Sue Ann Campbell

Department of Applied Mathematics, University of Waterloo

EDUCATION

Cornell University, Ithaca, New York, U.S.A. Sept. 1987 to Aug. 1991

Doctor of Philosophy (Theoretical and Applied Mechanics), August 1991.

Thesis Title The Effects of Symmetry on the Dynamics of Low Dimensional Modal Interactions.

Thesis Supervisor P.J. Holmes

University of Waterloo, Waterloo, Ontario Sept. 1982 to May 1986.

Bachelor of Mathematics (Honours Applied Math with Computer Science Minor), May 1986.

EMPLOYMENT HISTORY

July 2000 to present	**Associate Professor**, Department of Applied Mathematics University of Waterloo, Waterloo, Ontario
July 1994 to July 2000	**Assistant Professor**, Department of Applied Mathematics University of Waterloo, Waterloo, Ontario
Aug. 1993 to June 1994	**Assistant Professor**, Department of Mathematics and Statistics Concordia University, Montréal, Québec
Jan. 1992 to July 1993	**Postdoctoral Researcher**, Department of Mathematics and Statistics Université de Montréal, Montréal, Québec
Aug. 1991 to Dec. 1991	**Lecturer**, Department of Theoretical and Applied Mechanics Cornell University, Ithaca, New York
Jan. 1989 to Aug. 1991	**Graduate Research Assistant**, Theoretical and Applied Mechanics Cornell University, Ithaca, New York
Sept. 1988 to Dec. 1988	**Graduate Teaching Assistant**, Theoretical and Applied Mechanics Cornell University, Ithaca, New York
June 1987 to Aug. 1987	**Software Developer** Can–Car Rail, Thunder Bay, Ontario
May 1986 to June 1987	**Development Engineer**, Flight Group CAE Electronics Inc., Montréal Québec

FELLOWSHIPS AND AWARDS

Sage Fellowship (Cornell University)	1987–1990
René Descartes Fellowship (University of Waterloo)	1984–1985, 1985–1986
René Descartes Prize (University of Waterloo)	1984, 1985

RESEARCH PROGRAM

Themes

Modelling physiological and mechanical systems using ordinary and delay differential equations.
Stability and bifurcation analysis of these equations.
Understanding role of higher codimension and global bifurcations in producing complex behaviour.
Implementation in Maple of some computations required for nonlinear analysis.

Project I: *Oscillators with Time Delayed Feedback*

Location of and dynamics near resonant double Hopf bifurcations.
Effect of multiple feedback loops, nonlinearities in feedback and damping.
Application to postural control and to metal cutting.

Project II: *Artificial and Biological Neural Networks*

Networks of Hopfield Neurons – effects of connection matrix symmetry, nonlinearities and time delay in connections.
Coupled Biophysical Neurons – effects of nonlinearity and time delay in coupling, origin of bursting behaviour.
Application to understanding communication between neurons, storage and retrieval. of complex patterns in artificial neural networks.

GRANTS

Agency	Years	Title	Amount
NSERC	2002–2006	Stability and Patterns of Oscillation in Nonlinear Systems with Time Delays	\$23 000/yr
MITACS*	03/1999	Pattern Storage, Retrieval and Recognition using Neural	\$224 000
(NCE)	06/2001	Networks: Modelling and Control with Applications.	
(Project Leader: S.A. Campbell. Other Team Members: W. Langford, M. Hulliger H. Leung, M. Mackey, J. Milton, J. Wu, X. Zou.)			
Fields Institute	1998	Conference Grant (With J. Atlee, K. Hare and M. Thompson)	\$5 000
C.R.M.	1998	Conference Grant (With J. Atlee, K. Hare and M. Thompson)	\$5 000
NSERC	1998–2002	Delayed Feedback in Nonlinear Oscillators and Neural Networks	\$12 100†/yr
NSERC	1995–1998	Effects of Nonlinearity in Systems with Delayed Feedback	\$9 300/yr
UW	1994–1995	President's NSERC Starter Grant	\$5 000

* Mathematics of Information Technology and Complex Systems Network of Centres of Excellence
† Increased to \$12 705 for 1999–2002 due to NSERC budget increase.

TEACHING ACTIVITY

Courses Taught (Department of Applied Mathematics, University of Waterloo)

Name	Title
MATH 127	Calculus 1 (for Physics/Chemistry students)
MATH 128	Calculus 2 (for Physics/Chemistry students)
MATH 137	Calculus 1 (for Mathematics students)
MATH 138	Calculus 2 (for Mathematics students)
MATH 218	Differential Equations (for Engineering students)
AM 250*	Introduction to Differential Equations (for Mathematics students)
AM 351*	Ordinary Differential Equations (for AM majors)
AM 451*	Introduction to Dynamical Systems (for AM majors)
AM 496	Project in Dynamical Systems
AM 690A	Topics in Dynamical Systems
AM 751	Advanced Ordinary Differential Equation
AM 900	Delay Differential Equations

* Integrated the use of Maple into these courses.

GRADUATE STUDENT SUPERVISION

Leslie Shayer (M.Math.) 1996–1998 *Analysis of a System of Two Coupled Neurons with Two Time Delays* Co-supervised with J. Wainwright. Current position: Assistant Professor, College Universitaire de Saint-Boniface

Israel Ncube (Ph.D.) 1997–2001 *Stochastic Approximation of Artificial Neural Network-Type Learning Algorithms: A Dynamical Systems Approach* Co-supervised with E.R. Vrscay. Current position: PDF, Toronto Western Research Institute

Richard Taylor(Ph.D.) 1999–2004 *Probabilistic Properties of Delay Differential Equations* Current position: Assistant Professor, Okanagan University College

Sehjeong Kim (Ph.D.) 2000–present *Switching Systems with Delay* Co-supervising with X.Z. Liu.

THESIS COMMITTEE MEMBERSHIP

Student	**Position**	**Year**
Victor LeBlanc (Ph.D.)	Reader	1995
Raelene Driscoll (M.Math.)	Reader	1995
George Ballinger (M.Math.)	Reader	1995
Herb Kunze (Ph.D.)	Reader	1997
Spiro Daouissis (Ph.D., McMaster University)	External Examiner	1997
George Ballinger (Ph.D.)	Member, Advisory Committee	1997 – 1999
Debra MacLean (M.Math.)	Reader	1998
Jon-Paul Voroney (Ph.D., University of Guelph)	External Examiner	1998
Daniel Piché (Ph.D.)	Member, Advisory Committee	1998 – 2002
Carol Pirie (M.Math.)	Acting Supervisor	09/98 – 05/99
	Reader	1999
Leyland Fryer-Davis (M.Math.)	Reader	2000
Aaron Bruce (M.Math.)	Reader	2000
Paul Davies (Ph.D., Psychology)	Internal External Examiner	2000
Edmund Obasi (M.Math.)	Reader	2002
Robin Swain (M.Sc., Memorial University)	External Examiner	2003
Maya Mincheva (Ph.D.)	Reader	2003
Donald Campbell (Ph.D.)	Member, Advisory Committee	2002 – present
Anmar Khadra (Ph.D.)	Reader	2004
Andrei Titioura (Ph.D.)	Member, Advisory Committee	2004 – present
Yi Zhang (Ph.D.)	Member, Advisory Committee	2003 – 2004
Abdorreza Heidari (Ph.D., E.&C.E.)	Member, Advisory Committee	2004 – present

POSTDOCTORAL FELLOW SUPERVISION

Huaiping Zhu	October 1999–September 2000	*Neural networks; predator prey systems*
Israel Ncube	May–Aug 2002	*Symmetric Hopf bifurcation in neural systems*
Yuan Yuan	June–Aug 2002	*Rings of neurons with delayed connections*
Sharene Bungay	January 2004–present	*Numerical bifurcation analysis of symmetric systems with time delays*

UNDERGRADUATE STUDENT SUPERVISION

Simal Saujani May – August 1996 *Degenerate Double Hopf Bifurcation*
(M.Sc. 1998 University of Western Ontario, currently Ph.D. student at University of Toronto)
Michael Waite May – August 1999 *Coupled Fitzhugh-Nagumo Neurons*
(NSERC Undergraduate Research Award, Currently MSc student at McGill University)
Maria Landry May – August 2000 *Controlling the Delayed Inverted Pendulum*
(NSERC Undergraduate Research Award), Co-supervised with K. Morris
Craig Sloss May – August 2002 *Instability in a Hybrid Model for Low Immersion Milling*
(NSERC Undergraduate Research Award, Currently MMath student at Waterloo)
Maryam Kamgarpour May– August 2004 *Maximizing the Phase Margin in the Inverted Pendulum*
(NSERC Undergraduate Research Award), Co-supervised with K. Morris
Lloyd Elliott Sept. – Dec. 2004 *Nonautonomous Chaotic Maps*

SERVICE

Department
Graduate Admissions Committee Member (1995, 2004)
Undergraduate Affairs Committee Member (1997 – 1999, 2001 – 2002)
Applied Math Chair Nominating Committee Member (1997, 1999)
Advisory Committee on Appointments (2003 – 2004)
Faculty
Tutorial Centre Director Search Committee Member (1997)
C.S. High School Liaison Position Search Committee Member (1998)
Valedictorian Selection Committee Member (1996, 1997)
Outstanding Work Report Selection Committee Member (1998)
Canadian Mathematics Competition – Cayley Committee Member (1998 – 1999)
Women in Mathematics Committee: Member (1998 – 2000), Chair (1999 – 2000)
J. Alan George Award Committee Member (1999)
Promotion and Tenure Committee Member (2003 – present)
Dean of Mathematics Nominating Committee (2004)
University
St. Paul's College Board of Governors (2001 – present)
St. Paul's College Honorary Fellow (1996 – 2000)
St. Paul's College Principal Search Committee Member (January – June 1999)
Community
Westminster United Church: Vice-chair of council (1997 – 2001), Chair of council (2001-2002)
Habitat for Humanity (1997 – 2002): Build volunteer, garage sale volunteer

PROFESSIONAL ACTIVITIES

Member, Centre for Nonlinear Dynamics in Physiology and Medicine, McGill University
Scientific Society Memberships
Canadian Applied and Industrial Mathematics Society, (Secretary, 2001 – present)
Canadian Mathematical Society
Society for Industrial and Applied Mathematics
Society for Mathematical Biology
Association for Women in Mathematics

Conferences

Session organizer, *CMS summer meeting*, June 4–6, 2005, University of Waterloo

Minisymposium organizer. *Joint CAIMS/SIAM meeting*, June 16-20, 2003, Montréal, Québec

Program Chair. *International Conference on Dynamics of Continuous, Discrete and Impulsive System*
August 27–30, 2001. University of Western Ontario.

Scientific Program Committee. *Math 2000*. June 10–13, 2000. McMaster University.

Session organizer. *Second International Conference on Differential Equations and Dynamical Systems*
August 1–4, 1997, University of Waterloo

Organizing Committee Member, *Celebration of Women in Mathematics*,
May 22–23, 1998, University of Waterloo

Scientific Organizing Committee Member, Joint CMS/CAIMS/CSFD Meeting,
June 10–13, 2000, McMaster University

Refereeing

Editorial Board Member, *Journal of the Franklin Institute* (April 1996–present)

Managing Editor, *Dynamics of Continuous, Discrete and Impulsive Systems* (2001-2004)

Member, NSERC Visiting Fellowships/NATO Science Fellowships Selection Committee (2001-2004)

Proposals reviewed for

Canadian Foundation for Innovation, NSERC, FCAR, NSF, FONDECYT (Chile)

Articles reviewed for

Applied Mathematics Letters
Computers and Mathematics With Applications
Conference on Decision and Control (2002,2004)
Dynamical Systems
Dynamics of Continuous, Discrete and Impulsive Systems
IEEE Transactions on Circuits and Systems
IEEE Symposium on Circuits and Systems
IMA Journal of Mathematics
International Journal of Systems Science
Journal of Differential Equations
Journal of Differential Equations and Dynamical Systems
Journal of the Franklin Institute
Journal of Mathematical Analysis and Applications
Journal of Mathematical Biology
Journal of Symbolic Computation
Journal of Theoretical Biology
Mathematical Biosciences
Mathematical and Computer Modelling
Mechatronics
Neurocomputing
Nonlinear Dynamics
Physica D
Physical Letters A
Society of Industrial and Scientific Computing
SIAM J. Applied Mathematics
SIAM J. Applied Dynamical Systems
Systems and Control Letters

Texts reviewed for: Prentice Hall, Birkhaüser, Walter de Gruyter

PUBLICATIONS

Alphabetical ordering of authors indicates equal contribution by all, otherwise authors are ordered by size of contribution.

Refereed Journal Articles

1. M. Landry, S.A. Campell, K. Morris and C.O. Aguilar. Dynamics of an inverted pendulum with delayed feedback control. To appear in *SIAM Journal on Applied Dynamical Systems.*

2. Y. Yuan and S.A. Campbell. Stability and synchronization in a ring of identical cells with delayed coupling. To appear in *Journal of Dynamics and Differential Equations.* Special Issue in honour of the 60th birthday of Shui-Nee Chow.

3. S.A. Campbell, R. Edwards and P. van den Driessche. Delayed coupling between two neural network loops. To appear in *SIAM Journal on Applied Mathematics.* 20 pages in manuscript form.

4. E. Stone and S.A. Campbell. Stability and bifurcation analysis of a nonlinear DDE model for drilling. *Journal of Nonlinear Science* **14(1)** (2004), 27-57.

5. I. Ncube, S.A. Campbell and E.R. Vrscay. Stationary densities and the stochastic approximation of a certain class of random algorithms. *Differential Equations and Dynamical Systems* **11(1-2)** (2003), 171-207.

6. I. Ncube, S.A. Campbell and E.R. Vrscay. Stochastic approximation of a simple neural network-type learning algorithm via computer simulation. *Dynamics of Continuous, Discrete and Impulsive Systems.* **10(2)** (2003) 195-206.

7. H. Zhu, S.A. Campbell and G. Wolkowicz. Bifurcation Analysis of a Predator-Prey System With Nonmonotonic Functional Response. *SIAM Journal on Applied Mathematics.* **63(2)** (2002), 636-682.

8. S.A. Campbell, Delay independent stability for additive neural networks. *Differential Equations and Dynamical Systems* **9(3–4)** (2001) 115-138. Invited paper for new millennium special issue on neural networks and neurocomputing – theory, models, and applications, Part I.

9. S.A. Campbell and M. Waite, Multistability in coupled Fitzhugh-Nagumo oscillators. *Nonlinear Analysis* **47** (2001) 1093–1104.

10. L.P Shayer and S.A. Campbell, Stability, bifurcation and multistability in a system of two coupled neurons with multiple time delays. *SIAM Journal on Applied Mathematics* **61(2)** (2000), 673–700.

11. S.A. Campbell and J. Bélair, Resonant codimension two bifurcation in the harmonic oscillator with delayed forcing. *Canadian Applied Mathematics Quarterly* **17(3)** (1999), 217–238.

12. S.A. Campbell, S. Ruan and J. Wei, Qualitative analysis of a neural network model with multiple time delays. *International Journal of Bifurcation and Chaos* **9(8)** (1999), 1585–1595.

13. S.A. Campbell, Stability and bifurcation in the harmonic oscillator with multiple, delayed feedback loops. *Dynamics of Continuous, Discrete and Impulsive Systems* **5** (1999), 225–235.

14. S.A. Campbell and V.G. LeBlanc, Resonant Hopf-Hopf interactions in delay differential equations. *Journal of Dynamics and Differential Equations* **10(2)** (1998), 327–346.

15. S.A. Campbell, Resonant codimension two bifurcation in a neutral functional differential equation, *Nonlinear Analysis, Theory, Methods and Applications* **30(7)** (1997), 4577–4584.

16. J. Bélair and S.A. Campbell and P. van den Driessche, Frustration, stability and delay-induced oscillations in a neural network model. *SIAM Journal on Applied Mathematics* **56(1)** (1996), 245–255.

17. J. Milton, S.A. Campbell and J. Bélair, Dynamic feedback and the design of closed-loop drug delivery systems. *Journal of Biological Systems* **3** (1995), 711–718.

18. S.A. Campbell, J. Bélair, T. Ohira and J. Milton, Complex dynamics and multistability in a damped harmonic oscillator with delayed negative feedback. *CHAOS* **5(4)** (1995), 640–645.

19. S.A. Campbell and J. Bélair, Analytical and symbolically-assisted investigation of Hopf bifurcation in delay-differential equations. *Canadian Applied Mathematics Quarterly* **3(2)** (1995), 137–154.

20. S.A. Campbell, J. Bélair, T. Ohira and J. Milton, Limit cycles, tori and complex dynamics in a second-order differential equation with delayed negative feedback. *Journal of Dynamics and Differential Equations* **7(1)** (1995), 299–325.

21. J. Bélair and S.A. Campbell, Stability and bifurcations of equilibria in a multiple-delayed differential equation. *SIAM Journal on Applied Mathematics* **54(5)** (1994), 1402–1424.

22. S.A. Campbell and P.J. Holmes, Heteroclinic cycles and modulated travelling waves in a system with D_4 symmetry. *Physica D* **59** (1992), 52–78.

23. S.A. Campbell and P.J. Holmes, Bifurcation from $O(2)$ symmetric heteroclinic cycles with three interacting modes. *Nonlinearity* **4** (1991), 697–726.

Articles Submitted to Refereed Journals

24. S.A. Campbell, I. Ncube and J. Wu. Multistability and Stable Asynchronous Periodic Oscillations in a Multiple-Delayed Neural System. Submitted to *PhysicaD*. 33 pages in manuscript form.

25. F.K. Skinner, J.Y.J. Chung, I. Ncube, P.A. Murray, S.A. Campbell. Using heterogeneity to predict inhibitory network model characteristics. Submitted to *Journal of Neurophysiology* (in revision). 17 pages in manuscript form.

26. S. Kim, S.A. Campbell and X. Liu. Stability in a class of switching systems with time delay. Submitted to *IEEE Trans. on Circuits and Systems.* 16 pages in manuscript form.

Refereed Conference Proceedings

27. K. Tchizawa and S.A. Campbell. On winding duck solutions in $\mathcal{R}^4$. *Proceedings of the Second International Conference on Neural, Parallel and Scientific Computations* Vol. 2 (2002), 315–318.

28. I. Ncube, S.A. Campbell and J. Wu. Bifurcation of equilibria and modal interactions for a multiple-delayed system of three identical neurons. In "Dynamical Systems and Their Applications in Biology", S. Ruan, G.S.K. Wolkowicz and J. Wu, eds. *Fields Institute Communications* **36** (2003), 179–193.

29. S.A. Campbell, Stability and Bifurcation in a Simple Neural Network with Multiple Time Delays. In "Differential Equations with Application to Biology", S. Ruan, G.S.K. Wolkowicz and J. Wu, eds. *Fields Institute Communications* **21** (1999), 65–79.

30. S.A. Campbell and J. Bélair, Multiply delayed differential equations as models for physiological control systems. In *World Congress of Nonlinear Analysts '92*, V. Lakshmikantham, ed. Walter de Gruyter, N.Y., (1996), 3109–3117.

Conference Proceedings

31. S.A. Campbell and J. Bélair, Delays and tori in a nonlinear model from motor control. In *Chaos in Biology and Medicine*, W. Ditto, ed. Society of Photo-Optical Instrumentation Engineers (SPIE) Proceedings Series, vol. 2036, (1993), 256–268.

Book Reviews

1. S.A. Campbell, Review of "Stability by Liapunov's Matrix Function Method". *SIAM Review* **41(4)** (1999), 829–830.

2. J. Bélair and S.A. Campbell, Review of "Complexity, Chaos and Biological Evolution". *Nonlinear Science Today* **2(4)** (1993), 14.

Invited Presentations

- *International Workshop on Brain Connectivity 2005.* April 15-16, 2005. Boca Raton, Florida.
- *BIRS Workshop on Functional Differential Equations.* Nov. 6-11, 2004. Banff, Alberta.
- *Society for Mathematical Biology Annual Meeting.* July 25–28, 2004. Ann Arbor, Michigan.
- *Canadian Applied and Industrial Mathematics Society (CAIMS) Annual Meeting.* June 12–15, 2004. Halifax, Nova Scotia.
- *Fields Institute Workshop on Bifurcation Theory and Spatio-Temporal Pattern Formation in PDE.* December 11–13, 2003. Toronto, Ontario.
- *Fields Institute Applications of Mathematics in Medicine Workshop.* July 28–30, 2003. Toronto, Ontario.
- Minisymposium on Delay Differential Equations: Applications to Biological and Physical Systems. *CAIMS/SIAM Joint Meeting.* June 16–20, 2003. Montréal Québec.
- Minisymposium on Mathematical Biology. *CAIMS/SIAM Joint Meeting.* June 16–20, 2003. Montréal Québec.

- *Fifth Americas Conference on Differential Equations and Dynamical Systems.* July 7–12, 2002. Edmonton, Alberta.
- *International Workshop on Dynamical Systems and their Applications in Biology.* August 2–6, 2001. Cape Breton, Nova Scotia.
- *International Conference on Dynamics of Continuous, Discrete and Impulsive Systems.* July 27–31, 2001. University of Western Ontario.
- *CAIMS Annual Meeting.* June 7–9, 2001. University of Victoria.
- *Mathematics and Computer Science Division Seminar.* February 2, 2001. The Boeing Company. Seattle, WA.
- *Fourth Americas Conference on Differential Equations and Nonlinear Dynamics.* October 30 – November 3, 2000. Mérida, Venezuela.
- *Workshop on Memory, Delays and Multistability.* October 11–15, 2000. Centre de recherches mathématiques, Université de Montréal.
- *Workshop on Nonlinear Dynamics and Biomathematics.* October 3–6, 2000. Centre de recherches mathématiques, Université de Montréal.
- *Third World Congress of Nonlinear Analysts.* July 19–26, 2000. Catania, Italy.
- *Math 2000.* June 10–13, 2000. McMaster University.
- *Canadian Mathematical Society (CMS) Winter Meeting.* December 11–13, 1999. Montréal, Québec.
- *First Canada-China Congress on Mathematics.* August 23–27, 1999. Beijing, China.
- *CAIMS Annual Meeting.* June 11–13, 1999. Université Laval.
- *CMS Winter Meeting.* December 14-16, 1997. Victoria, British Columbia.
- *International Conference on Differential Equations and Dynamical Systems.* August 1–4, 1997. University of Waterloo.
- *2nd World Congress of Nonlinear Analysts.* July 10–17, 1996. Athens, Greece.
- *International Congress on Industrial and Applied Mathematics.* July 3–7, 1995. Hamburg, Germany.
- *CAMS Annual Meeting.* May 31–June 2, 1995. Memorial University, St. John's, Nfld.

Contributed Presentations

- *SIAM Conf. on Applications of Dynamical Systems.* May 20–24, 2001. Snowbird, Utah.
- *International Conference on Differential Equations with Applications to Biology.* July 25-29, 1997. Dalhousie University.
- *SIAM Conf. on Applications of Dynamical Systems*, May 18–22, 1997. Snowbird, Utah.
- *SIAM Conf. on Applications of Dynamical Systems.* May 21–24, 1995. Snowbird, Utah.