# CURRICULUM VITAE: CHRIS H. RYCROFT

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School of Engineering and Applied Sciences
Harvard University
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## EDUCATION

Massachusetts Institute of Technology 2002–2007
Ph. D. Mathematics
Advisor: Professor Martin Z. Bazant
Thesis title: *Multiscale Modeling in Granular Flow*

Pembroke College, University of Cambridge 2001–2002
Certificate of Advanced Study in Mathematics, Grade of Distinction

Pembroke College, University of Cambridge 1998–2001
Bachelor's in Mathematics, First Class Honours

## POSITIONS

School of Engineering and Applied Sciences, Harvard University 2014–present
*Assistant Professor*

Department of Mathematics, Lawrence Berkeley Laboratory 2010–present
*Visiting Faculty Scientist*

Department of Mathematics, University of California, Berkeley 2010–2013
*Morrey Assistant Professor*

Department of Mathematics, Lawrence Berkeley Laboratory 2007–2010
*Visiting Postdoctoral Scholar*

Idaho National Laboratory Summer 2006
*Research Assistant*

Westlakes Research Institute Summer 1999
*Research Assistant*

## RESEARCH INTERESTS

Broadly: interdisciplinary mathematical modeling, mechanics of complex materials, numerical methods

Specifically: numerical methods for elasto-plasticity: bulk metallic glasses, fluid–structure interaction;
mechanical modeling of biological systems: biomaterials, simulation of multiple interfaces;
the Voronoi tessellation: computational techniques, analysis of particle systems;
material porosity: high-throughput screening, mathematical modeling of fluid flow;
dense granular materials: rheology, mixing, stochastic methods, industrial applications;
multigrid methods, pseudospectral methods, conformal methods, adaptive grids, parallel computation

## JOURNAL PUBLICATIONS

G. Venugopalan, D. Camarillo, K. D. Webster, C. D. Reber, J. A. Sethian, V. M. Weaver, D. A. Fletcher, and C. H. Rycroft, *Multicellular architecture of malignant breast epithelia influences mechanics*, PLOS ONE **9**, e101955 (2014).

C. M. Freeman, K. L. Boyle, M. Reagan, J. Johnson, C. H. Rycroft, and G. J. Moridis, *MeshVoro: A three-dimensional Voronoi mesh building tool for the TOUGH family of codes*, Computers & Geosciences **70**, 26–34 (2014).

Q. Shi, R. P. Ghosh, H. Engelke, C. H. Rycroft, L. Cassereau, J. A. Sethian, V. M. Weaver, and J. T. Liphardt, *Rapid disorganization of mechanically interacting systems of mammary acini*, Proc. Natl. Acad. Sci. **111**, 658–663 (2014).

G. I. Barenblatt, P. J. M. Monteiro, and C. H. Rycroft, *On a boundary layer problem related to the gas flow in shales*, J. Eng. Math. **84**, 11–18 (2014).

C. H. Rycroft, A. Dehbi, T. Lind, and S. Güntay, *Granular flow in pebble-bed nuclear reactors: scaling, dust generation, and stress*, Nucl. Eng. Design. **265**, 69–84 (2013).

C. H. Rycroft and J. Wilkening, *Computation of three-dimensional standing water waves*, J. Comput. Phys. **255**, 612–638 (2013).

M. Pinheiro, R. L. Martin, C. H. Rycroft, and M. Haranczyk, *High accuracy geometric analysis of crystalline porous materials*, CrystEngComm **37**, 7531–7538 (2013).

M. Pinheiro, R. L. Martin, C. H. Rycroft, A. Jones, E. Iglesia, and M. Haranczyk, *Characterization and comparison of pore landscapes in crystalline porous materials*, J. Mol. Graph. Model. **44**, 208–219 (2013).

M. Theillard, C. H. Rycroft, and F. Gibou, *A multigrid method on non-graded adaptive octree and quadtree cartesian grids*, J. Sci. Comput. **55**, 1–15 (2013).

P. J. M. Monteiro, C. H. Rycroft, and G. I. Barenblatt, *A mathematical model of fluid and gas flow in nanoporous media*, Proc. Natl. Acad. Sci. **109**, 20309–20313 (2012).

C. H. Rycroft and E. Bouchbinder, *Fracture toughness of metallic glasses: annealing-induced embrittlement*, Phys. Rev. Lett. **109**, 194301 (2012).

K. Kamrin, C. H. Rycroft, J.-C. Nave, *Reference map technique for finite-strain elasticity and fluid–solid interaction*, J. Mech. Phys. Solids **60**, 1952–1969 (2012).

L.-C. Lin, A. H. Berger, R. L. Martin, J. Kim, J. A. Swisher, K. Jariwala, C. H. Rycroft, A. S. Bhown, M. W. Deem, M. Haranczyk, and B. Smit, *In silico screening of carbon capture materials*, Nature Materials **11**, 633–641 (2012).

C. H. Rycroft and F. Gibou, *Simulations of a stretching bar using a plasticity model from the shear transformation zone theory*, J. Comput. Phys. **231**, 2155–2179 (2012).

T. F. Willems, C. H. Rycroft, M. Kazi, J. C. Meza, and M. Haranczyk, *Algorithms and tools for high-throughput geometry-based analysis of crystalline porous materials*, Microporous and Mesoporous Materials **149**, 134–141 (2012).

C. H. Rycroft, Y. Wong, and M. Z. Bazant, *Fast spot-based multiscale simulations of granular flow*, Powder Technol. **200**, 1–11 (2010).

C. H. Rycroft, *Voro++: a three-dimensional Voronoi cell library in C++*, Chaos **19**, 041111 (2009).

## JOURNAL PUBLICATIONS (CONTINUED)

C. H. Rycroft, A. V. Orpe, and A. Kudrolli, *Physical test of a particle simulation model in a sheared granular system*, Phys. Rev. E **80**, 031305 (2009).

C. H. Rycroft, K. Kamrin, and M. Z. Bazant, *Assessing continuum relationships in simulations of granular flow*, J. Mech. Phys. Solids. **57**, 828–839 (2009).

K. Kamrin, C. H. Rycroft, and M. Z. Bazant, *The stochastic flow rule: a multi-scale model for granular plasticity*, Modelling Simul. Mater. Sci. Eng. **15**, S449–S464 (2007).

C. H. Rycroft, G. S. Grest, J. W. Landry, and M. Z. Bazant, *Analysis of granular flow in a pebble-bed nuclear reactor*, Phys. Rev. E **74**, 021306 (2006).

C. H. Rycroft, M. Z. Bazant, J. W. Landry, and G. S. Grest, *Dynamics of random packings in granular flow*, Phys. Rev. E **73**, 051306 (2006).

## JOURNAL ARTICLES IN REVIEW

C. H. Rycroft, Y. Sui, and E. Bouchbinder, *An Eulerian projection method for quasi-static elastoplasticity*, submitted to J. Comput. Phys.

B. Valkov, C. H. Rycroft, and K. Kamrin, *Eulerian method for fluid–solid interaction and submerged solid–solid contact problems*, submitted to Computers and Structures.

## CONFERENCE PUBLICATIONS AND TECHNICAL REPORTS

C. H. Rycroft, T. Lind, S. Güntay, and A. Dehbi, *Granular flows in pebble bed reactors: dust generation and scaling*, proceedings of ICAPP 2012, Chicago.

T. Lind, S. Güntay, A. Dehbi, Y. Liao, and C. H. Rycroft, *PSI project on HTR dust generation and transport*, Proceedings of HTR 2010, Prague.

C. H. Rycroft, *Voro++: a three-dimensional Voronoi cell library in C++*, Lawrence Berkeley National Laboratory, Paper LBNL-1430E (2009).

## FELLOWSHIPS AND AWARDS

Robert M. Rose Presidential Fellowship 2002–2003
Massachusetts Institute of Technology

Foundress Prize 2001
Pembroke College, University of Cambridge

Foundation Scholarship 2000–2001
Pembroke College, University of Cambridge

Legg Prize 1999
Pembroke College, University of Cambridge

## INVITED SEMINARS

| | |
|---|---|
| Institute for Applied Computational Science, Harvard University | September 19, 2014 |
| Department of Mechanical Engineering, Massachusetts Institute of Technology | April 15, 2014 |
| Department of Mathematics, Massachusetts Institute of Technology | February 11, 2014 |
| Department of Chemical Engineering, Massachusetts Institute of Technology | November 14, 2013 |
| Department of Mechanical Engineering, University of Washington | April 8, 2013 |
| School of Engineering and Applied Sciences, Harvard University | February 28, 2013 |
| School of Mathematics, University of Minnesota | February 21, 2013 |
| School of Computational Science & Engineering, Georgia Tech | February 8, 2013 |
| Department of Mathematics, University of North Carolina, Chapel Hill | February 6, 2013 |
| Department of Mathematics, University of Arizona | February 4, 2013 |
| Mathematics Institute, University of Warwick, United Kingdom | January 28, 2013 |
| Department of Mathematics, University of California, Davis | January 23, 2013 |
| Department of Mathematics, National University of Singapore, Singapore | January 16, 2013 |
| Mathematical Biology Seminar, University of California, Davis | May 7, 2012 |
| Joint ICBP–PSOC Seminar, University of California, Berkeley | February 15, 2012 |
| Scientific Computing Seminar, University of California, Berkeley | February 1, 2012 |
| Department of Chemical Physics, Weizmann Institute of Science, Israel | January 11, 2012 |
| Department of Mathematics, University of California, Davis | November 8, 2011 |
| Department of Mechanical Engineering, University of California, Santa Barbara | April 25, 2011 |
| Laboratory for Thermal-Hydraulics, Paul Scherrer Institute, Switzerland | July 2, 2010 |
| Courant Institute of Mathematical Sciences, New York | March 9, 2010 |
| Cancer Imaging Department, BC Cancer Research Centre, Vancouver | December 7, 2009 |
| Center for Nonlinear Studies, Los Alamos National Laboratory | November 30, 2009 |
| Department of Mathematics, Georgia Tech | November 16, 2009 |
| Complex Fluids Seminar, University of Michigan | May 2, 2008 |
| Department of Physics, University of California, Santa Barbara | April 4, 2007 |
| Department of Applied and Computational Mathematics, Caltech | March 30, 2007 |
| Department of Physics, Clark University | March 19, 2007 |
| Department of Mathematics, University of California, Berkeley | February 28, 2007 |
| Department of Mathematics, Massachusetts Institute of Technology | April 8, 2004 |

## SELECTED CONFERENCE PRESENTATIONS

*Interfacial dynamics of dissolving objects in fluid flow*, APS Division of Fluid Dynamics Annual Meeting, Pittsburgh, November 24–26, 2013.

*Mechanical simulation of mammalian acini*, SIAM Computational Science and Engineering 2013, Boston, February 26, 2013.

## SELECTED CONFERENCE PRESENTATIONS (CONTINUED)

*Granular flows in pebble-bed nuclear reactors: scaling and dust generation*, International Congress on Advances in Nuclear Power Plants, Chicago, June 24–28, 2012.

*Application of the Voronoi tessellation for high-throughput analysis of crystalline porous materials*, Applied Mathematics Principal Investigators Meeting, Washington DC, October 17–19, 2011.

*A mechanical model of mammalian acinus growth*, ICIAM 2011 – 7th International Congress on Industrial and Applied Mathematics, Vancouver, July 18–22, 2011.

*Computation of three-dimensional standing water waves*, SIAM Computational Science and Engineering 2011, Reno, February 28–March 4, 2011.

*Real-time control of mixing in dense granular flow*, Bay Area Scientific Computing Day, Lawrence Berkeley National Laboratory, Berkeley, May 9, 2009.

*Anisotropies in granular temperature in a dense sheared granular flow*, APS March Meeting, Pittsburgh, March 16–20, 2009.

*A multiscale simulation technique for granular flow*, IMA Conference on Dense Granular Flows, Isaac Newton Institute, University of Cambridge, January 5–9, 2009.

*A multiscale simulation technique for granular flow*, Canadian Mathematical Society Winter Meeting, Ottawa, December 6–8, 2008.

*A multiscale simulation technique for optimization of granular mixing*, Applied Mathematics Principal Investigators Meeting, Argonne National Laboratory, October 15–17, 2008.

*A coupled continuum/discrete model of dense granular flow*, Bay Area Scientific Computing Day, MSRI, Berkeley, March 29, 2008.

*Stress, strain rate, and packing fraction in granular flow*, APS March Meeting, Denver, March 2007.

*Voronoi volumes in dense granular flow*, APS March Meeting, Baltimore, March 2006.

*Dynamics of random packings in granular flow*, APS March Meeting, Los Angeles, March 2005.

*Toward a theory of diffusion in dense granular flow*, APS March Meeting, Montreal, March 2004.

## SOFTWARE

Co-author of Zeo++, a software library for high-throughput analysis of porous materials 2012–present
http://carboncapturematerials.org/zeo++/

Author of Voro++, a three-dimensional Voronoi cell library in C++ 2009–present
http://math.lbl.gov/voro++/

Co-author of PSLIB, a pseudospectral software library 2006–present
http://ktchu.serendipityresearch.org/software/pslib/

## TEACHING

Taught two courses in the Harvard School of Engineering and Applied Sciences:

| *Semester* | *Course* |
|---|---|
| Fall 2014 | Applied Math 205: Advanced Scientific Computing: Numerical Methods |
| Spring 2014 | Applied Math 50: Introduction to Applied Mathematics (with Dr. Avi Shapiro) |

Taught three courses in the UC Berkeley mathematics department:

| *Semester* | *Course* | *Website (mirrored)* |
|---|---|---|
| Spring 2013 | Math 121A: Math. Tools for Phys. Sciences | http://seas.harvard.edu/~chr/121A.S13/ |
| Spring 2012 | Math 104: Introduction to Analysis | http://seas.harvard.edu/~chr/104.S12/ |
| Spring 2011 | Math 104: Introduction to Analysis | http://seas.harvard.edu/~chr/104.S11/ |

Teaching assistant for six semesters at MIT, for five graduate courses and two undergraduate courses:

| *Semester* | *Course* | *Instructor* |
|---|---|---|
| Spring 2007 | 18.311 Principles of Applied Mathematics (undergraduate) | Prof. Martin Bazant |
| Fall 2006 | 18.366 Random Walks and Diffusion | Prof. Martin Bazant |
| Spring 2006 | 18.337 Applied Parallel Computing | Prof. Alan Edelman |
| Spring 2005 | 18.366 Random Walks and Diffusion | Prof. Martin Bazant |
| Spring 2005 | 18.311 Principles of Applied Mathematics (undergraduate) | Prof. Martin Bazant |
| Spring 2004 | 18.336 Numerical Methods of Applied Mathematics II | Dr. Plamen Koev |
| Fall 2003 | 18.435 Quantum Computation | Prof. Peter Shor |

## PROFESSIONAL ACTIVITIES

Advisory Board member — 2014–present
Institute for Applied Computational Science, Harvard University

Seminar organizer
Berkeley Applied Mathematics Seminar — 2008–2009, 2012–2013
http://math.lbl.gov/ams/

Simple Person's Applied Math Seminar, MIT — 2005–2006
http://math.mit.edu/spams/

Journal reviewer — 2007–present
Physical Review Letters, Physical Review E, Computational Mechanics,
Journal of the Mechanics and Physics of Solids, Journal of Fluids and Structures,
Journal of Statistical Mechanics, International Journal of Thermal Sciences,
Journal of Scientific Computing, Physics of Fluids, Annals of Nuclear Energy,
International Journal of Chemical Reactor Engineering, PLOS ONE,
Chaos: An Interdisciplinary Journal of Nonlinear Science,
Biophysical Journal, International Journal of Statistical Mechanics

Proposal reviewer — 2013–present
Advanced Scientific Computing Research (ASCR), U.S. Department of Energy

Member of professional societies
American Nuclear Society — 2012–2013
Society for Industrial and Applied Mathematics — 2010–present
American Physical Society — 2004–present

## POSTDOCTORAL MENTORING

Chen-Hung Wu 2014–present
*Jointly supervised with Prof. Ken Kamrin, MIT*

Thomas Fai 2014–present

Yue Yu Summer 2014
Summer project: *Sharp-interface reference map simulation methods*

## GRADUATE MENTORING

Minjae Kim 2014–present

Jordan Hoffmann 2014–present

Raphaël Pestourie 2014–present
Collaborative project: *Optimization methods applied to optics*

Taiyo Wilson Summer 2014
Summer project: *Optimization of jammable assemblies for prosthetic design*

Jue Chen Fall 2012
Research project: *Conformal methods for wave dynamics and dissolution processes*

## UNDERGRADUATE MENTORING

Jeffrey Wang 2014–2015
Research project: *Cell–matrix interactions in tumor growth*

Jung Heon Song 2011–2012
Reading course: *Random walks and diffusive processes*
LBL summer project: *Voronoi network simplification in porous material screening*

Yi Sui Spring 2012
Senior thesis: *Finite-difference simulations of bulk metallic glasses*

Cody Dance Summer 2011
LBL summer project: *Voronoi computations in arbitrary domains*