

Robert B. Kusner

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Professional and personal information

Rob Kusner is an expert on variational methods in geometric analysis. For most of his career he has focused on questions related to classifying embedded constant mean curvature (CMC) surfaces. He has also worked on variational problems in low dimensional geometry and topology (such as minimal surfaces, Willmore surfaces, conformally flat manifolds with constant scalar curvature, curvature flows, geometric knots and links, configuration spaces and contact structures), as well as issues of mathematical experimentation and visualization. In 1995, Rob joined the editorial board of the journal *Experimental Mathematics*, on which he remains quite active.

Kusner has been involved with the Center for Geometry, Analysis, Numerics & Graphics (GANG) since its inception in the 1980's, and became its Co-Director in 1993, after a year at the Institute for Advanced Study in Princeton on an NSF Fellowship. Rob returned to the IAS, and also participated in the special geometric topology year at MSRI in Berkeley, during the 1996-97 academic year. During his 2003-04 sabbatical, Rob was again in the Bay Area, participating in the MSRI special year in geometry, and working with colleagues at Berkeley, Stanford and Utah. Starting in 2008 (in conjunction with his most recent sabbatical), Kusner became a long-term visitor to the Mathematics and Physics Departments at the University of Pennsylvania.

Rob was born 6 March 1960, in Philadelphia, Pennsylvania. He attended the experimental Miquon School (1963-68) and the Friends' Select School (1968-77), while also working as a mechanic, farmer and house-builder. An advocate for alternative transportation, Kusner has served for many years on the Amherst Public Transit and Bicycle Committee, which he chaired from 1998-2000. He has also been a Conservation Commissioner (2000-03), and a Member of Amherst Representative Town Meeting (1994-95, 1998-2005). In March 2005, Rob was elected to Amherst's five-member Select Board, the executive body of the Town.

Degrees

University of California, Berkeley
Ph.D. Mathematics 1988
C. Phil. Mathematics 1984

Haverford College, Pennsylvania
B.A. Mathematics (High Honors) 1981
B.A. Physics (Honors) 1981

Post-Doctoral Advisor: Prof. Robert Hardt

Thesis Advisor: Prof. Richard M. Schoen

Experience

University of Massachusetts, Amherst

Professor, 1999–

Associate Professor, 1992–99

Assistant Professor, 1988–92

University of Pennsylvania

Visiting Professor 2008–

University of Utah

Visiting Professor 2004–

Universite' de Tours, France

Visiting Professor 2003–

Aspen Center for Physics

Member and Workshop Organizer 2004, 2008

Mathematical Sciences Research Institute, Berkeley

Member 2003–04, 2001, 1996–97, 1994

University of California, Berkeley

Visiting Professor 2003–04

Isaac Newton Institute, Cambridge, England

Member 2002

Max Planck Institute for Complex Systems, Dresden, Germany

Visiting Member 2002

Institute for Advanced Study, Princeton

Member 1996–97

Member 1992–93

University of Minnesota, Minneapolis

Visiting Professor 1996

Institute for Mathematics and its Applications, Minneapolis
Member 1996, 2008

Universidad del Granada, Spain
Visitor in Geometria 1996

Geometry Center, Minneapolis
Visiting Professor 1994

Rice University
Visiting Professor 1992

Five Colleges Geometry Institute
Research Director 1990–91
REU Mentor 1993

Technische Universitat, Berlin
Visitor in Geometrie 1990

I.H.E.S., Bures sur Yvette, France
Visiting Member 1989

University of California, Santa Barbara
Visiting Research Assistant Professor 1988–89

I.M.P.A., Rio de Janeiro, Brazil
Visiting Member 1988, 2007

Stanford University
Instructor & Visiting Scholar 1987–88

University of California, San Diego
Research & Teaching Associate 1985–87

University of California, Berkeley
Research & Teaching Assistant 1982–85

Thesis Students

Diego Belfiore (Ph.D. in progress)

Eli Damon [Cooper], The Gauss-Green Form on the Moduli Space of Unduloids, Ph.D. 2007.

Evan Innis, Undergraduate Senior Thesis 2006.

Elena Giorgi, M.S. 2000.

Huayong Yang, M.S. 1998.

James Lawrence, Undergraduate Senior Thesis 1998.

Jorgen Berglund, Minimal and CMC Surfaces in 3-Manifolds, Ph.D. 1997.

Nicholas Schmitt, Minimal Surfaces with Embedded Planar Ends, Ph.D. 1993.

Wayne Rossman, Constant Mean Curvature Surfaces in Euclidean and Hyperbolic 3-Space, Ph.D. 1992.

Postdoctoral Advisees

Hao Wu (presently at George Washington University)

Jesse Ratzkin (presently at University College, Cork, Ireland)

Bernd Ammann (presently at Universität Regensburg, Germany)

Jason H. Cantarella (presently at University of Georgia, Athens)

Nicholas Schmitt (presently at Universität Tübingen, Germany)

Bo Guan (presently at Ohio State University, Columbus)

John M. Sullivan (presently at University of Illinois, Urbana, and Technische Uni, Berlin)

Karsten G. Brauckmann (presently at Uni Darmstadt, Germany)

Publications

43. (with K.G. Brauckmann, N. Korevaar, & J. Sullivan)

42. (with Y. Diao)

41. (with K.G. Brauckmann)

40. Coplanar k-unduloids are nondegenerate surfaces [submitted, arXiv:0712.1865] (with K.G. Brauckmann, N. Korevaar, J. Ratzkin & J. Sullivan).

39. Some knotty ideas in geometry: pearl-number, ropelength, bandwidth and packing-density, [preprint under revision] (with W. Kusner).

38. On the nondegeneracy of constant mean curvature surfaces. *Geom. and Funct. Analysis* **16.4** (2006) 891-923 (with N. Korevaar & J. Ratzkin).

37. Coplanar Constant Mean Curvature Surfaces. *Comm. Anal. Geom.* **15** (2007) 985-1023 (with K.G. Brauckmann & J. Sullivan).

36. Ropelength Criticality, [preprint under revision] (with J. Cantarella, J. Fu, J. Sullivan & N. Wrinkle).

35. Criticality for the Gehring Link Problem, *Geometry & Topology* **10** (2006) 2045-2105 (with J. Cantarella, J. Fu, J. Sullivan & N. Wrinkle). URL: <http://www.msp.warwick.ac.uk/gt/2006/10/p045.xhtml> DOI: 10.2140/gt.2006.10.2045

34. The Average Crossing Number of Equilateral Random Polygons, *J. Physics A* **36** (2003) 11561-11574 (with Y. Diao, A. Dobay, K. Millett & A. Stasiak).
33. Three-Manifolds According to Grisha Perelman, *Sugaku Seminar* **42/10** (2003) 4-6 (in Japanese, with S. Okada & E. Cooper).
32. Triunduloids: Embedded CMC Surfaces of genus zero and three ends, *J. Reine Angew. Math.* **564** (2003) 35-61 (with K.G. Brauckmann & J. Sullivan).
31. The Second Hull of a Knotted Curve, *Amer. J. Math* **125** (2003) 1335-1348 (with J. Cantarella, G. Kuperberg & J. Sullivan).
30. Topology, Geometry and Conformal Structure of Properly Embedded Minimal Surfaces, *J. Diff. Geom.* **67** (2004) 377-393 (with P. Collin, W. Meeks & H. Rosenberg).
29. On the Minimum Ropelength of Knots and Links, *Inventiones Math.* **150** (2002) 257-286 (with J. Cantarella & J. Sullivan).
28. Conformal Structures and Necksizes of Embedded Constant Mean Curvature Surfaces, *Clay Mathematics Proceedings: Summer School on the Global Theory of Minimal Surfaces* **3** (2005) 585-596.
27. On Thickness and Packing Density for Knots and Links, *Contemporary Math.* **304** (2002) 175-180 [volume edited by Calvo, Millett & Rawdon].
26. Quantization of Energy and Writhe in Self-Repelling Knots, *New J. Phys.* **4** (2002) 1-11 (with P. Hoidn & A. Stasiak).
25. Constant Mean Curvature Surfaces with Three Ends, *Proc. Nat. Acad. Sci. (USA)* **97** (2000) 14067-14068 (with K.G. Brauckmann & J. Sullivan).
24. Embedded Constant Mean Curvature Surfaces with Special Symmetry, *Man. Math.* **99** 135-150 (1999) (with K.G. Brauckmann).
23. Tight knot values deviate from linear relations, *Nature* **392** (1998) 237-238 (with J. Cantarella & J. Sullivan).
22. Möbius-invariant knot energies, *Ideal Knots*, L. Kauffman, A. Stasiak & V. Katrich, eds. World Scientific, Singapore, 1998 (with J. Sullivan).
21. Constant mean curvature surfaces with cylindrical ends, *Mathematical Visualization*, C. Hege and K. Polthier, eds. Springer, Berlin, 1998, 107-116 & 371 (with K.G. Brauckmann & J. Sullivan).
20. On Distortion and Thickness of Knots, *Topology and Geometry in Polymer Science*, T. Lodge, D. Sumners and S. Whittington, eds. IMA Volumes in Math. and its Applications **103** (1997) 67-78 (with J. Sullivan).
19. In Memoriam, F. J. Almgren, Jr. *Experimental Math.* **6** (1997) 1-12 (with D. Epstein, E. Lieb, A. Marden & alii)

18. The Minimax Sphere Eversion, *Visualization and Mathematics*, C. Hege and K. Polthier, eds. Springer, Berlin, 1997, 3-20 & 359-360 (with K. Brakke, G. Francis and J. Sullivan).
17. The Spinor Representation of Surfaces in Space, arXiv dg-ga/9610005 (1996) and dg-ga/9512003 (1995) (with N. Schmitt).
16. Estimates for the Biharmonic Energy on Unbounded Planar Domains, and the Existence of Surfaces Minimizing the Squared Mean Curvature Integral, *Elliptic and Parabolic Methods in Geometry*, B. Chow, R. Gulliver & alii, eds. A.K. Peters, 1996, 67-72.
15. The Moduli Space of Complete Embedded Constant Mean Curvature Surfaces, *Geom. and Funct. Analysis* **6** (1996) 120-137 (with R. Mazzeo & D. Pollack).
14. Comparing the Weaire-Phelan Equal-volume Foam to Kelvin's Foam, *Forma* **11:3** (1996) 233-242 (with J. Sullivan). [Reprinted in: *The Kelvin problem*, Denis Weaire, editor. Taylor and Francis, London, 1997.]
13. New Surface Allotropes of Carbon, *Chem. Phys. Letters* **241** (1995) 522-527 (with P. Lahti & P. Lillya).
12. Möbius Energies for Knots and Links, Surfaces and Submanifolds, *Geometric Topology: Proceedings of the Georgia International Topology Conference*, William H. Kazez, editor. A.M.S./International Press (1997) 570-604 (with J. Sullivan).
11. The Global Structure of Constant Mean Curvature Surfaces, *Inventiones Math.* **114** (1993) 311-332 (with N. Korevaar).
10. Torus Knots Extremizing the Möbius Energy, *Experimental Math.* **2** (1993) 1-9 (with D. Kim).
9. The Structure of Constant Mean Curvature Embeddings in Euclidean Three Space, *Proceedings of A.M.S. Symposia in Pure Math* **54**, *Differential Geometry: Partial Differential Equations on Manifolds*, R. Greene and S.T. Yau, editors. (1993) 291-298 (with N. Korevaar).
8. The Number of Faces in a Minimal Foam, *Proc. Royal Soc. London A* **439** (1992) 683-686.
7. Minimizing the Squared Mean Curvature Integral for Surfaces in Space Forms, *Experimental Math.* **1** (1992) 191-207 (with L. Hsu & J. Sullivan).
6. Constant Mean Curvature Surfaces in Hyperbolic Space, *Amer. J. Math.* **114** (1992) 1-43 (with N. Korevaar, W.H. Meeks & B. Solomon).

5. A Maximum Principle at Infinity and the Topology of Complete Embedded Surfaces with Constant Mean Curvature, *Springer-Verlag Lecture Notes in Mathematics* **1481**, *Proceedings, Berlin Global Differential Geometry and Global Analysis* (1991) 108-114.
4. Bubbles, Conservation Laws, and Balanced Diagrams, *Geometric Analysis and Computer Graphics. MSRI Publications* **17** (1991) 103-108.
3. Structure of Complete Embedded Surfaces with Constant Mean Curvature, *J. Differential Geom.* **30** (1989) 465-503 (with N. Korevaar & B. Solomon).
2. Comparison Surfaces for the Willmore Problem, *Pacific J. Math.* **138** (1989) 317-345.
1. Conformal Geometry and Complete Minimal Surfaces, *Bull. Amer. Math. Soc.* **17** (1987) 291-295.
0. Global Geometry of Extremal Surfaces in Three Space, *Dissertation*, University of California, Berkeley.
- 1. An Olla-Podrida of Open Problems, Often Oddly Posed, *Amer. Math. Monthly* **90** (1983) 196-200 (with R. K. Guy).

Reports of work in general science journals

Rob Kusner's mathematical work has also been highlighted in several general science journals, including *Science News* (October 1998), *Science* (July 1998) and *New Scientist* (Winter 1995).

Professional activities

Journal Editor, *Experimental Mathematics* (1995–).

Co-Director of the Center for Geometry, Analysis, Numerics and Graphics (GANG), University of Massachusetts at Amherst (1993–).

Organizer, Workshop on Geometry of Condensed Matter, Apsen Center for Physics (2008)

Proposal Reviewer for NSF Programs in Geometric Analysis; Topology and Foundations; Computational Mathematics; Materials Theory; Gravitation Theory.

Referee for various journals and proceedings, including: *Journal of Differential Geometry*; *Annals of Mathematics*; *Communications in Analysis and Geometry*; *AMS Journals*; *Pacific J. Math.*; *Topology and its Appl.*; *Proc. Royal Soc. London*; *Math. Zeit.*; *Duke Math. J.*; *Amer. J. Physics*; *Tohoku Math. J.*; and several other journals involving analysis, geometry and topology.

Program Committee, Visualization and Mathematics (Berlin, Sep 1997).

Organizer of the Five Colleges Geometry Institute (1990–94).

Organizer of AMS Special Sessions on Low Dimensional Geometry (Philadelphia, Oct 1991), on Optimal Geometry (Urbana, Mar 1999), and on Geometric Analysis (Storrs, Oct 2007).

Mentor for NSF Research Experiences for Undergraduates (at Five Colleges Geometry Institute, at the Geometry Center, and at GANG).

Member of NSF panels reviewing CARGO, REU/RUI, RGI.

Member: American Mathematical Society; American Physical Society; Institute of Electrical and Electronics Engineers.

Grants

PI, NSF Grant DMS-0076085, Variational Problems in Low-Dimensional Geometry and Topology (2000–2004)

Co-PI, NSF Grant DMS-0079536, SCREMS (2000–2003)

Sponsoring Senior Scientist, NSF Postdoctoral Research Fellowship for Jason Cantarella, at University of Massachusetts, Amherst (1999–2000)

PI, NSF Grant DMS-9704949, Variational Problems in Low-Dimensional Geometry and Topology (1997–2000)

Co-PI, NSF Grant DMS-9626804, GANG: An Interdisciplinary Teaching and Research Environment (1997–2000)

PI, DOE Grant DE-FG02-86ER25015, Computation and Graphics in Mathematical Research (1994–95)

PI, NSF Grant DMS-9404278, Variational Problems in Geometry and Topology (1994–97)

Co-PI, NSF Grant DMS-9312087, Computational Methods in the Mathematical Sciences (1993–97)

Co-PI, DOE Grant DE-FG02-86ER25015, Computation and Graphics in Mathematical Research (1992–94)

Co-PI, NSF Grant DMS-9013220 establishing Five Colleges Geometry Institute, Geometry in the Machine Age, one of three NSF Regional Geometry Institutes (1990–94)

PI, NSF Grant DMS-8908064, Global Geometry of Extremal Surfaces (1989–91)

Other awards and honors

Shoemaker Distinguished Lecturer, University of Toledo (1999)

NSF Postdoctoral Research Fellowship (1991–94)

Regents Fellow, University of California, Berkeley (1985–86)

Wheeler and Goewy Fellow, University of California, Berkeley (1981–82)

Phi Beta Kappa (1980)

RPI Science Medal (1977)

Invited seminars

Plenary Addresses to the 2008 IMA workshop on Geometric Singularities (Minneapolis, USA), 2007 celebration for the 60th birthdays of W. Meeks and D. Hoffman (Buzios, BRAZIL), 2005 AIM workshop on the Global Theory of Minimal Surfaces (Palo Alto, USA), the 2005 Gordon Conference on Liquid Crystal Geometry (New London, New Hampshire, USA) the 2004 Kolloquium (Darmstadt, GERMANY), the 75th Birthday Celebration of Manfredo do Carmo in 2004 (Maceio, BRAZIL), the 2003 Retirement Celebration for Jean Taylor (Rutgers, USA), the 60th Birthday Celebration of Harold Rosenberg in 2002 (Dijon, FRANCE), the Euler Math Institute (St Petersburg, RUSSIA), the 2002 Texas Geometry and Topology Festival (Lubbock, USA), the 2001 Clay/MSRI Summer School (Berkeley, USA), the 2000 Spitalfields Day (Newton Institute, Cambridge, UK), the 1999 JAMI Workshop at Johns Hopkins (Baltimore, USA), the 1997 Lehigh Geometry Festival (Bethlehem, USA), the 1993 International Topology Conference (Athens, Georgia, USA), the 1992 Texas Geometry and Topology Festival (Houston, USA), the 1991 GADGET Workshop (Granada, SPAIN), and the 60th Birthday Celebration of Manfredo do Carmo in 1988 (Rio de Janeiro, BRAZIL); also over one hundred other research lectures at mathematics and physics institutions and professional meetings (as well as presentations at more than a dozen AMS special sessions) over the past decade, including: Ecole Normale Supérieure (Paris, FRANCE), Institute for Advanced Study (Princeton, USA), Mathematische Institut and SFB256 (Bonn, GERMANY), KFA Nuclear Physics Center (Jülich, GERMANY), Technische Universität (Berlin, GERMANY), I.H.E.S. (Bures sur Yvette, FRANCE), Mathematisches Forschungsinstitut (Oberwolfach, GERMANY), Freie Universität (Berlin, GERMANY), MSRI (Berkeley, USA), Universidad del Granada (SPAIN), I.M.P.A. (Rio de Janeiro, BRAZIL), Centre de Physique (Les Houches, FRANCE), Stanford University (USA), University of California (Berkeley, USA), Courant Institute (New York, USA), CUNY Graduate Center (New York, USA), University of Pennsylvania (Philadelphia, USA), University of Minnesota (Minneapolis, USA), Indiana University (Bloomington, USA), University of Texas (Austin, USA), Lehigh University (Bethlehem, USA), University of Washington (Seattle, USA), University of Iowa (Iowa City, USA), University of Connecticut (Storrs, USA), Rutgers University (New Brunswick, USA), Washington University (St. Louis,

USA), University of Arizona (Tucson, USA), University of Illinois (Urbana, USA), University of Chicago (USA), Harvard University (Cambridge, USA), George Washington University (DC, USA), Northeastern University (Boston, USA), MIT (Cambridge, USA), Johns Hopkins University (Baltimore, USA), EPFL (Lausanne, SWITZERLAND), NCTS (Hsinchu, TAIWAN), Kobe University (JAPAN), Seoul National University (KOREA), University of Tennessee (Knoxville, USA), University of North Carolina (USA), University of Warwick (UK), University of Wisconsin (Madison, USA), University of Utah (Salt Lake City, USA), Universite' de Paris VII (France), Universite' de Tours (FRANCE), University of California (Davis, USA), the University of California (Santa Cruz, USA), BIRS (Banff, CANADA), UFC (Fortaleza, BRAZIL), UBR (Brasilia, BRAZIL), Aspen Center for Physics (Aspen, USA), and Brandeis University (Waltham, USA).