2,601,500)

Air Force Office of Scientific Research (AFOSR)

2016 – 2019: “Pixel Matrices and other compositional analyses of interconnected systems”, \$600,000

2013 – 2018: “Categorical Approach to Agent Interaction”, \$900,000

National Science Foundation (NSF)

2016 – 2017: “I-Corps: Solving Information-Integration Problems Using Category Theory”, \$50,000

2015: “I-Corps Site Program Award”, \$1,500

Office of Naval Research (ONR)

2013 – 2015: “Categorical Informatics,” \$540,000

2010 – 2013: “Categorical Information Theory,” \$360,000

2009 – 2010: “Databases and Networks,” \$150,000

As Co-Principal Investigator (totaling \$300,000)

National Aeronautics and Space Administration (NASA)

2014 – 2017: “Category-theoretic Approaches for the Analysis of Distributed Systems”, \$300,000

Publications*Books*

Spivak, D.I. (2014) *Category Theory for the Sciences*. Cambridge: MIT Press. 486 pages

Schultz, P.; **Spivak, D.I.** (2017) *Temporal Type Theory: a topos-theoretic approach to systems and behavior*. Springer Birkhäuser (*to appear*). Available online: <https://arxiv.org/pdf/1710.10258.pdf>.

Journal Articles and Book Chapters

Spivak, D.I. (2017) “Categories as mathematical models.” *Categories for the Working Philosopher*. Oxford University Press. Available online <http://arxiv.org/abs/1409.6067>

Wisnesky, R.; Breiner, S.; Jones, A.; **Spivak, D.I.**; Subrahmanian, E. (2017) “Using category theory to facilitate multiple manufacturing service database integration.” *ASME. Journal of Computing and Information Science in Engineering* 17(2).

Spivak, D.I.; Schultz, P.; Rupel, D. (2017) “String diagrams for traced and compact categories are oriented 1-cobordisms.” *Journal of Pure and Applied Algebra*. Volume 221, Issue 8, pp. 2064 – 2110. Available online: <http://arxiv.org/abs/1508.01069>

Schultz, P.; **Spivak, D.I.**; Vasilakopoulou, C.; Wisnesky, R. (2016) “Algebraic databases.” Accepted for publication in *Theory and Applications of Categories*. Available online: <http://arxiv.org/abs/1602.03501>

Spivak, D.I.; Tan, J.Z. (2016) “Nesting of dynamic systems and mode-dependent networks.” *Journal of Complex Networks*. doi: 10.1093/comnet/cnw022. Available online: <https://arxiv.org/abs/1502.07380>.

Kock, J.; **Spivak, D.I.** (2016) “Homotopy composition of cospans.” *Communications in Contemporary Mathematics* DOI: 10.1142/S0219199716500474. Available online: <http://arxiv.org/abs/1602.1493699>

Vagner, D.; **Spivak, D.I.**; Lerman, E. (2015) "Algebras of open dynamical systems on the operad of wiring diagrams." *Theory and Application of Categories* Vol. 30, No. 51, pp. 1793–1822. Available online: <http://www.tac.mta.ca/tac/volumes/30/51/30-51abs.html>.

Giesa, T.; Jagadeesan, R.; **Spivak, D.I.**; Buehler, M.J. (2015) "Matriarch: a Python library for materials architecture." *ACS Biomaterials Science & Engineering*, <http://pubs.acs.org/doi/full/10.1021/acsbomaterials.5b00251>.

Brommer D.B.; Giesa T.; **Spivak, D.I.**; Buehler, M.J. (2015) "Categorical prototyping: Incorporating molecular mechanisms into 3D printing." *Nanotechnology*, article reference: NANO-108127.

Spivak, D.I. (2014) "Database queries and constraints via lifting problems." *Mathematical structures in computer science*. Available online: <http://arxiv.org/abs/1202.2591>

Spivak, D.I. (2012) "Functorial data migration." *Information and Communication*. Vol 217, pp. 31 – 51. Available online: <http://arxiv.org/abs/1009.1166>

Giesa, T.; **Spivak, D.I.**; Buehler, M.J. (2012) "Category theory based solution for the building block replacement problem in materials design." *Advanced Engineering Materials*. DOI: 10.1002/adem.201200109

Spivak, D.I.; Kent, R.E. (2012) "Ologs: A categorical framework for knowledge representation." *PLoS ONE* 7(1): e24274. doi:10.1371/journal.pone.0024274.

Wong, J.Y.; McDonald, J.; Taylor-Pinney, M.; **Spivak, D.I.**; Kaplan, D.L.; Buehler, M.J. (2012) "Materials by design: Merging proteins and music." *Nano Today* 7, issue 6, pp. 488 – 495.

Giesa, T.; **Spivak, D.I.**; Buehler M.J. (2011) "Reoccurring patterns in hierarchical protein materials and music: The power of analogies." *BioNanoScience* 1 no. 4, pp. 153-161.

Spivak, D.I.; Giesa, T.; Wood, E.; Buehler, M.J. (2011) "Category theoretic analysis of hierarchical protein materials and social networks." *PLoS ONE* 6(9): e23911. doi:10.1371/journal.pone.0023911

Dugger, D.; **Spivak, D.I.** (2011) "Rigidification of quasi-categories." *Algebraic and Geometric Topology* 11 pp. 225-261.

Dugger, D.; **Spivak, D.I.** (2011) "Mapping spaces in quasi-categories." *Algebraic and Geometric Topology* 11 pp. 263-325.

Spivak, D.I. (2010) "Derived smooth manifolds." *Duke Mathematical Journal* 153, no. 1, pp. 55-128.

Batra, P.; Dobrescu, B.A.; **Spivak, D.I.** (2006) "Anomaly-free sets of fermions." *Journal of Mathematical Physics*, **47**, 082301.

Refereed Conference Papers and Technical Reports

Wisnesky, R.; **Spivak, D.I.**; Schultz, P. (2017) "Algebraic model management." *WADT'16 post-proceedings*, Springer.

Spivak, D.I.; Ernadote, D.; Hammami, O. (2016) "Pixel matrices: An elementary technique for solving nonlinear systems." *2016 IEEE International Symposium on Systems Engineering (ISSE)*. Available online <http://arxiv.org/abs/1605.00190>.

Forsell, H.; Gylterud, H.K.; **Spivak, D.I.** (2016) "Type theoretical databases." *Logical Foundations of Computer Science*. Available online <http://arxiv.org/abs/1406.6268>.

Subrahmanian, E.; Wisnesky, R.; **Spivak, D.I.**; Schultz, P. (2015) “Functorial data migration: From theory to practice.” *NIST Interagency/Internal Report (NISTIR)*. Available online: <http://arxiv.org/abs/1502.05947>.

Morton, J.; **Spivak, D.I.** (2015) “A operad-based normal form for morphism expressions in a closed compact category.” *Higher-dimensional rewriting and applications*, <http://hdra15.gforge.inria.fr>.

Spivak, D.I.; Wisnesky, R. (2015) “Relational foundations for functorial data migration.” *Proceedings of the International Symposium on Database Programming Languages (DBPL)*, ACM. Available online: <http://arxiv.org/abs/1212.5303>.

Gross, J.; Chlipala, A.; **Spivak, D.I.** (2014) “Experience implementing a performant category-theory library in Coq.” *5th conference on interactive theorem proving (ITP’14)*. Available online: <http://arxiv.org/abs/1401.7694>.

Spivak, D.I.; Wisnesky, R. (2013) “A functorial query language.” *Data-Centric Programming workshop (DCP2014)*. Available online: <http://research.microsoft.com/en-us/events/dcp2014/wisnesky.pdf>.

Preprints

Fong, B.; **Spivak, D.I.** (2018) *Seven Sketches in Compositionality: An Invitation to Applied Category Theory*. 243 pages. Available online: <https://arxiv.org/abs/1803.05316>.

Speranzon, A.; Spivak, D.I.; Varadarajan, S. (2018) “Abstraction, Composition and Contracts: A Sheaf Theoretic Approach”. Available online: <http://arxiv.org/abs/1802.03080>.

Fong, B.; **Spivak, D.I.**; Tuyéras, R. (2017) “Backprop as Functor: A compositional perspective on supervised learning”. Available online: <http://arxiv.org/abs/1711.10455>.

Spivak, D.I.; Vasilakopoulou C.; Schultz, P. (2016) “Dynamical systems and sheaves.” *Submitted*. Available online: <http://arxiv.org/abs/1609.08086>.

Spivak, D.I.; Dobson, M.R.C.; Kumari, S.; Wu, L. (2016) “Pixel Arrays: A fast and elementary method for solving nonlinear systems.” *Submitted*. Available online: <https://arxiv.org/abs/1609.00061>.

Lerman, E.; **Spivak, D.I.** (2016) “An algebra of open continuous time dynamical systems and networks.” *Submitted*. Available online: <http://arxiv.org/abs/1602.01017>.

Spivak, D.I. (2015) “The steady states of coupled dynamical systems compose according to matrix arithmetic.” Available online: <http://arxiv.org/abs/1512.00802>.

Schultz, P.; **Spivak, D.I.**; Wisnesky, R. (2015) “QINL: Query-integrated Languages.” Available online: <http://arxiv.org/abs/1511.06459>.

Pérez, M.; **Spivak, D.I.** (2015) “Toward formalizing ologs: Linguistic structures, instantiations, and mappings.” *Submitted*. Available online: <http://arxiv.org/abs/1503.08326>.

Spivak, D.I.; Schultz, P.; Wisnesky, R. (2015) “A purely equational formalism for functorial data migration.” Available online: <http://arxiv.org/abs/1503.03571>.

Rupel, D.; **Spivak, D.I.** (2013) “The operad of temporal wiring diagrams: formalizing a graphical language for discrete-time processes.” *Submitted*. Available online <http://arxiv.org/abs/1307.6894>.

Spivak, D.I. (2013) "The operad of wiring diagrams: Formalizing a graphical language for databases, recursion, and plug-and-play circuits." Available online: <http://arxiv.org/abs/1305.0297>.

Spivak, D.I. (2012) "Kleisli database instances." Available online: <http://arxiv.org/abs/1209.1011>.

Spivak, D.I. (2010) "Table manipulation in simplicial databases." Available online: <http://arxiv.org/abs/1003.2682>.

Spivak, D.I. (2009) "Simplicial databases." Available online: <http://arxiv.org/abs/0904.2012>.

Teaching Experience

At Massachusetts Institute of Technology

Graduate classes

Category Theory for Scientists, Spring 2013

Undergraduate classes

Differential Equations (as Teaching Assistant), Spring 2012

Informal reading course

Category Theory, 2015 – 2016

At University of Oregon

Graduate classes

Categorical Informatics, Winter 2010

Characteristic Classes, Fall 2008

Undergraduate classes

Linear Algebra, Spring 2010, Winter 2008

Calculus III, Winter 2009

Differential Equations, Winter 2009, Fall 2007

Calculus II, Fall 2008

Discrete Mathematics, Fall 2007

Semester-long Seminars

"Category Theory in Computer Science", Spring 2008

"Mathematical Methods in Computer Science", Fall 2008

At University of California, Berkeley

Undergraduate classes

Precalculus (160 students, managing four TAs leading sections), Spring 2005, Fall 2004

Various undergraduate classes (as Teaching Assistant), Fall 2001 – Spring 2007

*At University of Maryland, College Park***Undergraduate classes**

Calculus I, II (as Teaching Assistant), Fall 1999 – Spring 2000

Mini-courses

“Category Theory”, one-day, 6-hour mini-course, LambdaConf, 2017

“Applied Category Theory”, four-day, 8-hour mini-course, École Polytechnique Fédéral Lausanne, 2015

“Derived Manifolds”, two-day, 4-hour mini-course, University of Toronto, 2010

Awards and Honors

Best Poster Award, Hybrid Systems: Computation and Control conference, 2017

Outstanding Graduate Student Instructor, University of California, Berkeley, 2002

VIGRE Fellowship, University of California, Berkeley, 2000-2001

Graduated Magna Cum Laude, with Honors in Mathematics, University of Maryland, 2000

Outstanding Senior Award, University of Maryland, 2000

Carol Karp Award for Outstanding Logic Student, University of Maryland, 2000

Related Professional Experience*Mentorship and Management***Supervised Postdocs**

Dr. Rémy Tuyéras, Massachusetts Institute of Technology, 2017 – present

Dr. Patrick Schultz, Massachusetts Institute of Technology, 2014 – present

Dr. Christina Vasilakopoulou, Massachusetts Institute of Technology, 2015 – 2016

Dr. Marco Pérez, Massachusetts Institute of Technology, 2014 – 2015

Dr. Ryan Wisnesky, Massachusetts Institute of Technology, 2014 – 2015

Postdoc research papers on which I am not an author:

Tuyéras, R., “Category Theory for Genetics.” Available online: <https://arxiv.org/abs/1708.05255>.

Malecha, G.; **Wisnesky, R.** (2015) “Using Dependent Types and Tactics to Enable Semantic-optimization of Language-integrated Queries”, *International Symposium on Database Programming Languages*.

Schultz, P. (2015) “Regular and exact (virtual) double categories.” Available online: <http://arxiv.org/abs/1505.00712>.

Schultz, P.; Wisnesky, R. (2017) “Algebraic Data Integration.” *Journal of Functional Programming (to appear)*. Available online: <https://arxiv.org/abs/1503.03571>.

Supervised Graduate Student Research

David Darais, student at Harvard University, 2014
 Ryan Wisnesky, student at Harvard University, 2012 – 2013
 Ralph Hutchison, student at University of Oregon, 2010
 Paea LePendou, student at University of Oregon, 2009

Supervised Undergraduate Student Research

Lawrence Wu, Advanced Undergraduate Project in Electrical Engineering and Computer Science, 2016

21 students, totaling 29 student-semesters, in the MIT Undergraduate Research Opportunity Program, 2011 – present

Undergraduate research papers on which I am not an author:

Ngotiaoco, T. (2017) “Compositionality of the Runge-Kutta Method.” <https://arxiv.org/abs/1707.02804>

Supervised High School Student Research

Ravi Jagadeesan, Research Science Institute; supervised jointly with Professor Markus Buehler and Tristan Giesa, 2013

*Committees***Ph.D. Qualifying Examination Committee**

William Yu, Massachusetts Institute of Technology, Department of Mathematics, 2014

Ph.D. Thesis Committee

Elie Adam, Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science, 2016

Organizing Committees

Agent-based Complex Systems workshop, *Institute of Pure and Applied Math* (Los Angeles, CA 2009)

Workshop on Topology and Abstract Algebra for Biomedicine, *Pacific Symposium for Biocomputing*, Big Island, HI 2016

Novel Approaches for Modeling, Abstraction, Composition, and Analysis of Systems of Systems mini-symposium, *SIAM Conference on Control and its Applications*, Pittsburgh, PA 2017

Program Committee

1st Annual Workshop on String Diagrams in Computation, Logic, and Physics, Oxford, UK 2017

*Categorical Informatics Company***Co-founded a Company**

Categorical Informatics Inc., co-founded with former postdoc Ryan Wisnesky in 2015. Our technology applies my group’s categorical informatics research to database integration problems.

Consulting

Consulted for Honeywell Inc.

Languages

English (native) and French (intermediate)

Presentations

Applied Category Theory

Invited Presentations

1. Applied Category Theory workshop, Lorentz Center, 2018/04/30
2. Applied Category Theory workshop, National Institute of Standards and Technology, 2018/03/16
3. Oxford Advanced Seminar on Informatic Structures, Oxford 2018/02/01
4. Applied topology seminar, University of Aberdeen, 2018/01/30
5. Applied Algebra and Topology seminar, MIT, 2017/12/05
6. Biomolecular Feedback Systems seminar, MIT, 2017/11/15
7. AMBER lab Robotics seminar, Caltech University, 2017/11/03
8. Category theory and Logic seminar, McGill University, 2017/10/03
9. Applied math seminar, McGill University, 2017/10/02
10. Topology Seminar, Universitat Autònoma de Barcelona, 2017/06/12
11. Emerging Topics in Network Dynamical Systems workshop, Lorentz Center, 2017/06/08
12. Compositionality workshop, Simons Institute for the Theory of Computing, 2016/12/06
13. Agenda des Écoles, Grand École Télécom Bretagne, 2016/11/10
14. Numerical Methods for PDEs Seminar, MIT Mathematics, 2016/10/26
15. E3 Science Lecture Series, Sandia National Labs, 2016/09/27
16. Workshop on Probability, Uncertainty, and Decisions, AFRL Dayton, 2016/06/27
17. 5th Mini-Symposium on Computational Topology, Boston, 2016/06/15
18. Mathematics Colloquium, New York University, Binghamton, 2016/04/07
19. Generalized Network Structures and Dynamics workshop, Mathematical Biosciences Institute, 2016/03/22
20. Invited Presentation, Amgen, 2016/03/17
21. Mathematics Colloquium, University of Massachusetts, Boston, 2015/10/14
22. Computational Category Theory Workshop, National Institute of Standards and Technology, 2015/09/28
23. Seminar, University of Oslo Department of Informatics, 2015/09/21
24. Lunch Seminar, MIT Laboratory for Information and Decision Systems, 2015/06/26
25. Invited Presentation, National Institute of Standards and Technology, 2015/06/18
26. Invited Presentation, National Institute of Standards and Technology, 2015/06/16
27. Foundational Methods in Computer Science conference, Colgate University, 2015/06/06
28. Categorical Foundations of Network Theory workshop, Institute for Scientific Interchange, 2015/05/28
29. Complex Systems Seminar, University of Pennsylvania, 2015/04/03

30. Applied Algebra and Network Theory Seminar, Pennsylvania State University, 2015/03/18
31. International Workshop on Design Theory, MINES ParisTech, 2015/01/26
32. Programming Languages Seminar, MIT Computer Science and Artificial Intelligence Laboratory, 2014/04/15
33. Bar talk, Institute for Advanced Study, 2014/03/20
34. Invited Presentation, PARC, 2014/03/03
35. Invited Presentation, Amgen, 2014/03/04
36. Invited Presentation, Oracle, 2014/02/28
37. Topology Seminar, University of Illinois Urbana-Champaign, 2014/02/25
38. Programming Languages Seminar, Harvard University, 2014/02/19
39. Principles of Programming Seminar, Carnegie Mellon University, 2014/01/23
40. Invited Presentation, National Institute of Standards and Technology, 2013/06/12
41. Topology Seminar, University of Oregon, 2012/11/12
42. Geometry and Topology Seminar, Brown University, 2012/09/19
43. Invited Presentation, Mathfest Madison WI, 2012/08/04
44. Colloquium Presentation, Stanford Center for Biomedical Informatics Research, 2012/07/27
45. Invited Presentation, Office of Naval Research, 2012/06/13
46. Special Geometry Seminar, University of Texas, Austin, 2012/01/31
47. Invited Presentation, Amgen, 2012/01/24–25
48. Principles of Programming Seminar, Carnegie Mellon University, 2012/01/18
49. Mathematics in Science and Society Colloquium, University of Illinois Urbana-Champaign, 2011/11/29
50. Agent-based Complex Systems conference, Institute of Pure and Applied Mathematics, 2009/10/13
51. Topology Seminar, Johns Hopkins University, 2011/11/21
52. Invited Presentation, Amgen, 2011/02/17–18
53. Invited Presentation, Boston Haskell, 2011/01/20
54. Electrical Engineering and Computer Science seminar, Harvard University, 2010/11/03
55. Tech Talk, Galois, 2010/10/22
56. Topology Seminar, MIT Mathematics, 2010/09/20
57. Database Seminar, MIT Computer Science and Artificial Intelligence Laboratory, 2010/09/16
58. Semantics Reading Group, MIT Linguistics, 2010/09/15
59. Foundational Methods in Computer Science conference, University of Calgary, 2010/06/12
60. Tech Talk, Galois, 2010/06/03
61. Topology Seminar, University of Chicago, 2010/05/11
62. Mathematics Colloquium, Reed College, 2010/03/25
63. Invited Presentation, Amgen, 2010/03/15-16
64. Category Theory Seminar, Carnegie Mellon University, 2009/11/13
65. Agent-based Complex Systems conference, Institute for Pure and Applied Mathematics, 2009/10/13.

- 66. Category Theory Seminar, McGill University, 2009/05/19
- 67. Mathematics Colloquium, University of California, Riverside, 2009/04/29
- 68. Algebraic Topological Methods in Computer Science conference, University of Paris 7, 2008/07/07
- 69. Topology Seminar, University of Oregon, 2008/05/06
- 70. Computer Science Colloquium, University of Oregon, 2008/02/07.

Contributed Presentations

- 71. AMS Special session on Applied Category Theory, UC Riverside, 2017/11/04
- 72. Novel Approaches for Systems of Systems mini-symposium, SIAM, 2017/07/12
- 73. Dynamical Systems and Nonlinear Analysis session, SIAM, 2017/07/11
- 74. IAP Lecture, MIT Mathematics, 2017/01/30
- 75. Plenary Talk, International Category Theory conference, 2016/08/10
- 76. IAP Lecture, MIT Mathematics, 2016/01/11
- 77. IAP Lecture, MIT Mathematics, 2014/01/27

Derived Manifolds

Invited Presentations

- 78. Derived Algebraic Geometry conference, University of Salamanca, Spain, 2009/06/04
- 79. Category Theory Seminar, Université du Québec à Montréal, 2009/05/22
- 80. Topology Seminar, MIT Mathematics, 2009/05/04
- 81. Topology Seminar, Stanford University, 2009/02/03
- 82. Topology Seminar, University of Illinois Urbana-Champaign, 2008/10/04
- 83. CATS3 Conference, Centro de Giorgi, Pisa, Italia, 2008/09/03.

Contributed Presentations

- 84. Special Session on Homotopy Theory and Higher Algebraic Structures, American Mathematical Society Riverside, CA, 2009/04/30
- 85. Cascade Topology Conference, Portland State University, 2008/11/08
- 86. American Mathematical Society Sectional, U. British Columbia, 2008/10/04

Mapping Spaces in Quasi-categories

Invited Presentations

- 87. Topology Seminar, University of Illinois, Chicago, 2009/12/09
- 88. Deformation Theory Seminar, University of Pennsylvania,, 2009/11/18
- 89. Novemberfest Category Theory Conference, Carnegie Mellon University, 2009/11/15

Contributed Presentations

- 90. AMS sectional, University of California, Riverside, 2009/11/08.