David Rand

Academic Career

2006-2011	EPSRC Senior Research Fellow
2006-present	Associate Director Systems Biology Doctoral Training Centre
2005-2008	Co-director, Systems Biology Centre, University of Warwick
2003-2007	Associate Director MOAC Doctoral Training Centre
2000-2005	Chair, Mathematics Institute, University of Warwick.
1996-2000	Director, MIR@W (Mathematical Interdisciplinary Research at Warwick).
1986-1998	Director, Nonlinear Systems Laboratory, University of Warwick.
1986-present	Professor of Mathematics, University of Warwick.

Awards and Honors

1986	Whitehead Prize of the London Mathematical Society.
1988	Wolfson Research Award.
1988	Founding editor of Nonlinearity
2004	Fellow, Institute of Mathematics and Its Applications (by invitation)
2005	Britten Lecturer. McMaster University
2006	EPSRC Senior Research Fellowship

Main Research Achievements

David Rand has made lasting contributions to pure and applied dynamical systems, and also to theoretical physics, fluid dynamics, ecology and epidemiology, immunology and circadian rhythms. His most recent work is on the interface between mathematics and systems biology.

David Rand did foundational work on dynamics and symmetry [15,16] using the symmetries to predict the space-time structure of flows in systems with S1 and O(2) symmetry and their bifurcations with applications to rotating fluids. These two papers have approximately 166 and 77 citations respectively.

David Rand and L. Jonker discovered and proved the topological-dynamical structure of 1-dimensional unimodal maps (see [12, 13, 14]).

The papers [17,18] opened up a substantial area in dynamical systems by discovering the universal fine-scale structure of the transition from quasi-periodic dynamics to chaotic behaviour in circle maps and the breakdown of invariant circles in dissipative systems, and also explaining this in terms of a renormalisation transformation with a conjectured hyperbolic structure. These papers have received over 500 citations.

In [20], David Rand and his coauthors uncovered the detailed scaling and fractal structure of quasiperiodic Schrodinger operators, particularly at the boundary of extended states.

The papers [22] and [27] contain the first non-heuristic and rigorous formulation of the thermodynamic formalism for multifractal invariants such as $f(\alpha)$ relating geometric, ergodic, dynamical and fractal properties of attractors and repellers. These papers are highly cited (approximately 166 and 77).

David Rand and his coauthors developed new general dynamical theory of evolutionary stability and coevolution [39,40,54,55]. This puts Darwinian evolution in such mean-field models of complex dynamical ecologies onto a firm mathematical basis.

David Rand and his coauthors developed pair approximations and correlation equation methods for spatial ecologies and infection [51,54,55,58].

In [30], Rand and Wilson introduced the notion of chaotic stochasticity. This paper has been influential and has received over 110 citations.

David Rand and Alberto A. Pinto have developed an extensive theory characterising the flexibility and rigidity of one and two dimensional hyperbolic dynamical systems and have constructing Teichmüller spaces for them, in particular for their C^{1+} conjugacy classes. This work that has appeared in a number of papers (e.g. [44,59,61,63,66,71,96]) has been collected into a monograph that is to be published by Springer in 2008.

In [6], David Rand published a dynamical game based on Cournot duopoly and showed that under rather natural conditions this game would have chaotic trajectories.

David Rand, Hugo van den Berg and Nigel Burroughs developed a new approach to one of the central questions of immunology: how can the exquisite antigen specificity of T cells be reconciled with the low affinity of the binding between the T cell receptor (TCR) and the MHC/peptide complex and how can this lead to an effective and safe immune response.

In chronobiology, David Rand has addressed two centrally important current problems: (a) To determine how the structure of the genetic network allows it to accommodate multiple, possibly conflicting goals, and to characterise these goals [65,70]. (b) To understand why circadian clocks have multiple intertwined regulatory loops and complex genetic control at the core of the clock mechanism even though a single feedback loop with a very simple structure will produce robust oscillations [65,76,77]. This work is part of a larger project to develop analytical tools that will aid in the understanding of regulatory and signaling networks. In particular, Rand has worked on: infinitesimal response curves (IRCs) (see [65,70]); mapping sensitivity (see [77]); flexibility (see [65,70]); experimental optimization (see [65,89]); statistical estimation of regulatory and signaling networks (see [73]).

Other areas where David Rand has contributed include: game theory and economics, the evolution of altruism and cooperation, bifurcation theory, nonlinear oscillations, the topological classification of Lorenz attractors, singularity theory and eikonal equations, local adaptive Galerkin bases, mechanisms for localised turbulence, turbulent transport, vortex dynamics, turbulence and linear stability in Ginzburg-Landau models, spatio-temporal chaos, patterns in spatially-extended ecologies, epidemics on dynamic networks, the timing of flowering, temperature compensation in circadian clocks. Several of the papers in these other areas have significant citations.

Spontaneous commentaries from other authors

A chapter in a recent book "Oligopoly Dynamics: Models and Tools, Tönu Puu and Irina Sushko (Eds.)" is devoted to a review of this work and that which followed it up. To quote from a review of this book in the Journal of Economic Behavior Organization: "The second chapter, by J. Barkley Rosser, surveys the recent literature on nonlinear oligopoly dynamics that followed the seminal work of David Rand from 1978. Using the Cournot duopoly model, Rand was the first to make a thorough study of nonlinear dynamics in an economic framework."

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List of publications

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2. D. Kirby D. A. Rand, Regular rings and valuation ideals. Oxford Quarterly J. of Mathematics 25 329-340 (1974).

3. D. A. Rand, A space of valuation subalgebras. Oxford Quarterly J. of Mathematics 26 263-267 (1975).

4. D. A. Rand, Thresholds in Pareto sets. J. Math. Econ. 3 139-154 (1976).

5. D. A. Rand, The bifurcations of Duffing's equation. Journal of Sound and Vibration 44 237-253 (1976).

6. D. A. Rand, Exotic phenomena in games and duopoly models. J. of Math. Economics. 5 173-184 (1978).

7. D. A. Rand, The Topological classification of Lorenz attractors. Math. Proc. Camb. Phil. Soc. 83 451-460 (1978). (Reprinted in: Strange Attractors, editors Y Sinai and A Kolmogorov, (1981) (in Russian)).

8. P. Holmes D. A. Rand, Bifurcation of the forced Van der Pol equation. Quart. Applied Math. 50 495-509 (1978).

9. L. Jonker D. A. Rand, Une bourne inferieure pour l'entropie de certaines

applications de l'interval. C.R. Acad. Sci. Paris 287 (1978).

10. D. A. Rand, On the stability of wave fronts defined by eikonal equations. Proc. Royal Soc. of Edinurgh. 85A 195-232 (1980).

11. P. Holmes D. A. Rand, Phase portraits and bifurcations of a nonlinear oscillator. Int. J. Nonlinear Mechanics 15 (6) 449-458 (1980).

12. L. Jonker D. A. Rand, The periodic orbits and entropy of certain maps of the unit interval. J. Lond. Math. Soc. 22 175-181 (1980).

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14. L. Jonker D. A. Rand, Bifurcations in one-dimension. II. A versal model for bifurcations. Inventiones Matematicae 63 1-15 (1981).

15. M. Gorman, D. A. Rand H. Swinney, Doubly-periodic circular Couette flow: experiments compared with predictions from dynamics and symmetry. Phys. Rev. Letters, 46 (15) 992-995 (1981).

16. D. A. Rand, Dynamics and symmetry. Predictions for modulated waves in rotating fluids. Archive for Rational Mechanics and Analysis, 79(1) 1-37 (1982).

17. D. A. Rand, S. Ostlund, J. Sethna and E. Siggia, Universal transition from quasiperiodicity to chaos in dissipative systems. Phys. Rev. Letters 49(2) 132-135 (1982).

18. S. Ostlund D. A. Rand, J. Sethna and E. Siggia, Universal properties of the transition from quasi-periodicity to chaos. Physica D, 8 1-54 (1983).

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20. S. Ostlund, R. Pandit, D. A. Rand, H. Schellnhuber and E. Siggia, The 1-dimensional Schrodinger equation with an almost-periodic potential. Phys. Rev. Letts. 50 1873-1876 (1983).

21. D. A. Rand, Fractal bifurcation sets, renormalization strange sets and their universal invariants. Proc. R. Soc. Lond. A 413 45-61 (1987). Proceedings of the Royal Society Discussion Meeting on Dynamical Chaos. December, 1986.

22. D. A. Rand T. Bohr, The entropy function for characteristic exponents. Physica D 25 387-398 (1987).

23. D. A. Rand ,Universality and renormalisation in dynamical systems. In New Directions in Dynamical Systems (ed. T. Bedford and J. Swift) 1-56, (1988), CUP.

24. D. A. Rand, Global universality, smooth conjugacies and renormalisation. I: The C^{1+} case. Nonlinearity 1 181-202 (1988).

25. A. C. Newell, D. A. Rand and D. Russell, Turbulent transport and the random occurrence of coherent events. Physica D, 33 (1988) 281-303.

26. A. C. Newell, D. A. Rand and D. Russell, Turbulent dissipation rates and the random occurrence of coherent events. Physics Letters A D, 132 (1988) 112-123.

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28. T. Bohr D. A. Rand, A mechanism for localised turbulence. Physica D 52 (1991) 532-543.

29. D. Broomhead, R. Indik, A. C. Newell D. A. Rand,, Local adaptive Galerkin bases for large-dimensional dynamical systems. Nonlinearity 4 (1991) 159-197.

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39. H. Wilson D. A. Rand, Evolutionary catastophes, punctuated equilibria and gradualism in ecosystem evolution. Proc. Roy. Soc. B 253 (1993) 137-141.

40. D. A. Rand, H. Wilson and J. M. McGlade, Dynamics and evolution: Evolutionarily stable attractors, invasion exponents and phenotype dynamics. Phil. Trans. R. Soc. Lond. 343 (1994) 261-283.

41. D. A. Rand, Measuring and characterising spatial patterns, dynamics and chaos in spatially-extended dynamical systems and ecologies. Phil. Trans. R. Soc. Lond. A 348 (1994) 497-514.

42. D. A. Rand, Expanded version of [41] in Chaos and Forecasting: Proceedings of the Royal Society Discussion Meeting (ed. H. Tong) World Scientific, 1995.

43. D. A. Rand H. Wilson, Using spatio-temporal chaos and intermediate-scale determinism to quantify spatially-extended ecosystems. Proc. R. Soc. Lond. B (1995) 259, 111-117.

44. A. A. Pinto D. A. Rand, Classifying C1+ structures on dynamical fractals: 1. The moduli space of solenoid functions for Markov maps on train tracks. Ergodic Theory and Dynamical Systems. 15 (1995) 697-734.

45. A. A. Pinto D. A. Rand, Classifying C1+ structures on dynamical fractals: 2. Embedded trees. Ergodic Theory and Dynamical Systems. 15 (1995) 969-992.

46. D. A. Rand, M. Keeling and H. Wilson, Invasion, stability and evolution to criticality in spatially extended host-pathogen systems. Proc. R. Soc. Lond. B (1995) 259, 55-63.

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51. M. Keeling, A. Morris D. A. Rand, Correlation models for childhood epidemics. Proc. R. Soc. B 264 (1997) 1149-1156.

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62. H van den Berg, N J Burroughs D. A. Rand, Quantifying the strength of ligand antagonism in TCR triggering. Bull. Math. Biol. 64 (2002) 781-808.

63. A. A. Pinto D. A. Rand, Teichmüller spaces and HR structures for

hyperbolic surface dynamics. Ergodic Theory and Dynamical Systems 22(6) (2002) 1905-1931.

64. H van den Berg D. A. Rand, Antigen presentation as a diversity filter that enhances immune efficacy. J. Theor. Biol. 224(2) $(2003_2 49-267$.

65. D. A. Rand , B. V. Shulgin, D. Salazar , A. J. Millar, Design principles underlying circadian clocks. Journal of The Royal Society, Interface 1 (2004) online at DOI: 10.1098/rsif.2004.0014

66. A. A. Pinto D. A. Rand, Rigidity of hyperbolic surface dynamics. J. Lond. Math. Soc. 71(2) (2004) 481-502.

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72. H. van den Berg D. A. Rand, Quantitative theories of T cell responsiveness. Immunological Reviews. 216(1) (2007) 81-92.

73. E. Heron, B. Finkenstadt, D. Rand, Statistical inference for delayed transcriptional gene regulation, an application to the Hes1 system,. Bioinformatics. doi: 10.1093/bioinformatics/btm367

74. A. A. Pinto, D. A. Rand F. Ferreira, Hausdorff dimension bounds for smoothness of holonomies for codimension one hyperbolic dynamics. Journal of Differential Equations 243(2) (2007) 168-178.

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