Curriculum Vitae

PROFESSOR MICHAEL J FIELD

February 3, 2019

CITIZENSHIP:	USA (& UK)
ACADEMIC ADDRESS	Department of Mathematics Rice University 6100 S Main St Houston, TX 77005-1892
POSTAL ADDRESS:	5024 Walnut Park Dr Santa Barbara CA 93111-1838
EMAIL:	mikefield@gmail.com
PHONE:	832 531 4741
URLS (clickable):	wwwf.imperial.ac.uk/~mjfield1/index.html, math.rice.edu/~mjf8

DEGREES:
BSc, Univ. of Cambridge, 1967
MA, Univ. of Cambridge, 1968
PhD, Univ. of Warwick, 1970
Thesis: *Equivariant Dynamical Systems*
Advisors: Sir Christopher Zeeman, FRS, & James Eells

Employment Elliott Automation, aircraft controls division, Rochester, Kent, UK, 1963–1964; Shell, computer division, London, UK, 1967; Lecturer, University of Warwick, UK, September 1970–May 1976 (tenured from 1971); Lecturer, University of Sydney, Australia, May 1976–1985 (Sen. Lecturer from 1979); Reader, University of Sydney, January 1985–1994; Professor University of Houston, September 1992–August 2012; (Adjunct) Research Professor, Rice University, July 2012–present; Senior Research Investigator (SRI), Imperial College, 2016–August, 2018.

Visiting positions: Lecturer, UNDP supported summer school on Global Analysis, ICTP, Trieste, July–August, 1972; Exchange Lecturer, Univ. Minnesota, Fall term, 1972; Visiting Lecturer, Univ. Minnesota, Winter and Summer terms, 1973; Lecturer, UNDP supported summer school on Complex Analysis, ICTP, Trieste, June–July, 1975; Visiting Scholar, Univ. California, Berkeley, April–June, 1980; Visiting Prof. Univ. Wisconsin-Madison, 1984–85; SERC Research Fellow, University of Warwick, June–July, 1989; Visiting Scientist, Mathematical Sciences Institute, Cornell, August 1989–June 1990; Visiting CNRS fellow, University of Nice, Parc Valrose, November–December, 1991; Visiting Fellow, Centre for Mathematics and its Applications, Australian National University, Canberra, ACT, June 19–July 9, 1994; Master Class Lecturer, University of Twente, Netherlands, November–December 1995; EPSRC Visiting Fellowship, University of Guildford, UK, June 1997; EPSRC Visiting Fellowship, UMIST, UK, August, 1998; EPSRC Visiting Fellowship, Exeter, UK,

October 2001–July 2002 (5 weeks in Exeter); EPSRC supported collaboration during the period August 2002–July 2004 with Prof I Melbourne, University of Surrey; Visiting Leverhulme Professor, Imperial College London, September 2004–July 2005; Visiting Ulam Professor, Univ. of Colorado, Boulder, Fall 2005; Gaines Scholar, University of Richmond, Virginia, Fall 2006; LMS Scheme II visitor, July 2009 (Exeter, Manchester, Warwick); Honorary Visiting Professor, Exeter University (UK), from 2009; Visiting Professor, University of Manchester, May 1–31 July, 2010; Marie Curie Fellow (2 year fellowship), Imperial College (2014–2016). Senior Teaching Fellow, University of Bristol, August 1, 2017–July 2018.

Awards & Honours:
Fellow of the Institute of Physics (2004)
Visiting Leverhulme Professorship, Imperial College (2004–2005)
Visiting Ulam Professor, Boulder (2005)
Gaines Scholar, University of Richmond (2006)
Honorary Visiting Professor, Exeter University (from 2009)
Inaugural AMS Fellow (2012)
On Fulbright Specialist Roster (from 2013)
Marie Curie International Fellow, Imperial College (2014–2016)

Professional Organizations: American Mathematical Society, London Mathematical Society, European Mathematical Society, European Society for Mathematics and Arts (ESMA).

Editorial, Refereeing etc: Editor of *Nonlinearity* (from 1998), *Discrete and Continuous Dynamical Systems* (2001–2010), and Journal of Mathematics and the Arts (2006–2016). Refereeing work for a wide range of journals and institutions (including EPSRC, NSF Panels and publishers). Organizing Committee, SIAM, Snowbird 2009. Member of the Board of Directors of ESMA and Chair of Educational Outreach Committee.

Recent Grants Texas Advanced Research Program (TARP), 1/1/1994-12/31/96, 'Pattern formation and symmetry in chaotic systems', $56,096 (with M Golubitsky); TARP, 1/1/96-12/31/97, 'Symmetric patterns, symmetric dynamics', $66,500 (with M Golubitsky); TARP, 1/1/98-12/31/99, 'Coupled cell systems and patterns', $66,500 (with M Golubitsky); NSF, 7/1/1994-6/30/96, 'Dynamics and Symmetry', $213,000 (with M Golubitsky and I Melbourne); NSF, 7/1/97–6/30/00, 'Dynamics, patterns and symmetry', $300,000; NSF, 7/1/00–6/30/03; (with Golubitsky, Melbourne & Török); Office of Naval Research, 2/15/94-11/15/96, 'Dynamics, Symmetry and PDEs', $111,018 (with M Golubitsky and I Melbourne). EPSRC (UK) grants to support work with Dr P Ashwin (Exeter) and Prof I Melbourne (Surrey); NSF Focused research grant 5/1/03-5/31/05, 'Synchrony and Structure in Coupled Cell Systems', $885,984 (with M Golubitsky, K Josic, A Török & I Stewart); NSF, 06/10/06-05/31/09, 'Statistical and Geometric Properties of Dynamical Systems', $308,000 (with Matthew Nicol and Andrew Török); NSF, 'Dynamics of Coupled Cell Systems', 06/01/2008—11/30/2012, $196,353; NSF, 'Progress and Problems in Dynamics' (workshop) (with Török & Nicol), 04/15/12—04/14/13, $37,000; NSF, 'Dynamics of Asynchronous Networks, Adaptation and Visualization', 07/15/12—06/30/17, $286,925.

PUBLICATIONS

Books and Monographs

1. *Differential Calculus and its Applications*, Van Nostrand Reinhold, London, 1970. (Reprinted by *Dover*, 2012.)

2. *Several Complex Variables and Complex Manifolds I*, London Mathematical Society Lecture Note Series in Mathematics, **65**, Cambridge University Press, 1982. (Reprinted 2011.)

3. *Several Complex Variables and Complex Manifolds II*, London Mathematical Society Lecture Note Series in Mathematics, **66**, Cambridge University Press, 1982.

4. (with M Golubitsky) *Symmetry in Chaos*, Oxford University Press, November, 1992.

5. (with M Golubitsky) *La Symétrie du Chaos*, InterEditions, 1993. (French translation of *Symmetry in Chaos.*)

6. (with M Golubitsky) *Chaotische Symmetrien*, Birkhäuser, November, 1993. (German translation of *Symmetry in Chaos.*)

7. *Symmetry breaking for compact Lie groups*, Mem. Amer. Math. Soc., **574**, 1996.

8. *Dynamics, Bifurcation and Symmetry*, Pitman Research Notes in Mathematics, **356**, 1996.

9. (with M Nicol) *Ergodic Theory of Equivariant diffeomorphisms: Markov partitions and stable ergodicity*, Mem. Amer. Math. Soc., **803**, 2004.

10. *Dynamics and Symmetry* (Imperial College Press Advanced Texts in Mathematics — Vol. 3, 2007.)

11. (with M Golubitsky) Revision and new edition of *Symmetry in Chaos* (SIAM, May 2009).

12. *Essential Real Analysis* (Springer Undergraduate Mathematics Series, Springer International Publishing AG, 2017.)

13. *Abstract Algebra for Engineers and Applied Mathematicians* (In preparation; partly based on experience at University of Bristol).

Papers

14. 'Equivariant dynamical systems', *Bull. Amer. Math. Soc.* **76** (1970), 1314–1318.

15. 'A finiteness result on the ring of analytic functions defined on a Banach space', *Studia Mathematica*, t XXLVI (1973), 17–20.

16. 'Lectures on holomorphic function theory and complex manifolds', *Proc. of seminar course on Global Analysis and its Applications*, IAEA, Vienna (1974), 83–134.

17. 'Sheaf cohomology, structures on manifolds and vanishing theory', *Proc. of seminar course on Global Analysis and its Applications*, IAEA, Vienna (1974), 167–188.

18. 'Complex analysis on Banach spaces', *Proc. of seminar course on Global Analysis and its Applications*, IAEA, Vienna (1974), 189–192.

19. 'Singularity theory and equivariant dynamical systems', *Proc. of Int. Conf. on Dynamical Systems in Mathematical Phy.*, Rennes (1975).

20. 'Singularity theory and equivariant dynamical systems', *Astérisque*, **40** (1976), 67–78 (revised version of preceding).

21. 'Transversalité dans les G-variétiés', *C. R. Acad. Sc. Paris*, t. 282 (Janvier, 1976), 115–117.

22. 'Several Complex Variables', *Proc. of summer school on complex analysis*, IAEA, Vienna (1976), 234–253.

23. 'Transversality in G-manifolds', *Trans. Amer. Math. Soc.* **231** (1977), 429–450.

24. 'Stratifications of equivariant varieties', *Bull. Austral. Math. Soc.* **16** (1977), 279–295.

25. (With D I Cartwright). 'A refinement of the Arithmetic mean–Geometric mean inequality', *Proc. Amer. Math. Soc.* **71**(1) (1978), 36–38.

26. 'Resolving actions of compact Lie groups', *Bull. Austral. Math. Soc.* **18** (1978), 243–254.

27. 'Equivariant dynamical systems', *Trans. Amer. Math. Soc.* **259**(1) (1980), 185–205.

28. 'Handlebody decompositions for G-manifolds', *Bull. Austral. Math. Soc.* **25**(1) (1982), 29–36.

29. 'On the structure of a class of equivariant maps', *Bull. Austral. Math. Soc.* **26**(2) (1982), 161–180.

30. 'Isotopy and stability of equivariant diffeomorphisms', *Proc. London Math. Soc.* **46**(3) (1983), 487–516.

31. 'Equivariant diffeomorphisms hyperbolic transverse to a G-action', *J. London Math. Soc.* **27**(2) (1983), 563–576.

32. 'Equivariant dynamics', *Contemporary Math.* **56** (1986), 69–96.

33. (With R W Richardson). 'Symmetry Breaking and the Maximal Isotropy Subgroup Conjecture for Reflection Groups', *Arch. for Rational Mech. and Anal.* **105**(1) (1989), 61–94.

34. 'Equivariant Bifurcation Theory and Symmetry Breaking', *J. Dynamics and Diff. Eqns.* **1**(4) (1989), 369–421.

35. (With R W Richardson). 'Symmetry breaking in equivariant bifurcation problems', *Bull. Amer. Math. Soc.* **22**(1) (1990), 79–84.

36. (With M Golubitsky). 'Symmetric Chaos', *Computers in Physics* (1990), 470 – 479.

37. 'Local structure of equivariant dynamics', *Singularities, Bifurcations, and Dynamics*, Proceedings of Symposium on Singularity Theory and its Applications, Warwick, 1989 (eds. R. M. Roberts and I. N. Stewart), Lect. Notes in Math. **1463**, Springer-Verlag, Heidelberg (1991), 168-195.

38. (With J W Swift). 'Stationary bifurcation to limit cycles and heteroclinic cycles', *Nonlinearity* **4** (1991), 1001–1043.

39. (With M Golubitsky and I N Stewart). 'Hemisphere bifurcations', *Journal of Nonlinear Science* **1** (1991), 201–223.

40. (With R W Richardson). 'Symmetry breaking and branching patterns in equivariant bifurcation theory I', *Arch. Rational Mech. and Anal.* **118** (1992), 297–348.

41. (With R W Richardson). 'Symmetry breaking and branching patterns in equivariant bifurcation theory II', *Arch. Rational Mech. and Anal.* **120** (1992), 147–190.

42. (With M Golubitsky). 'Symmetries on the edge of chaos', *New Scientist* **1855** 9 January (1993), 32–35.

43. (With J W Swift). 'Hopf bifurcation and the Hopf fibration', *Nonlinearity* **7** (1994), 385–402.

44. 'Determinacy and branching patterns for the equivariant Hopf bifurcation', *Nonlinearity* **7** (1994), 403–415.

45. (With M. Golubitsky and M. Nicol). 'A note on symmetries of invariant sets with compact group actions', *Tatra Mountains Math. Publ.* **4** (1994), 93–104.

46. 'Blowing-up in equivariant bifurcation theory', in *Dynamics, Bifurcation and Symmetries: New Trends and New Tools* (P Chossat and J.-M Gambaudo, Eds) NATO ARW Series, Kluwer, Amsterdam (1994), 111–122.

47. (With P Chossat). 'Geometric analysis of the effect of symmetry breaking perturbations on an $O(2)$ invariant homoclinic cycle', In: Normal forms and Homoclinic Chaos. *Fields Institute Communications* **4** (1995), 21–42.

48. (With M Golubitsky) 'Symmetric Chaos: How and Why', *Notices of the Amer. Math. Soc.* **42**(2) (1995), 240–244.

49. (With M Dellnitz, M Golubitsky, A Hohmann & J Ma). 'Cycling Chaos', *Intern. J. Bifur. & Chaos* **5**(4) (1995), 1487–1501 (also appeared in: *IEEE Trans. Circuits & Syst.* **42** (10) (1995), 821–823).

50. (With I Melbourne and M Nicol). 'Symmetric attractors for diffeomorphisms and flows', *Proc. London Math. Soc.* **72** (1996) 657–696.

51. 'Geometric methods in bifurcation theory', In: Pattern formation and symmetry breaking in PDEs. *Fields Institute Communications* **6** (1996), 181–208.

52. 'Symmetry breaking for equivariant maps', In: *Algebraic groups and Lie groups*, Volume in Honour of R. W. Richardson, Cambridge University Press, (1997), 219–253.

53. 'Generators for compact Lie groups', *Proc. AMS.* **127** (1999), 3361–3365.

54. (With W Parry). 'Stable ergodicity of skew extensions by compact Lie groups', *Topology*, **38**(1) (1999), 167–187.

55. (With P Ashwin). 'Heteroclinic networks in coupled cell systems', *Arch. Rat. Mech. & Anal.* **148** (1999), 107–143.

56. 'Heteroclinic cycles in symmetrically coupled systems', *Proc. IMA workshop on Pattern Formation in Continuous and Coupled Systems*, May 11-18, 1998 (eds Golubitsky, Luss, Strogatz), IMA volumes no 115, Springer-Verlag, 1999, 49-64.

57. 'Ergodicity and robustness of symmetric attractors', in: *Proc. Equadiff Berlin, 1999* (eds Fiedler, Groger and Sprekels), World Scientific, Vol 1 (2000), 169-174.

58. (With V Niţică) 'Stable topological transitivity of skew and principal extensions', *Nonlinearity*, **14** (2001), 1055–1070.

59. (With I Melbourne and A Török) 'Decay of Correlations, Central Limit Theorems and Approximation by Brownian Motion for Compact Lie Group Extensions', *Erg Th. & Dynam. Sys.* **23** (1) (2003), 87–110.

60. 'Persistent Ergodicity and Stably Ergodic SRB Attractors in Equivariant Dynamics', *Trends in Mathematics: Bifurcations, Symmetry and Patterns*, Birkhäuser, (2003), 75–86.

61. (With P Ashwin, A M Rucklidge and R Sturman) 'Phase resetting effects for robust cycles between chaotic sets', *Chaos* **13** (2003), 973–981.

62. 'Combinatorial dynamics', *Dynamical Systems* **19** (2004), 217–243.

63. (With I Melbourne and A Török) 'Stable ergodicity for smooth compact Lie group extensions of hyperbolic basic sets', *Erg Th. & Dynam. Sys.*, **25**(2) (2005), 517–551.

64. (With P Ashwin) 'Product dynamics for homoclinic attractors', *Proc. Royal Soc., ser. A*, **461** (2005), 155–177.

65. (With I Melbourne, M Nicol and A Török) 'Statistical properties of compact group extensions of hyperbolic flows and their time one maps', *Discrete and Continuous Dynamical Systems*, **12** (1) (2005), 79–96.

66. (With I Melbourne and A Török) 'Stability of mixing and rapid mixing for hyperbolic flows', *Annals of Math.* **166**(1) (2007), 269–291.

67. (With A L Alejandro-Quinones, K E Bassler,J L McCauley, M Nicol, I Timofeyev, A Török, and G Gunaratne) 'A Theory of Fluctuations in Stock Prices', *Physica A*, **363**(2) (2006), 383–392.

68. 'Singularity and stratification theory applied to dynamical systems', *Singularity Theory* (Proceedings of 2005 meeting at Luminy, eds Chéiot et al., World Scientific, 2007), 219–240.

69. (With M Aguiar, P Ashwin and A Dias) 'Dynamics of coupled cell networks: synchrony, heteroclinic cycles and inflation', *Journal of Nonlinear Science*, **21**(2) (2011), 271–323.

70. (With N Agarwal) 'Dynamical equivalence of networks of coupled dynamical systems I: Asymmetric inputs', *Nonlinearity* **23** (2010), 1245–1268.

71. (With N Agarwal) 'Dynamical equivalence of networks of coupled dynamical systems II: general case', *Nonlinearity*, **23** (2010), 1269–1289.

72. 'Exponential mixing for smooth hyperbolic suspension flows'. *Regular and Chaotic Dynamics* **16**(1-2) (2011), 91-104.

73. (With N Agarwal and A Rodrigues) 'Dynamics near the Product of Planar Heteroclinic Attractors', *Dynamical Systems: an international journal* **26**(4) (2011), 447–481.

74. 'Heteroclinic Networks in Homogeneous and Heterogeneous Identical Cell Systems', *J. Nonlinear Science* **25**(3) (2015), 779–813.

75. (With C Bick) 'Functional Asynchronous Networks: Factorization of Dynamics and Function', (MATEC Web of Conferences, **83** (2016), CSNDD 2016 - International Conference on Structural Nonlinear Dynamics and Diagnosis, Marrakech, May 23–25, 2016).

76. (With C Bick) 'Asynchronous Networks and Event Driven Dynamics', *Nonlinearity* **30**(2) (2017), 558–594.

77. (With C Bick) 'Asynchronous Networks: Modularization of Dynamics Theorem', *Nonlinearity* **30**(2) (2017), 595–621.

78. (With C Bick) 'Asynchronous Networks', *Research perspectives CRM Barcelona: Nonsmooth Dynamics* (Birkhauser, 2017), 13–18.

79. 'Patterns of desynchronization and resynchronization in heteroclinic networks', *Nonlinearity* **30**(2) (2017), 516–558.

80. (With M Aguiar and A Dias) 'Feedforward Networks: Adaptation, Feedback, and Synchrony', *J. Nonlinear Sci.*, November, 2018.

81. (With M Aguiar and A Dias) 'Feedforward Networks: Bifurcation and Dynamics', in preparation.

82. 'Asynchronous networks', in preparation.

83. 'The concept of a fundamental dynamical network unit', in preparation.

Other mathematically related refereed papers

84. 'Harmony, Chromatics, and Chaos', *Proc. Bridges Conference, 1999*,(ed Reza Sarhangi) Southwestern College, Kansas, 1–21.

85. 'Color symmetries in chaotic quilt patterns', In *Proc. ISAMA 99 Conference*,(eds N Friedman and J Barrallo), Universidad del Pais Vasco, 1999, 181–187.

86. 'Designer chaos', invited article, *J. Computer Aided Design*, **33** (5), (2001), 349–365.

87. 'Mathematics through Art — Art through Mathematics'. *Proc. MOSAIC 2000 Conference*, University of Washington, Seattle, 2000, 137–146.

88. 'The art and science of symmetric design'. *Proc. of the 2000 Bridges Conference* (ed Reza Sarhangi), Southwestern College, Kansas, 2000, 53–60. (Slightly revised version with color images in on-line journal *Visual Mathematics* **2** (3) (2000), dedicated to the Bridges 2000 conference.)

89. 'The Design of 2-Colour Wallpaper Patterns Using Methods Based on Chaotic Dynamics and Symmetry', In: *Mathematics and Art. Mathematical Visualization in Art and Education*, (ed Claude P Bruter), Springer, Berlin, 2002, 43–60.

90. 'Forum: Comment l'art peut-il venir en aide à l'enseignement des mathématiques?', In: *Mathematics and Art. Mathematical Visualization in Art and Education*, (ed Claude P Bruter), Springer, Berlin, 2002, 168–172.

91. 'Dynamics, Chaos and Design', invited article for *The Visual Mind II*, MIT Press, April 2005, 473–494.

92. 'Mathematics: why get involved?', invited article for *On Common Ground*, Yale, Spring 2005.

93. Invited article for *Notices AMS* on 'Bridges London, 2006', *Notices AMS* **54**(6), 730–732.

94. (With G Greenfield) 'Post-process recoloring of time-based digital images', proceedings of the Fifth Mathematics & Design International Conference, Univ. Regional de Blumenau, Blumenau, SC — Brazil.

95. 'Using Mathematics in Art', *Proceedings of the 2010 Bridges Conference, Pécs, Hungary*, (eds George W Hart and Reza Sarhangi), 2010.

96. 'GPS: Geometry, Probability & Statistics', *Mathematics Teaching* – Geometry special issue, **229** (July 2012).

Conference/Seminar/Workshop talks – from 1993

Mathematics

1. 'Blowing-up in equivariant bifurcation theory', invited address at EBG meeting on *Dynamics, Bifurcation and Symmetries*, Cargese, September, 1993.

2. Invited talk on 'The effect of breaking symmetry from $O(2)$ to Z_2 on a homoclinic cycle in the Armbruster-Guckenheimer-Holmes model', Fields Institute meeting on *Normal forms and Homoclinic chaos*, November, 1993.

3. Seminar, Rayleigh-Durham, Dynamics Days, Jan 1994.

4. Invited series of three talks on 'Geometric methods in bifurcation theory', at Fields Institute meeting on *Pattern formation in PDEs*, February, 1994.

5. Invited speaker at *Sigma Xi* day on chaos, Texas A&M, May, 1994.

6. 'Patterns in Chaos', Invited address at inaugural *Australasian Dynamics Days*, Melbourne, Australia, 14-16 June, 1994.

7. Colloquium talk, Rice University, 1994.

8. Colloquium speaker, Mathematics Department, Australian National University, Canberra, June 30, 1994.

9. Colloquium speaker, Joint Sydney-NSW colloquium, July 1, 1994.

10. 'Structure of symmetric attractors', Invited address at conference on *Symmetry in Dynamical Systems*, Utah State University, September 9–11, 1994.

11. Oberwolfach, *Bifurkation und Symmetrie*, June 25 – July 1, 1995.

12. Invited speaker at workshop on *Equivariant Dynamical Systems*, ICIAM meeting July, 1995.

13. Invited speaker at Workshop on *Dynamics and Symmetry* at the Newton Institute, Cambridge 30 Oct – 3 Nov, 1995.

14. Master class lecturer on 'Symmetry', 13 Nov–11 Dec, 1995, Twente, Holland (series of 16 hours of lectures).

15. Principal invited speaker at Johann Bernoulli *Dynamical Systems Conference*, 11–15 December, 1995, Groningen.

16. Colloquium talk on 'Generators for compact Lie groups', University of Houston, November, 1996.

17. Seminar on 'Generators for compact Lie groups', UMIST, 1996.

18. Speaker at *Southwest Dynamical Systems* meeting, Denton, N. Texas (April 11 – 13, 1997).

19. Invited speaker at meeting on *Equivariant dynamics*, Berlin, 19 – 22 May, 1997 (three one hour talks on symmetric attractors, supported by DFG).

20. Principal speaker at Workshop on *Symmetric Chaos and Dynamical Systems*, University of Surrey, June 16–17, 1997. (Statistics on symmetric attractors.)

21. Talk on 'Stable ergodicity', *International Conference on Differential Equations and Dynamical Systems*, University of Waterloo, August 2, 1997.

22. Invited talk in Dynamical systems seminar at Northwestern on 'Stable ergodicity', October 28, 1997.

23. Colloquium talk on 'Fubini Foiled', University of Houston, November, 1997.

24. Invited talk in Rice Geometric analysis seminar on 'Stable ergodicity', January 1998.

25. Talk on 'Stable Ergodicity', 'Global Analysis 30 Years Later', Cincinnati, March 25 – 28, 1998.

26. Invited talk on 'Heteroclinic cycles in Coupled oscillators', in IMA workshop on Pattern Formation in Continuous and Coupled Systems, May 11 – 15, 1998.

27. Seminar on 'Stable Ergodicity of skew extensions', Moscow State University, June 9, 1998.

28. Principal speaker at workshop on Skew Products, UMIST, August 12, 1998.

29. Principal speaker at Workshop on Equivariant dynamics, University of Surrey, August 19, 1998.

30. Seminar on 'Equivariant dynamics', Cornell University, November 13, 1998.

31. Mathematics Colloquium on 'Ergodicity' at Claremont Colleges, April 14, 1999.

32. Speaker at May SIAM dynamical systems meeting at Snowbird, 1999.

33. Speaker and organizer at Minisymposium on Symmetry, Equadiff, Berlin, August 1-7, 1999.

34. Invited speaker on 'Stable Ergodicity' at DFG meeting, Weierstrass Institute, Berlin, August 7–10, 1999.

35. Seminar on *Cycling Chaos*, Boston University, November, 1999.

36. Speaker in *Geometric Analysis* seminar, Rice University, Fall, 1999.

37. Invited principal speaker, Conference on "Bifurcations, Symmetry and Patterns", University of Porto, Porto, Portugal, 29 June – 4 July 2000.

38. Instructor at Summer School on "Bifurcations, Symmetry and Patterns", Wednesday 5th to Friday 14th July, 2000: Complex Dynamics in Symmetric Systems.

39. Talk on 'Dynamics on the orbit space', AMS regional meeting on 'Geometric and Symbolic Dynamical Systems', October 20–22, 2000, San Francisco State University.

40. Talk on 'Robust Ergodicity and Mixing in Equivariant Dynamics' at Southwest Regional Workshop in Dynamical Systems, 16–19 November, 2000, University of Southern California.

41. Invited speaker on "Stable ergodicity for dynamics equivariant by a compact Lie group" at conference on *Partial Hyperbolicity* in honor of Charles Pugh's 60th birthday, May 29 - June 2, 2001.

42. Invited speaker on "Ergodic properties of equivariant diffeomorphisms" at Prodyn meeting on 'Statistical properties of partially hyperbolic dynamical systems', University of Surrey, 28 August - 1st September, 2001.

43. Colloquium talk on 'Statistics, symmetry and Skew products', Rice University, September 13th, 2001.

44. Seminar on 'ergodic theory of equivariant diffeomorphisms', Trinity University, October 2nd, 2001.

45. Seminar on 'Statistics, symmetry and skew products', University of Exeter, UK, October 29, 2001.

46. Seminar on 'Skew extensions', AMS Western Sectional Meeting, Irvine, California, Nov 11-12, 2001.

47. Seminar on skew extensions, Imperial College, London, May 29, 2002.

48. Seminar on stable transitivity, workshop on piecewise isometries. Luminy, France, June, 2002.

49. Colloquium talk on 'Statistics, symmetry and Skew products', Texas Christian University, October 8, 2002.

50. Colloquium, Physics department, UH, February 4, 2003.

51. Colloquium, Mathematics Department, University of Porto, February 25, 2003.

52. Seminar on 'Stable mixing for hyperbolic flows', geometric analysis seminar, Rice University, April 9, 2003.

53. Speaker/participant at BIRS workshop on 'Symmetry and Bifurcation in Biology', 31 May to 5 June, 2003.

54. Seminar on 'Stability of mixing for hyperbolic flows', Manchester University, 14th May, 2003.

55. Speaker at minisymposium on 'Heteroclinic cycles', Snowbird meeting on Applications of Dynamical Systems (May 27-31 2003).

56. Speaker and minisymposium *Statistical properties of dynamical systems* organizer at 2003 ICIAM meeting in Sydney, Australia.

57. Speaker at minisymposium on *Geometric aspects of dynamics*, 2003 ICIAM meeting in Sydney, Australia.

58. Colloquium talk on 'Randomness, Statistics and Structure in deterministic Chaos', Mathematics Department, University of Sydney, July 11, 2003.

59. Seminar on 'Product dynamics', University of Porto, September 19, 2003.

60. 'Product dynamics', Fields Institute, December 12, 2003.

61. 'Stability of mixing for hyperbolic flows', Annual meeting of AMS, AMS-AWS session on hyperbolic dynamics, Phoenix, 9th January, 2004.

62. 'Stability of rapid mixing for hyperbolic flows', One day ergodic theory meeting, University of Surrey, March 26, 2004.

63. 'Combinatorial Dynamics', Imperial College, UK, March 24, 2004.

64. 'Stability of rapid mixing for hyperbolic flows', One day ergodic theory meeting, University of Surrey, March 26, 2004.

65. 'Stability of rapid mixing for hyperbolic flows', AMS sectional meeting, USC, April 3-4, 2004.

66. Colloquium talk on 'Combinatorial Dynamics', New Mexico State university, Las Cruces, May 6, 2004.

67. 'Combinatorial Dynamics', Turing Institute, UMIST, September 15, 2004.

68. 'Stability of mixing and rapid mixing for Axiom A flows', Recent progress in dynamics, MSRI-Clay Institute, Berkeley, Sept. 27 – Oct. 1, 2004.

69. 'Geometry, Symmetry and Bifurcation', Colloquium, Imperial College London, October 5, 2004.

70. 'Stability of rapid mixing for Axiom A flows', University of Warwick, November 2, 2004,

71. 'Combinatorial Dynamics: Networks', Workshop on Coupled Cell Systems, Imperial College,

72. 'Stability of rapid mixing for Axiom A flows', University of Exeter, November 29th, 2004. November 4, 2004,

73. 'Heteroclinic cycles in coupled cell systems', Coupled 60 workshop, University of Houston, February 3 – 6, 2005.

74. 'Geometric methods in bifurcation theory', Applications of Singularities Workshop, 7 – 11 February, 2005, Luminy, Marseille.

75. 'Geometry, Symmetry and Dynamics'. Colloquium, University of Warwick, February 18, 2005.

76. 'Stability of Mixing', University of Manchester, March 2nd, 2005.

77. 'Stability and mixing rates for hyperbolic flows', Queen Mary College, London, March 7, 2005.

78. 'Heteroclinic cycles in asymmetric coupled cell systems', University of Leeds, Applied mathematics colloquium, March 14, 2005.

79. 'Heteroclinic cycles in coupled cell systems', University College London, March 21st, 2005.

80. 'The Structure of Chaos', Kempner colloquium, UCB, March 31st, 2005.

81. 'Geometry, Symmetry and Dynamics', Yorkshire-Durham Geometry Day, April 15, 2005.

82. 'Heteroclinic cycles in coupled cell systems', Applied mathematics colloquium, Bristol University, 18 April, 2005.

83. 'Heteroclinic cycles', DAMTP, Cambridge, 26 April, 2005.

84. 'Heteroclinic cycles in coupled cell systems', University of Porto, Portugal, May 8th, 2005.

85. 'Geometric invariants for hyperbolic flows', University of Porto, Portugal, May 10th, 2005.

86. 'Geometry, Symmetry and Dynamics', Colloquium, University of Southampton, June 10th, 2005.

87. 'Geometric invariants for hyperbolic flows', Workshop on Probabilistic Limit Laws for Dynamical Systems, Edinburgh, June 13–17, 2005.

88. 'Heteroclinic cycles in coupled cell systems', Applied maths seminar, University of Colorado, Boulder, September 15, 2005.

89. 'Heteroclinic cycles and dynamics in coupled cell systems', Newton Institute, Workshop on Theory and Applications of Coupled Cell Networks, September 30, 2005.

90. 'Zeta functions in dynamics', Colloquium, University of Colorado, Boulder, November 7, 2005.

91. 'Mixing for Flows', SFO State, AMS Sectional (45 minutes) April 29, 2006.

92. 'Dynamics and Symmetry', Dynamical Systems and Statistical Mechanics, Durham, 3–13 July 2006.

93. 'Heteroclinic cycles in coupled cell systems', Exeter Neurodynamics Meeting, 17 July, 2006, Exeter University, UK.

94. 'Mixing', Colloquium, University of Richmond, December 4, 2006.

95. 'Dynamical zeta functions and mixing', University of Southern California, April 9, 2007.

96. 'Heteroclinic Cycles in Coupled Cell Systems', 2007 SIAM Conference on Applications of Dynamical Systems, Snowbird, May 2007.

97. 'Mixing for hyperbolic flows', AMS Fall sectional meeting, De Paul University, Chicago, October 5, 2007.

98. Applied mathematics colloquium, Imperial College London, November 20th, 2007.

99. 'Global dynamics in coupled cell systems', Department of Mathematic Colloquium, Purdue University, February 26, 2008.

100. 'Global Dynamics in Coupled Cell Systems', CICADA, Manchester, UK, 28th March, 2008.

101. 'Rates of mixing for flows', principal speaker at Regional LMS meeting, Manchester, UK, 31st March, 2008.

102. 'Rates of mixing for flows and skew extensions', 1 hour talk, Rocky Mountain Conference on Dynamical Systems, May 12–16, 2008.

103. 'Dynamical zeta functions and mixing', joint University of New South Wales/University of Sydney Colloquium, June 2008.

104. 'Global dynamics and combinatorics of coupled cell systems', Dynamics seminar, University of New South Wales, June 2008.

105. 'Global dynamics and heteroclinic cycles in coupled cell networks', 5th European Mathematical Congress, Amsterdam, July 2008.

106. 'Global dynamics and heteroclinic cycles in coupled cell systems', seminar, Exeter University, July 2008.

107. 'Resolution and intersection: three problems in equivariant geometry', Texas Geometry and Topology Conference, February, 2009.

108. 'Equivalence of coupled systems', SIAM, Snowbird, May 2009.

109. 'Dynamical equivalence of coupled dynamical systems', Workshop on Network Dynamics, University of Exeter, July 15, 2009.

110. 'Rates of mixing for flows and skew extensions', ISAACS meeting, Imperial College London, July 17, 2009.

111. 'Dynamical equivalence of coupled dynamical systems', CICADA, University of Manchester, July 21, 2009.

112. 'Dynamical equivalence of coupled dynamical systems', University of Warwick, July 22, 2009.

113. 'Mixing for flows and skew extensions', Global Dynamics beyond Uniform Hyperbolicity, Beijing, August, 2009.

114. 'Measuring & Seeing Chaos', seminar, Trinity University, Texas, September 17, 2009.

115. 'Exponential mixing for hyperbolic flows', ergodic theory seminar, University of Warwick, 29 September, 2009.

116. 'Dynamics & Equivalence of Coupled Dynamical Systems', NET2009 workshop, University of Warwick, 28 September – 2 October, 2009.

117. 'Exponential Mixing for Hyperbolic Flows', AMS Sectional meeting, UC Riverside, November 7–8, 2009.

118. 'Dynamics, inflation and equivalence of networks', UC Santa Barbara, March 17, 2010.

119. 'Dynamics, inflation and equivalence of networks of coupled dynamical systems', Conference on Network Dynamics and Synchronization, University of Manchester U, May 15–17, 2010.

120. 'Axiomatizing the brain: a discrete neural model with interesting properties', University of Exeter, September 14, 2010.

121. Plenary lecture: 'Symmetry, statistics and stochastic fluctuations', AMS Sectional meeting, Richmond VA, 5 – 7 November, 2010.

122. 'The nature of chaos and some models of neural dynamics', colloquium, University of Hamburg, February 3, 2011.

123. 'Not so trivial, trivial dynamics', Dynamics seminar, University of Hamburg, February 4, 2011.

124. 'A discrete neural model with interesting properties', Networks seminar, University of Houston, April 1, 2011.

125. 'Product Dynamics', Dynamical Systems seminar, University of Houston, April 13, 2011.

126. 'Asynchronous Dynamics', Equadiff, Loughborough, August 1, 2011.

127. 'Mixing Rates for flows', JMM meeting, Boston, 6 January, 2012.

128. 'Dynamics, adaptivity and asynchronous logic in large networks of coupled dynamical systems', Workshop on Stability of Dynamical Systems, Exeter, 27 march, 2012.

129. 'The nature of chaos and randomness in dynamics and some problems for the 21st century inspired by theoretical and computational neuroscience', colloquium, DePaul University, April 13, 2012.

130. 'Adaptivity and asynchronous logic in large networks of coupled hybrid dynamical systems', seminar, Rice University, April 20, 2012.

131. '21^{st} century problems; 20^{th} century solutions: Analyticity and Averaging', workshop on Progress & Problems in Dynamics, Houston, May 14–16, 2012.

132. 'Heteroclinic cycles in complex systems', 9th AIMS Conference on Dynamical Systems, Florida, July 1–5, 2012.

133. 'Dynamics, asynchrony and adaptivity in (large) networks of discrete dynamical systems', Dynamics Days 2012, Gothenberg, September 2 – 7, 2012.

134. 'Asynchronous Networks', University of Porto, September 28, 2012.

135. 'Illuminating Chaos – Art on Average', Colloquium, University of St Thomas, MN, October 17, 2012.

136. 'Problems in Mathematics Inspired by Neuroscience', University of St Thomas, MN, October 18, 2012.

137. 'Asynchronous Networks', University of Manchester, UK , March 2013.

138. 'Asynchronous Networks', Imperial College, London, March 2013.

139. 'Asynchronous Networks', University of Toledo, Ohio, March 2013.

140. 'Asynchronous Networks', Rice University, August, 2013.

141. 'Dynamics on Asynchronous Networks', Queen Mary, UL, September, 2013.

142. 'Dynamics on Asynchronous Networks', Leeds University, September, 2013.

143. 'Asynchronous Networks: Structure and Dynamics', Workshop on Coupled Cell Systems, University of Porto, February, 2014.

144. 'Asynchronous Networks', University of Warwick, January, 2015.

145. 'Asynchronous Networks', University of Exeter, March, 2015.

146. 'Realisation of heteroclinic cycles and networks', AMS-EMS-SPM meeting Porto, 10–13 June, 2015.

147. 'Asynchronous Networks & Event Driven Dynamics', AMS-EMS-SPM meeting Porto, 10–13 June, 2015.

148. 'Asynchronous Networks & Event Driven Dynamics', Open problems in nonsmooth dynamics, CRM, Barcelona, February 1, 2016.

149. 'Robust heteroclinic networks in coupled identical cell systems and patterns of desynchronization and resynchronization along heteroclinic connections', Porto, February 12, 2016.

150. 'Asynchronous Networks and Modularization of Dynamics', University of Southampton, May 3, 2016.

151. 'Robust Heteroclinic Networks in Coupled Identical Cell Networks:Realization and Patterns of Synchronization', NSC-2016, São José dos Campos, May 16, 2016.

152. 'A Modularization of Dynamics Theorem for Asynchronous Networks' (Plenary talk), NSC-2016, São José dos Campos, 20 de Maio de 2016.

153. 'Functional Asynchronous Networks and Factorization of Dynamics+Function', Nonlinear Structural Dynamics and Diagnostics, 23 - 25 May 2016, Marrakech, Morocco.

154. 'Functional Asynchronous Networks and a Modularization of Dynamics Theorem', Dynamics Days, Corfu, June 6 – 10, 2016.

155. 'Functional Asynchronous Networks', Weierstrass Institute/Freie Universität Berlin, June 28, 2016.

156. 'Heteroclinic Dynamics', course given at Coimbra Mathematics Summer School, Portugal, September 5-9, 2016 (10 1 hour lectures).

157. 'Heteroclinic Networks: Construction and Stability', seminar, University of Bath, October 2016.

158. 'Functional Asynchronous Networks', seminar, University of Bath, October 2016.

159. 'Chaos and the Art of Visualizing Complexity', IMI Public Lecture, University of Bath, October, 2016.

160. 'Functional Networks', Advances in Ergodic Theory, Hyperbolic Dynamics and Statistical Laws, ANU, Australia, November 30, 2016.

161. 'Networks and Function', OCIAM seminar, Oxford University, 19 January, 2017

162. 'Heteroclinic Networks in Dynamical Networks', University of Exeter, February 9, 2017.

163. 'Kuramoto Networks and Chimeras', *Aspects of Dynamics* meeting, 16–18 March, 2017, Imperial College.

164. 'Functional Asynchronous Networks', SIAM Conference on Applications of Dynamical Systems, May 23, 2017.

165. 'Functional Asynchronous Networks of Feed Forward type', Emerging Topics in Network Dynamical Systems, Lorentz Institute, Leiden, June 6, 2017.

166. 'Models for Network Dynamics', seminar, University of Bristol, October 20, 2017.

167. 'Dynamics of adaptive feedforward networks with some feedback', Perspectives in Nonlinear Science, Institut d'Études Scientifiques de Cargèse (IESC), March 28, 2018.

168. 'Dynamics of adaptive feedforward networks with some feedback', Applied Mathematics Seminar, University of Southampton, May 1, 2018.

169. 'Dynamics on feedforward networks with adaptation and feedback', seminar, University of Porto, June 21, 2018.

170. 'Models for network dynamics: function, primitive elements and evolutionary bifurcation', Center for Control, Dynamical Systems and Computation, UC Santa Barbara, February 1, 2019.

Mathematics related

171. Invited principal speaker at 'Art-Math98 conference', Berkeley, August, 'Designer Chaos'. Also, presenter of Workshop at the meeting on PRISM ('PRogram for the Interactive Study of Maps').

172. Plenary lecturer on 'Symmetry, Patterns and Designs', Houston Teachers Institute, University of Houston, February, 1999.

173. Plenary speaker at Bridges Conference, Southwestern College, Kansas, July 28–August 31.

174. Plenary speaker at ISAMA 99 conference, June 1999, San Sebastian, Spain.

175. Plenary speaker at The Third Annual Bridges Conference, July 28–July 30, 2000.

176. Plenary speaker at University of Maubeuge (France) meeting on Maths & Arts, September 2000.

177. Organizer of, and speaker in, three hour symposium 'Beauty and the Beast: Visual symbiosis of Art and Mathematics', AAAS yearly meeting, February 15–20, 2001, San Francisco.

178. Organizer of workshop at The Fourth Annual Bridges Conference, July 2001.

179. 'Designer Chaos', SIGGRAPH, Los Angeles, August 12, 2001.

180. Panel member for forum on Art and Mathematics held at Rice University, November, 2001.

181. Speaker at session on 'Mathematics and the Visual Arts', MathFest, summer meeting of the MAA, Boulder Colorado, July 31–August 2, 2003.

182. 'Illuminating Chaos', Institute Henri Poincaré, January 22nd, 2005.

183. 'Illuminating Chaos', Institute of Education: London Knowledge Lab, London, UK, June 8th, 2005.

184. 'Teacher professional development for mathematics and science in the USA: The Yale-New Haven and Houston Teachers Institutes', Institute of Education, London, UK, July 11, 2005.

185. Plenary speaker, Bridges Conference, London, August 4 – 8, 2006, 'Illuminating Chaos — Art on Average'.

186. Public lecture 'Illuminating Chaos', University of Richmond, October 11, 2006.

187. 'Motivating mathematics: Why? How?', Dana conference, UT Austin, October 27, 2006.

188. Inaugural meeting of ESMA, plenary talk: 'Using mathematics in art — Using art in mathematics', Institut Henri Poincaré, Paris, July 19, 2010.

189. 'Using Mathematics in Art — Using art in Mathematics', Bridges Conference, Pécs, Hungary, July 25, 2010.

190. 'The Art & Mathematics of Chaos', *London Knowledge Lab*, September 16, 2010.

191. 'Illuminating Chaos', Mathematics Colloquium, Texas Southern University, March 2014.

192. 'Visualization of complex structure', AMS-EMS-SPM meeting Porto, 10–13 June, 2015.

193. 'Illuminating Chaos: Art (and Science) on Average', public lecture, Dynamics Days, Exeter, September 2015.

194. 'Using Mathematics and Art in Educational Outreach', European Society for Mathematics and Art, general meeting, Ljubljana, September 20–25, 2016.

Miscellaneous

Organization, with M Golubitsky & J. Bennett, of *Bridge Program* mathematics activity on 'chaos and fractals' for high school students, 1994; Talk to prospective students on 'Chaos and Symmetry' at Texas Christian University, October 8, 2002; Talk to high school students, Bideford, Exeter, May 17, 2005. Review of *Indra's Pearls's*, by Mumford, Series and Wright, for *Science*. (March 7, 2003). Review of *Images of a Complex World. The Art and Poetry of Chaos*, by Robin Chapman and Julien Clinton Sprott, Jnr. Math & the Arts **2**(4) (2008), 208–211. Review of 'A Gallery of Chua Attractors', WSC, 2007, Jnr. Math & the Arts **4**(1) 2010, 49–51; Review of 'Beauty of Fractals: Six Different Views, by Denny Gulick and Jon Scott, Editors', Jnr. Math & the Arts, **6**(1) (2012), 56–58.

Teaching

Engineering Mathematics, University of Bristol. 2017–2018.
Undergraduate projects in Mathematics Modelling. Second year course: designed and supervised eight group projects: "Transport problems in Circlevale" (developing a mathematical model to explain the difficulties of running a circular railway which intersects and overlaps other lines); "Off the grid with a microgrid" (addressing the energy needs of the community of Exitville which wants to be independent and as self-sufficient as possible); "Slowdown for speed-up" (investigating and developing a model for traffic flow on freeways); "Finding Chaos" (comparing various techniques, including the 0-1 test and positive Liapunov exponents, for detecting chaos in a chemical system); "An exotic food chain on Fangatafua" (mutant species in a complex heteroclinic cycle); "Segregation in Social Networks" (an adaptive network modelling two media groups which attempting to maximize their audience from amongst the members of a large social network); "Ticketing model for discounted travel" (modelling an advance purchase ticketing model designed to minimize dislocation through delay propagation); "Rainwater storage tanks" (modelling the sloshing of water in a rainwater tank during an earthquake).
Four weeks of lectures on abstract algebra for engineers (groups and other algebraic structures). Basis for a short primer on abstract algebra for engineers—in preparation.

Undergraduate courses taught (1992–2012) at the University of Houston include:

Calculus I, II & III,
Differential equations (junior level),
Patterns, symmetry and design (junior/senior level),
Nonlinear Analysis and Chaos (2 semester senior sequence),
Real Analysis (2 semester senior/graduate sequence),
Topics courses (capstone, honors projects, etc) to individual undergraduates include geometry, graph theory, differential equations and computing, and symbolic dynamics.
Semester length seminars in the Houston teachers Institute in 1999, 2001 & 2004 (see below).

Undergraduate courses taught (1976–1992) at the University of Sydney include:

Point set topology (third year honors), analysis sequence (first and second year honors), complex analysis (3rd year level), linear algebra (1st year level), differential topology and degree theory (honors year), dynamical systems (honors and graduate level), elliptic and pseudo differential operators (graduate level), several complex variable (graduate level).

Courses taught (1970–1976) at the University of Warwick include:

Vector Calculus (2nd year), Differential equations (1st year), Lie groups and representation theory (graduate).

Major course development since 1992:

Senior level course on Nonlinear Analysis & Chaos (now part of regular UH catalog).
Real analysis: senior/graduate level course on analysis.
Ergodic Theory (new graduate course, Spring 2000).
Interdisciplinary course on 'Patterns, Design and Symmetry'. The course was first given in the Department of Art, Fall 1997, and again in Fall 1998, and Fall 2000.

The Analysis sequence course (Sydney University), Real Analysis sequence (University of Houston) and Vector Calculus course (University of Warwick), form the basis of the book *Essential Real Analysis* published in the Springer Sums Series (2017, 450 pages, about 570 exercises).

Graduate & Seminar teaching

A wide range of courses including *Elliptic & Pseudodifferential Operators* (Sydney), *Representation theory of finite and compact Lie groups* (Warwick & Houston), *Differential manifolds and topology* (Sydney & Houston), *Dynamical Systems* (Sydney), *Ergodic Theory* (Houston), *Several complex variables* (Sydney & Houston), *de Rham theory, sheaf cohomology* (Houston), *Statistical properties of dynamical systems* (Houston), *Networks* (Houston). Recent seminar courses on *networks* (Houston and Imperial), and *heteroclinic networks and cycles* (Houston and Coimbra), special topics seminar on Mathematical Neuroscience (Houston, 2 semesters), special topics reading seminar on Max Plus (Tropical) Algebra (Houston) and many Masters tutorials and undergraduate honours projects (Sydney & Houston). Graduate level course on equivariant dynamical systems (Imperial, 2004—basis of the book *Dynamics and Symmetry* [10]) and course on Dynamics and Bifurcation (University of Twente, 1995, basis of monograph *Dynamics, Bifurcation and Symmetry* [6]). Masters thesis on quantum chaos, Antonio Rieser (2004); Doctoral supervision at University of Houston (Nikita Agarwal, 2011, Philip Jacobs, 2004). Thesis Committees (University of Houston): many, including Committees in Electrical, Mechanical and Chemical Engineering and Computer Science (2 Masters research oriented on parallel computing). Senior Jury member for thesis of Manuela Aguiar, University Porto, and Wruck, Hamburg).

Outreach and other activities

Houston Teachers Institute

I was very involved with the *Houston Teachers Institute* (HTI) from its inception in 1998 to 2009 when the association with the Yale National Initiative ceased. I was co-chair of the University Faculty Advisory Council until Fall 2009. I was also a member of the National University Advisory Council of the Yale National Initiative. During the life of HTI, I was actively involved in and chaired many meetings hosted by the Yale-Newhaven Teachers Institute at Yale. The Houston Teachers Institute was based on the successful Yale-New Haven teachers institute model and gave innovative semester long seminars to teachers in the local school district (HISD).

I led three seminars in 1999, 2001 and 2004. The 1999 seminar, which was on symmetry, patterns and designs, ran two hours/week over the Spring semester and into summer. The ten teachers enrolled in the seminar produced curriculum units in the area of symmetry, patterns and designs. The curriculum units produced by the teachers were published and accessible online. The 2001 seminar was on statistics and probability ('Figuring the Odds: Learning to Live with Life's Uncertainty'). There were 11 teachers in the seminar and the curriculum units produced by the teachers have been published and were accessible online. The 2004 seminar was in the area of geometry ('Hands on Geometry: How we can use geometry to see the world around us'.) There were 12 HISD teachers in the seminar (just under 40 applied—the most heavily subscribed seminar in the history of HTI).

Computer art based on geometry and dynamics

Logo designed for *Marie Curie* EU funded project on Asynchronous Networks (click on logo for project summary).

My work has been shown in a number of exhibitions including:
Ars (Dis)Symmetrica '99 exhibition, part of UNESCO-ICSU World Conference on Science, Budapest, June 26–July 1, 1999; *The Frontier between Art and Science* international exhibition, 1999–2001. Spain: Valladolid, March 1–15; Salamanca, April 6-23; León, April 26-May 14; Granada, June 26–July 7. Belgrade, Sep 29–Oct 6; Vienna, Oct 9–13; Anglet, France, 8–17 Dec.; Special exhibit as part of the Fractal Alhambra project, Granada, June 26–July 7; *8th Digital Salon*, School of Visual Arts, New York, Nov 6–Dec 9, 2000; International tour 2001: Madrid, Jan 19–Feb 6; Dijon, Feb 15–March 19; Valladolid, May 8–May 30; Malaga, July 25–September 15; *Art & Math 2000*, Cooper Union, New York, Nov 7–Dec 15, 2000; *Art & Math 2001*, Berkshire College, Pittsfield, Mass., Feb 1–Mar 30, 2001; *"Math=Art"*, Kingwood College, Texas, Nov 2–Nov 22, 2000; *Art Gallery: N-Space*, August 12–August 17, Los Angeles, SIGGRAPH, 2001; *Digital Salon: Selected works*, Corning Gallery, New York, July 11–Sep 8, 2001; *ACM/SIGGRAPH Travelling art show 2001*, 2001–2003, Cape Town, Afrigraph conference, 4–7 Nov, 2001; Rocky Mountains December; Detroit January 2002; *Art: The Visual Messenger*, Kingwood College, October, 2001; *9th Digital Salon*, School of Visual Arts, New York City, Dec 17, 2001–Jan 16, 2002; *Celebrating the Human Drive for Community Through Art*, Kingwood College, December 2001 - January 2002; *Midwest Computer Art Exhibition*, University of Saint Francis, Fort Wayne, Indiana, Feb 2–Mar 8, 2002; MathArt-ArtMath, Selby Gallery, Ringling School of Art and Design, February–March 2002; *Bridges: Mathematical Connections in Visual Art*, Towson University's Holtzman Art Gallery, July 13 to August 10, 2002; *Rhythm and Structure*, Fire Patrol No.5 Gallery, January 2003, New York; *Art Gallery*, July 27–July 31, 2003, SanDiego, SIGGRAPH 2003 (3 pieces); *ACM/SIGGRAPH Travelling art show 2003*, 2003–2005; Mathematical art exhibit, Annual meeting AMS, Phoenix, Arizona, January 2004; Mathematical art exhibit, Annual meeting AMS, Atlanta, Georgia, January 2005; Mathematical art exhibit, Institute Henri Poincaré, 2005 & 2010; Mathematical art exhibit, Bridges, London 2006 & Pécs, 2010; Mathematical art exhibit, Annual meeting AMS, San Diego, California, January 2008; Component of the *Cartesian MathArt Hive* organized by John Sims, held at Bowery Petry Club, NY, NY.
Mathematical art permanent exhibits: Fields Institute, Canada; University of Warwick; University of Waterloo, Canada; London Knowledge Lab; University of Manchester. Numerous frontispieces including the 2009 AMS book *Mathematics Under the Microscope* by Alexandre Borovik (Manchester) and Steven Strogatz' text *Nonlinear Dynamics and Chaos.* Design and computation of high resolution image of IMA (Minneapolis) logo and recomputation of the IMA Logo (1998).