

Paul K. Newton

Aerospace & Mechanical Engineering and Mathematics

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EDUCATION

1986: **Ph.D.** Applied Mathematics, Brown University

1982: **Sc.M.** Applied Mathematics, Brown University

1981: **B.S. (Cum laude)** Applied Math/Physics, Harvard University

ACADEMIC POSITIONS

1998– present: **Professor**, Aerospace & Mechanical Engineering and Mathematics, USC

Spring 2007: **Visiting Professor**, Department of Mathematics, UC Santa Barbara

Visiting Professor, Department of Mathematics, Hokkaido University

Spring 2000: **Visiting Professor**, Institute for Theoretical Physics, UC Santa Barbara

Visiting Professor, Control & Dynamical Systems, Caltech

1993-98: **Associate Professor**, Aerospace & Mechanical Engineering and Mathematics, USC

1992-93: **Associate Professor**, Department of Mathematics and

Center for Complex Systems Research, University of Illinois Urbana-Champaign

1987-92: **Assistant Professor**, Department of Mathematics and

Center for Complex Systems Research, University of Illinois Urbana-Champaign

Spring 1989: **Visiting Assistant Professor**, Division of Applied Mathematics Brown University

1985-87: **Postdoctoral Fellow** (*w/ J.B. Keller*), Department of Mathematics Stanford University

RESEARCH INTERESTS

Nonlinear dynamical systems; Fluid mechanics; Computational cancer modeling; Biological locomotion; Markov chain/Monte Carlo modeling

HONORS and AWARDS

2011: Mellon Foundation Mentoring Award, Viterbi School of Engineering, USC

1993-94: Beckman Institute Research Award, UIUC.

1993: Oakley-Kund University Wide Teaching Award Finalist, University of Illinois.

1989-93: Listed in ‘Teachers ranked excellent by students’, University of Illinois.

EDITORIAL and ADVISORY BOARDS

2011- Present: *Managing Editor*: Journal of Nonlinear Science

1998 - Present: *Editorial Board*: Texts in Applied Mathematics, Springer-Verlag

2001- Present *Communicating Editor*: Journal of Nonlinear Science

2009-Present: *Physical Sciences Oncology Center Advisory Committee*: The Scripps Research Institute

ACTIVE GRANTS

PI: PS-OC Trans-Network Grant, NIH/NCI, ‘Data assimilation and ensemble statistical forecasting methods applied to the MSKCC longitudinal metastatic breast cancer cohort, Oct. 1 2013-2014, (100,000)

PI: NIH/NCI Subcontract 1 U54 CA143906-05: Physical Sciences Oncology Center Award, NIH/NCI, 4DB Center: Physics and Mathematics of Metastasis over Time and Space, Sept. 1, 2013-Aug. 2014 (152,773)

PI: Zumberge Research Foundation (USC) - ‘Establishing the Center for Integrative Computational Oncology at USC’: 2012-2013 (~ \$50,000)

PI: NSF-DMS : N-Vortex Problems: Modeling, Analysis, Numerics: 2008-2013 (~ \$250,000)

Co-PI: NCI: The Physics and Mathematics of Cancer: 2010-2015 (~ \$10,000,000) (Sub-contract to USC)

RECENT KEYNOTE/INVITED TALKS

- ◇ **Invited Address:** ‘Spreaders and sponges of cancer’, National Cancer Institute, Theoretical viewpoints emerging around the PS-OC network, Aug. 18-19, 2013.
- ◇ **Invited Address:** ‘Metastatic entropy’, The Scripps Research Institute, Aug. 23, 2013.
- ◇ **Invited Address:** Cold Spring Harbor Lab - The emerging intersection of the physical sciences and oncology, July 14-15, 2013.
- ◇ **Keynote Address:** ‘Vortex lattice theory: A particle interaction perspective’, *Nonlinear Phenomena: A View From Mathematics and Physics*, National Taiwan University, Jan. 10-14, 2011.

Ph.D. STUDENTS/POSTDOCS MENTORED

Postdoctoral Mentoring:

- ◇ S.D. Ross (Ph.D. Caltech Control and Dynamical Systems), NSF-Postdoctoral Fellowship in Applied Mathematics 2004-2006.
- ◇ R Tiron (Ph.D. U North Carolina Applied Math), 2009-2010.

Ph.D. Theses Supervised:

1. Q. Bu, On initial-boundary value problems: Nonlinear Schrödinger equations and the Ginzburg-Landau equations, Ph.D. Mathematics UIUC, 1992
2. R. Axel, The interaction of shock waves and dispersive waves, Ph.D. Mathematics UIUC, 1996
3. B. Shashikanth, Vortex motion and the geometric phase, Ph.D. Aerospace Engineering, USC, 1998
4. R. Kidambi, Integrable point vortex motion on a sphere, Ph.D. Aerospace Engineering, USC, 1999
5. M. Jamalooddeen, Hamiltonian methods for some geophysical vortex dynamics problems, Ph.D. Mathematics, USC, 2000
6. B. Khushalani, Symplectic sub-cluster methods and periodic vortex motion on a sphere, Ph.D. Aerospace Engineering, USC, 2004
7. E. Upchurch, Miscible flooding of porous media, Ph.D. Aerospace Engineering, USC, 2005
8. B. Cooley, Regular and chaotic dynamics of N-beads on a ring, Ph.D. Aerospace Engineering, USC, 2006
9. H. Shokraneh, N-vortex problem on a rotating sphere, Ph.D. Aerospace Engineering, USC, 2007
10. R. Basilio, Controlled and uncontrolled motion in the circular, restricted three-vortex problem: Dynamically natural spacecraft formations, Ph.D. Aerospace Engineering, USC, 2007
11. G. Chamoun, Vortex lattice theory: A linear algebra approach, Ph.D. Aerospace Engineering, USC, 2008
12. J. Chen, Multiple degree of freedom inverted pendula, Ph.D. Aerospace Engineering, USC, 2008
13. S. Campagnola, New techniques in astrodynamics for moon systems exploration, Ph.D. Aerospace Engineering, USC, 2010

14. K. Aslam, A stochastic Markov chain approach for tennis: Monte Carlo simulation and modeling, Ph.D. Aerospace Engineering, USC, 2012
15. V. Ostrovskiy, Point singularities on 2D surfaces, Ph.D. Mathematics, USC, 2012
16. J. Mason, A stochastic Markov chain model for cancer metastasis, Ph.D. Aerospace and Mechanical Engineering, USC Aug. 2013.

Publications of P. K. Newton

Books authored:

The N-Vortex Problem: Analytical Techniques, 430pp, Springer-Verlag, Applied Mathematical Sciences Vol. 145, 2001.

Books/Journals Edited:

Journal of Mathematical Physics: Special Focus Issue on Mathematical Fluid Mechanics. co-edited with C.R. Doering, June 2007.

Geometry, Mechanics, and Dynamics, (co-edited with P. Holmes, A. Weinstein) Springer-Verlag, Special Volume in Honor of the 60th birthday of J.E. Marsden, 2002.

Refereed Journal/Book articles:

89. M. Kirby, P.K. Newton, K. Bethel, A. Kolatkar, T. Emerson, M. Luttgen, S. O'Hara, P. Kuhn [2013], Fourier-ring descriptor to characterize rare circulating cells from images generated using immunofluorescence microscopy, preprint.
88. A. Itakura, J.E. Aslan, B.T. Kusanto, K.G. Phillips, J.E. Porter, P.K. Newton, X. Nan, R.H. Install, J. Chernoff, O.J.T. McCarty [2013], p21-activated kinase (PAK) regulates cytoskeletal reorganization and directional migration in human neutrophils, to appear PLoS ONE, to appear.
87. P.K. Newton, J. Mason, B. Hurt, K. Bethel, L. A. Bazhenova, J. Nieva, P. Kuhn [2013], The entropy of metastatic cancer, USC preprint.
86. P.K. Newton [2013], Point vortex dynamics in the post-Aref era, Special Issue, *Fluid Dynamics Research*, IUTAM Symposium Keynote Lecture Article, Vortex Dynamics: Formation, Structure, and Function, March 10-14, 2013, Fukuoka Japan.
85. L. Bazhenova, P.K. Newton, J. Mason, K. Bethel, J. Nieva, P. Kuhn [2013], Adrenal metastases in lung cancer: Clinical implications of a mathematical model, submitted, J. Clinical Oncology.
84. P. K. Newton, J. Mason, K. Bethel, L. A. Bazhenova, J. Nieva, L. Norton, P. Kuhn [2013], Spreaders and sponges define metastasis in lung cancer: A Markov chain Monte Carlo model, *Cancer Research*, **73(9)**, 2760-2769.
83. P. K. Newton, J. Mason, K. Bethel, L. A. Bazhenova, J. Nieva, P. Kuhn [2012], A Markov chain mathematical model to describe lung cancer growth and metastasis, *PLoS ONE*, **7(4)**, e34637 April.
82. A. Lee, M.A. Berny-Lang, S. Liao, E. Kanso, P. Kuhn, O.J.T. McCarty, P. K. Newton [2012], A low-dimensional deformation model for cancer cells in flow, *Physics of Fluids*, **24(8)**, 081903 **Feature Article**.
81. A. Lee, G.W. Tormoen, E. Kanso, O.J.T. McCarty, P.K. Newton [2012], Modeling and simulation of procoagulant circulating tumor cells in flow, *Frontiers in Oncology*, Special Volume: Frontiers in Cancer Molecular Targets and Therapeutics, Ed. M.R. King, **2(108)**, Sept., 1-9.
80. P.K. Newton, V. Ostrovskiy [2012], Stationary equilibrium singularity distributions in the plane, *Nonlinearity*, **25** 495-511.
79. F. Jing, E. Kanso, P.K. Newton [2012], Insights into symmetric and asymmetric vortex mergers using the core growth model, *Physics of Fluids*, **24** 073101.
78. A.A. Tchieu, E. Kanso, P.K. Newton [2012], The finite-dipole dynamical system, *Proc. Roy. Soc. A*, **468** 3006-3026.
77. P.K. Newton, V. Ostrovskiy [2012], Stability of icosahedral configurations of point vortices on a sphere, *Journal of Nonlinear Science*, **22** 499-515.

76. Tiron R, E. Kanso, P.K. Newton [2011], Hydrodynamically coupled oscillators, *J. Fluid Mech.*, **Vol. 677**, 589-606.
75. Ysasi A., E. Kanso, P.K. Newton [2011], Wake structure of a deformable Joukowsky airfoil, Special Issue, *Physica D*, 240, 1574-1582.
74. Oskouei, B., E.Kanso, P.K. Newton [2011], Streamline bifurcations and scaling theory for a multiple-wake model, *J.of Non-linear Mechanics*, 46, 592-601.
73. Newton, P.K., T. Sakajo [2011], Point vortex equilibria and optimal packings of circles on a sphere, *Proc. Roy. Soc. A*, May Vol. 467, no. 2129 1468-1490.
72. V.V. Meleshko, V. Ostrovskiy, P.K. Newton [2010], Stability of the configurations of point vortices on a sphere, *Journal of Mathematical Sciences*, Vol. 171, No. 5, 603-619.
71. Jing F., E. Kanso, P.K. Newton [2010], Viscous evolution of point vortex equilibria: The collinear state, *Phys. Fluids*, 22, 123102.
70. Newton P.K., S. DeSalvo [2010] The Shannon entropy of Sudoku matrices, *Proc. Roy. Soc. A*, **Vol. 466**, 1957–1975.
69. Barrierio, A., J. Bronski, P.K. Newton [2010], Spectral gradient flow and point vortex equilibria, *Proc. Roy. Soc. A*, **Vol. 466**, 1687–1702.
68. Kanso, E., P.K. Newton [2009], Locomotory advantages to flapping out of phase, *J. of Experimental Mechanics (Special Issue on Locomotion)* DOI 10.1007/s11340-009-9287-9.
67. Kanso, E., P.K. Newton [2009], Passive locomotion via normal mode coupling in a submerged spring-mass system, *J. Fluid Mech.* **Vol. 461** 205–215.
66. Chamoun, G., E. Kanso, P.K. Newton [2009], Von Karman vortex streets on the sphere, *Physics of Fluids*, **Vol. 21** 116603.
65. Newton, P.K., K. Aslam [2009], Monte Carlo tennis: A stochastic Markov chain model, *J. of Quantitative Analysis in Sports*, **Vol. 5**, Issue 3, Article 7.
64. Newton, P.K., T. Sakajo [2009], Point vortex equilibria on the sphere via Brownian ratchets, *Proc. Roy. Soc. A* **465** 437-455.
63. Newton, P.K., G. Chamoun [2009], Vortex lattice theory: A particle interaction perspective, *SIAM Review*, **Vol. 51**(3) 501–542.
62. Newton, P.K. [2009], The N -vortex problem on a sphere: Geophysical mechanisms which break integrability, Invited Keynote Article, *Theoretical and Computational Fluid Dynamics*, Special Volume: IUTAM Symposium ‘150 Years of Vortex Dynamics’, Technical University of Denmark, Copenhagen, Oct. 12-16, 2008.
61. Newton, P.K., H. Shokraneh [2008], Interacting dipole pairs on a rotating sphere, *Proc. Roy. Soc. A*, **464** 1525–1541.
60. Chamoun, G., E. Kanso, P.K. Newton [2008], Single vortex streets on the sphere, *Proceedings of DSCC 2008*, DSCC2008-12345.
59. Campagnola, S., M. Lo, P.K. Newton [2008], Subregions of motion and elliptic halo orbits in the elliptic restricted three-body problem, *AAS 08-200*.
58. Doering, C.R., P.K. Newton [2007], Introduction: Mathematical fluid dynamics, *Journal of Mathematical Physics*, Special Volume on Mathematical Fluid Dynamics, **Vol. 48**, no. 1.
57. Newton, P.K., G. Chamoun [2007], Construction of point vortex equilibria via Brownian ratchets, *Proc. Roy. Soc. A* **463** 1525–1540.
56. Newton, P.K., B. Cooley [2007], Eigenvalue distributions from impacts on a ring, *Regular and Chaotic Dynamics*, **Vol. 12**, no. 1, 12–26.

55. Newton, P.K. [2007], The two layer quasi-geostrophic potential vorticity model, *Journal of Mathematical Physics*, Special Volume on Mathematical Fluid Dynamics, **Vol. 48**, no. 1.
54. Newton, P.K., T. Sakajo [2007], The N-vortex problem on a rotating sphere. III. Ring configurations coupled to a background field, *Proc. Roy. Soc. A*, **Vol. 463** 961–977.
53. Newton, P.K. [2007], N-Vortex equilibrium theory, *Disc. and Cont. Dyn. Sys. A* **19**(2), Special Issue on Variational Problems and Applications, eds. C.C. Lim, M. Otani, J. Shi, Oct. 411–418.
52. Jing, F., E. Kanso, P.K. Newton [2007], Motion control of a spinning disc on rotating earth, *46th IEEE Conference on Decision and Control*.
51. Newton, P.K., S. Ross [2006], Chaotic advection for the restricted four-vortex problem on a sphere, *Physica D*, **Vol. 223**, Issue 1, 36–53, 1 Nov.
50. Newton, P.K., K. Aslam [2006], Monte Carlo tennis, *SIAM Review*, **Vol. 48**, no. 4, 722–742.
49. Jamaloodeen, M.J., P.K. Newton [2006], The N-vortex problem on a rotating sphere. II. Heterogeneous equilibria, *Proc. Roy. Soc. A*, **Vol. 462**, 3277–3299.
48. Newton, P.K., H. Shokraneh [2006], The N-vortex problem on a rotating sphere. I. Multi-frequency states, *Proc. Roy. Soc. A*, **Vol. 462**, 149–169.
47. Newton, P.K., M. Ruith, E. Upchurch [2005], The constrained planar N-Vortex problem: I. Integrability, *Discrete and Continuous Dynamical Systems, Series B*, **5**(1), 137–152, Feb.
46. Newton, P.K., B. Cooley [2005], Iterated impact dynamics of N-beads on a ring, *SIAM Review*, **Vol. 42**, No. 2, 273–300.
45. Newton, P.K., J.B. Keller [2005], Probability of winning at tennis. I. Theory and data, *Studies in Appl. Math.*, 114: 241–269.
44. Newton, P.K. [2005], The dipole dynamical system, *Discrete and Cont. Dyn. Sys. B*, 692–699.
43. Newton, P.K., V. Papanicolaou [2005], Nonlinear dissipative eigenvalue problems with large initial conditions, *J. Math. Phys.*, **46**, 1–10.
42. ‘Chaos versus turbulence’, with H. Aref [2005], *Encyclopedia of Nonlinear Science*, Routledge Press.
41. ‘Berry’s phase’, with J.E. Marsden [2005], *Encyclopedia of Nonlinear Science*, Routledge Press.
40. ‘Vortex dipole coordinates on the sphere’, with H. Shokraneh [2005], Chapter 10, 169–180, **Vortex Dominated Flows: A Volume Celebrating Lu Ting’s 80th Birthday**, World Scientific Publishing.
39. Newton, P.K., B. Cooley [2004], Random number generation from chaotic impact collisions, *Regular and Chaotic Dynamics*, **9**(3), 1–14.
38. Newton, P.K., E. Gutkin [2004], Green’s functions and the method of images on spheres, *Journal of Physics A: Math. Gen.*, **37**, 11989–12003.
37. Aref, H., P.K. Newton, M. Stremmer, T. Tokieda, D.L. Vainchtein [2003], Vortex crystals, *Advances in Applied Mech.*, 1–79, **39**.
36. Newton, P.K., V. Papanicolaou [2003], Power law asymptotics for nonlinear eigenvalue problems, Invited Chapter, **Perspectives and Problems in Nonlinear Science**, eds. E. Kaplan, J. Marsden, K. Sreenivasan, *Applied Mathematical Sciences*, Springer-Verlag, 24pp.
35. Newton, P.K., I. Mezic [2002], Non-equilibrium statistical mechanics for a vortex gas, *J. Turbulence*, 7pp.
34. Newton, P.K., B. Khushalani [2002], Integrable decomposition methods and ensemble averaging for non-integrable N-vortex problems, *J. Turbulence*, 9pp.

33. Newton, P.K., R. Axel [2002], Amplitude Equation Models for the Interaction of Shocks with Nonlinear Dispersive Wave Envelopes, Invited Chapter, in **Selected Topics in Nonlinear Wave Mechanics**, eds. C.I. Christov, A. Guran, Birkhäuser, 35–74.
32. Newton, P.K., R. Kidambi [2000], Streamline topologies for integrable vortex motion on a sphere, *Physica D* 140, 95–125.
31. Newton, P.K., R. Kidambi [2000], Vortex motion on a sphere with solid boundaries, *Phys. Fluids* 12(3), 581–588, March.
30. Newton, P.K., B. Shashikanth [2000], Geometric phases for co-rotating elliptical vortex patches, *J. Math. Phys.*, 41(12), 8148–8162, Dec.
29. Newton, P.K., B. Shashikanth [1999], Vortex motion and the geometric phase: Part II. Slowly varying spiral structures, *Journal of Nonlinear Sci.*, Vol. 9(2), 233–254.
28. Newton, P.K., R. Kidambi [1999], Collapse of three vortices on a sphere, *Il Nuovo Cimento*, Vol. 22C, No. 6, 779–791.
27. Newton, P.K., R. Axel [1998], On the interaction of shocks with dispersive waves: Part II. Incompressible-integrable limit, *Studies in Applied Mathematics*, 100: 311–363.
26. Newton, P.K., B. Shashikanth [1998], Vortex motion and the geometric phase: Part I. Basic configurations and asymptotics, *Journal of Nonlinear Sci.*, Vol. 8, 183–214.
25. Newton, P.K., R. Kidambi [1998], Motion of three point vortices on a sphere, *Physica D* 116, 143–175.
24. Newton, P.K., R. Axel [1996], On the interaction of shocks with dispersive waves: Part I. Weak coupling limit, *Studies in Applied Mathematics*, 96, 201–246.
23. Newton, P.K., M. O'Connor [1996], Scaling laws near nonlinear Schrödinger defect sites, *Physical Review E*, Vol. 53, No. 4, 3442–3447, April.
22. Newton, P.K., E. Meiburg, N. Raju, G. Ruetsch, [1995], Unsteady models for the nonlinear evolution of the mixing layer, *Physical Review E*, Vol. 52, no. 2, 1639–1657, August.
21. Marcu, B., E. Meiburg, P.K. Newton [1995], Dynamics of heavy particles in a Burgers vortex, *Physics of Fluids*, Vol. 7(2), 400–410, Feb.
20. Newton, P.K., I.M. Moroz [1995], Phase-Amplitude dynamics of the nonlinear Schrödinger equation with rapid forcing, *Journal of Mathematical Physics*, 36(9), 4923–4939, September.
19. Newton, P.K. [1994], Hannay-Berry phase and the restricted three vortex problem, *Physica D* 79, 416–423, Dec.
18. Newton, P.K., [1993], Rapidly forced initial value problems, *SIAM Journal of Applied Math*, Vol. 53, No. 5, 1331–1351, Oct.
17. Newton, P.K., S. Watanabe [1993], The geometry of nonlinear Schrödinger standing waves: pure power nonlinearities, *Physica D* 67, 19–44.
16. Newton, P.K. [1992], Dynamics of perturbed amplitude equations, in **Research Trends in Physics: Chaotic Dynamics and Transport in Fluids and Plasmas**, Ed. I. Prigogine, AIP, 272–285.
15. Meiburg, E., P.K. Newton [1991], Particle dynamics and mixing in a viscously decaying shear layer, *J. Fluid Mech.*, Vol. 227, June.
14. Newton, P.K. [1991], Wave interactions in the singular Zakharov system, *Journal of Mathematical Physics*, 32(2), 431–440, Feb.
13. Newton, P.K. [1991], Branching near plane waves in perturbed dispersive systems, *Studies in Applied Math.*, Vol. 85.
12. Newton, P.K., E. Meiburg [1991], Particle dynamics in a viscously decaying cat's eye: The effect of finite Schmidt numbers, *Physics of Fluids A*, Vol. 3, no. 5, 1068–1072, May.

11. Newton, P.K. [1989], Branching near nonlinear plane waves in dispersive systems, *SIAM Journal of Appl. Math.*, Vol. 49, No. 4, 1210–1222, Aug.
10. Newton, P.K. [1989], Escape from KAM regions and the breakdown of uniform rotation, *Phys. Rev. A.*, Vol. 40, No. 6, 3254–3264, Sept. 15.
9. Newton, P.K. [1988], Chaos in Rayleigh-Benard convection with external driving, *Phys. Rev. A.*, Vol. 37, No. 3, 932–935, Feb. 1.
8. Newton, P.K., J.B. Keller [1988], Stability of plane wave solutions of nonlinear systems, *Wave Motion* 10, 183–191.
7. Newton, P.K. [1988], The perturbed cubic Schrödinger equation: selection mechanism, resonant limits and spatial chaos, *Journal of Mathematical Physics*, 29(10), 2245–2249, October.
6. Newton, P.K., J.B. Keller [1987], Stability of periodic plane waves, *SIAM Journal Appl. Math.*, Vol. 47, No. 5, 959–964, October.
5. Newton, P.K., L. Sirovich [1986], Ginzburg-Landau equation: stability and bifurcations, in **Stability of Time Dependent and Spatially Varying Flows**, eds. D. L. Dwoyer, M. Y. Hussaini, Springer-Verlag.
4. Newton, P.K., L. Sirovich [1986], Instabilities in the Ginzburg-Landau equation: periodic solutions, *Quarterly of Applied Mathematics*, Vol. XLIV, No. 1, 49–58, April.
3. Newton, P.K., L. Sirovich [1986], Instabilities in the Ginzburg-Landau equation Part II: secondary bifurcations, *Quarterly of Applied Mathematics*, Vol. XLIV, No. 2, 367–374, July.
2. Sirovich, L., P.K. Newton [1986], Periodic solutions of the Ginzburg-Landau equation, *Physica D* 21, 115–125.
1. Newton, P.K. [1984], Development of a zero memory strategy for a betting game, *Journal of Undergraduate Mathematics*.