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Personal Information

Born in Youghal, Republic of Ireland; U.S. and Irish citizen

Education

B.S. in Mathematics, 1966, Rutgers University, Phi Beta Kappa: Age 19
Ph.D. in Mathematics, 1971, Rutgers University

Principal Professional Positions

1996–2007: Chair, Department of Mathematics, UMD
1994–1996: Undergraduate Chair, Department of Mathematics, UMD
1984–present: Professor of Mathematics, UMD
1971–1973: Courant Instructor, Courant Institute of Mathematical Sciences, N.Y.U.
1973–1975: L. E. Dickson Instructor, Department of Mathematics, University of Chicago

Current Research Interests

My research interests lie in the study of topological methods in nonlinear operator theory, with particular interest in the study of bifurcation of solutions of parametrized families of nonlinear partial differential equations. One aspect of this has been the development of a topological degree for nonlinear Fredholm mappings. The essential novelty of this degree is that it presents a new, precise description of the homotopy property of degree that is needed to establish bifurcation for one parameter families of such mappings (see [39], [40], [42] and [43]). This homotopy property is associated with an invariant called *parity*, an integer defined for paths of general linear Fredholm operators with invertible end-points on a real Banach space. The parity of the path of linearizations about the trivial solution was, in the absence of variational structure, shown to be a complete invariant for the determining of bifurcation via linearization. For problems that have a variational formulation there are more particular criteria to determine bifurcation based, in the finite dimensional setting, on Morse theory, and, in general, on the concept of spectral flow, which is defined for paths of *self-adjoint* Fredholm operators on a real Hilbert space. In the study of bifurcation for one parameter families of variational problems a stable bifurcation criterion has been described in terms of the nonvanishing of spectral flow (see [46], [47], [48], and [49]) which, in [52], was shown to be a complete invariant for the determining of bifurcation via linearization for variational problems. These methods can be used to study important classes of pde's (see [48], for instance). However, there are important problems that lie outside the present methods: roughly speaking, these are problems whose linearization are necessarily *unbounded* self-adjoint operators. In recent work, I have been studying spectral flow of paths of unbounded self-adjoint operators and its application to bifurcation of homoclinic orbits and nonlinear pde's. Much of this work has been done in a longstanding partnership with Jacobo Pejsachowicz of the Politecnico di Torino.

Books

1. Halsey Royden and Patrick M. Fitzpatrick *Real Analysis, 4th Edition*, Prentice-Hall 2010, pp. 1–498+X, ISBN-13 978-0131437470
2. Halsey Royden and Patrick M. Fitzpatrick *Real Analysis, 5th Edition*, Prentice-Hall, 2021 (in press)
3. Patrick M. Fitzpatrick, *Advanced Calculus, 2nd Edition*, Pure and Applied Undergraduate Texts, Vol 5, American Math Society, 2009, pp. 1–510+XIII, ISBN 0-534-92612-6 (Previous versions are not listed here.)
4. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, *Orientation and the Leray–Schauder Theory for Fully Nonlinear Elliptic Boundary Value problems*, Memoirs of the American Mathematical Society, Vol 101, Number 483, 1993, pp. 1–129, ISBN 0-8218–2544–5.
5. Patrick M. Fitzpatrick et al., *Topological Methods for Ordinary Differential Equations*, Lecture Notes in Mathematics, No. 1537, 1993, pp. 1–209, Springer–Verlag, ISBN 3–540–56461–6.

Research Articles

1. Patrick M. Fitzpatrick, *A generalized degree for the uniform limit of A–proper mappings*, Journal of Mathematical Analysis and Applications, Vol. 35 (1971), pp. 536-552.
2. Patrick M. Fitzpatrick and W.V. Petryshyn, *New existence theorems for nonlinear equations of Hammerstein type*, Transactions of the American Mathematical Society, Vol. 169 (1971), pp. 39-63.
3. Patrick M. Fitzpatrick, *A-proper mappings and their uniform limits*, Bulletin of the American Mathematical Society, Vol. 78, No. 5 (1972), pp. 806-809.
4. Patrick M. Fitzpatrick, Tosio Kato and Peter Hess, *On the local boundedness of monotonic operators*, Proceedings of the Japan Academy, Vol. 48, No. 5 (1972), pp. 275-277.
5. Patrick M. Fitzpatrick and W.V. Petryshyn. *Degree theory for noncompact multivalued vector fields*, Bulletin of the American Mathematical Society, Vol. 79, No. 3 (1973), pp. 609-613.
6. Patrick M. Fitzpatrick, *On the structure of the set of solutions of equations involving A-proper mappings*, Transactions of the American Mathematical Society, Vol. 189 (1974), pp. 107-131.
7. Patrick M. Fitzpatrick and W.V. Petryshyn, *On 1–set and 1–ball contractions with applications to perturbation problems for nonlinear bijective maps and linear Fredholm maps*, Bollettino della Unione Matematica Italiana, (4) 7 (1973), pp. 102-124.
8. Patrick M. Fitzpatrick, *Surjectivity results for nonlinear mappings from a Banach space to its dual*, Mathematische Annalen, Vol. 204 (1973), pp. 177-188.
9. Patrick M. Fitzpatrick and W.V. Petryshyn, *A degree theory, fixed point theorems and mapping theorems for multivalued noncompact mappings*, Transactions of the American Mathematical Society, Vol. 194 (1974), pp. 1-25.
10. Patrick M. Fitzpatrick, *Fixed point theorems for multivalued noncompact inward mappings*, Journal of Mathematical Analysis and Applications, Vol. 46, No. 3 (1974), pp. 756-767.
11. Patrick M. Fitzpatrick and W.V. Petryshyn, *Fixed point theorems for multivalued noncompact acyclic mappings*, Pacific Journal of Mathematics, Vol. 54, No. 2 (1974), pp. 16-23.

12. Patrick M. Fitzpatrick and W.V. Petryshyn, **Fixed point theorems and the fixed point index for multivalued mappings in cones**, Journal of the London Mathematical Society, (2), 12 (1974), pp. 75-85.
13. Patrick M. Fitzpatrick and W.V. Petryshyn, **Positive eigenvalues of nonlinear operators**, Journal of Differential Equations, Vol. 22, No. 2 (1976), pp. 428-441.
14. Patrick M. Fitzpatrick, **Existence results for equations involving noncompact perturbations of Fredholm mappings, with applications to differential equations**, Journal of Mathematical Analysis and Applications, Vol. 66, 1 (1978), pp. 151-177.
15. Patrick M. Fitzpatrick and W.V. Petryshyn, **On the nonlinear eigenvalue problem $T(u) = \lambda C(u)$ involving noncompact abstract and differential operators**, Bollettina della Unione Matematica Italiana, (5) (1978), pp. 80-107.
16. Patrick M. Fitzpatrick and W.V. Petryshyn, **Galerkin methods in the constructive solvability of nonlinear Hammerstein equations, with applications to differential equations**, Transactions of the American Mathematical Society, Vol. 238 (1978), pp. 321-340.
17. Patrick M. Fitzpatrick, **On nonlinear perturbations of second order elliptic boundary value problems**, Mathematical Proceedings of the Cambridge Philosophical Society, Vol. 84 (1978), pp. 143-157.
18. Patrick M. Fitzpatrick and J. Alexander, **The homotopy of certain spaces of nonlinear operators, and its relation to global bifurcation of the fixed points of parametrized condensing operators**, Journal of Functional Analysis, Vol. 34 (1979), pp. 87-106.
19. Patrick M. Fitzpatrick and W.V. Petryshyn, **Some applications of A-proper mappings**, Journal of Nonlinear Analysis, Vol. 3 (1979), pp. 525-532.
20. Patrick M. Fitzpatrick and J. C. Alexander, **Galerkin approximations in several parameter bifurcation problems**, Mathematical Proceedings of the Cambridge Philosophical Society, Vol. 86 (1980), pp. 1-12.
21. Patrick M. Fitzpatrick, **Global bifurcation for several parameter problems**, Proceedings of the 3rd Mathematics Workshop Seminar in Nonlinear Functional Analysis and Fixed Point Theory, A. Carbone, Ed., Cosenza (1981), pp. 45-56.
22. Patrick M. Fitzpatrick and J. Alexander, **Global bifurcation for solutions of equations involving several parameter multivalued condensing mappings**, in Fixed Point Theory, E. Fadell and G. Fournier, Eds., Lecture Notes in Mathematics, No. 886 (1981), Springer-Verlag, pp. 1-19.
23. Patrick M. Fitzpatrick, **Calculating homotopy types and global bifurcation**, Metodi Asintotici e Topologici in Problemi Differenziali Non Lineari, L. Boccardo and A. M. Micheletti, Eds., Pitagora Editrici, Bologna, 1982, pp. 231-241.
24. Patrick M. Fitzpatrick and W.V. Petryshyn, **On connected components of solutions of nonlinear eigenvalue problems**, Houston Journal of Mathematics, Vol. 8, No. 2, (1982), pp. 1-24.
25. Patrick M. Fitzpatrick, I. Massobó and Jacobo Pejsachowicz, **Complementing maps, continuation and bifurcation**, Bulletin of the American Mathematical Society, Vol. 9, No. 1 (1983), pp. 79-81.
26. Patrick M. Fitzpatrick. **Multiple zeros of compact perturbations of Fredholm mappings of positive index**, Nonlinear Partial Differential Equations and Their Applications, College de France Seminar, Vol. 5, Pittman's Research Notes in Math., No. 93 (1983)

27. Patrick M. Fitzpatrick, I. Massabó and Jacobo Pejsachowicz, [Global several-parameter bifurcation and continuation theorems: a unified approach via complementing maps](#), *Mathematische Annalen*, Vol. 263, (1983), pp. 61-73.
28. Patrick M. Fitzpatrick, I. Massabó and Jacobo Pejsachowicz, [A global description of the periodic solutions of some ordinary differential equations](#), *Journal of the London Mathematical Society*, (2), 29 (1984), 499-508.
29. Patrick M. Fitzpatrick, I. Massabó and Jacobo Pejsachowicz, The global n-dimensional structure of solutions of underdetermined nonlinear equations, *Methodes topologiques en analyse non lineaire*, Séminaire de Mathématiques Supérieures, 95 (1985) Les Presses de L'Université de Montréal, pp. 71-94.
30. Patrick M. Fitzpatrick, I. Massabó and Jacobo Pejsachowicz, [On the covering dimension of the set of solutions of some nonlinear equations](#), *Transactions of the American Mathematical Society*, Vol. 294, 2 (1986), pp. 1-22
31. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [An extension of the Leray-Schauder degree for fully nonlinear elliptic problems](#), *Nonlinear Functional Analysis and its applications*, *Proceedings of Symposia in Pure Mathematics*, Vol. 45, Part I, (1986), pp. 425-448.
32. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [The fundamental group of the space of linear Fredholm operators and the global analysis of semilinear equations](#), *Contemporary Mathematics Series*, American Mathematics Society, Vol.72 (1988), pp. 47-87.
33. Patrick M. Fitzpatrick, [Bifurcation, homotopy and linearization](#), *Journal of Nonlinear Analysis*, Volume 123, Number 2 (1988), pp.171-184.
34. Patrick M. Fitzpatrick, [The stability of parity and global bifurcation via Galerkin approximation](#), *Journal of the London Mathematical Society*, 2 (38), (1988), pp. 153-165.
35. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [Local bifurcation for \$C^1\$ -Fredholm maps](#), *Proceedings of the American Mathematical Society*, Vol. 109, No. 4 (1990), pp. 995-1002.
36. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and P. Rabier, [Topological degree for \$C^2\$ -Fredholm mappings](#), *Comptes Rendues de L'Académie de Sciences*, Paris (1990), t. 311, Série 1, pp. 711- 716.
37. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [Parity and generalized multiplicity](#), *Transactions of the American Mathematical Society*, Vol. 326, No. 1 (1991), pp. 281-305.
38. Patrick M. Fitzpatrick and S. Goldberg, [A remark on a paper of Ji-Shou](#), *Proceedings of the American Mathematical Society*, Vol. 109, No. 4 (1991), pp. 995-996.
39. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [Nonorientability of the index bundle and several-parameter bifurcation](#), *Journal of Functional Analysis*, Vol. 98, No. 1 (1991), pp. 42-58.
40. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and P. Rabier, [Topological degree for proper \$C^2\$ -Fredholm mappings on simply connected domains](#), *Journal für die reine und angewandte Mathematik*, 427 (1992), pp. 1-33.
41. Patrick M. Fitzpatrick, [The parity as an invariant for detecting bifurcation of the zeroes of a family on nonlinear Fredholm mappings](#), *Topological Methods in Differential Equations*, E. Furi and P. Zecca, Eds., *Lecture Notes in Mathematics*, No. 1537 (1993), Springer-Verlag, pp. 1-40.

42. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and P. Rabier, [Orientability of Fredholm families and topological degree for orientable nonlinear Fredholm maps](#), Journal of Functional Analysis, Vol. 124, No. 1 (1994), pp. 1-39.
43. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and P. Rabier, [The degree of proper \$C^2\$ -Fredholm mappings: The covariant theory](#), Topological Methods in Nonlinear Analysis, Vol 3 (1994), pp. 325-367.
44. Patrick M. Fitzpatrick and Maria Testa, [The parity of paths of closed Fredholm Operators](#), Journal of Differential and Integral Equations, Vol 7, No. 3 (1994), pp. 823-846
45. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [Dopolnienie otobrayenia v singulliarnoi tochkie maksimalnogo ranga](#) (Complementing a map at a singular point of maximal range), Izvestia Vuzov, Vol 2 (1997), pp. 97-107
46. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and L. Recht, [Spectral flow and bifurcation of critical points](#), Comptes Rendues de L'Académie de Sciences, Paris, t.325, Série 1 (1997), pp. 743-747
47. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and L. Recht, [Spectral flow and bifurcation of critical points of strongly-indefinite functionals; Part I](#), General theory, Journal of Functional Analysis, Vol 162, No 1 (1999), pp. 52-95
48. Patrick M. Fitzpatrick, Jacobo Pejsachowicz and L. Recht, [Spectral flow and bifurcation of critical points of strongly-indefinite functionals; Part II, Bifurcation of periodic orbits of Hamiltonian systems](#), Journal of Differential Equations, Vol 163, No 1 (2000), pp 18-40
49. E. Ciriza, Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [Uniqueness of spectral flow](#), Journal of Mathematical and Computer Modelling, Vol 32, Nos 11-13 (2000), pp. 1495-1501
50. Patrick M. Fitzpatrick, [A note on the functional calculus for unbounded self-adjoint operators](#), Journal of Fixed Point Theory and Applications, 13 (2013), no. 2, 633-640
51. Patrick M. Fitzpatrick and Brian Hunt, [Absolute continuity of a function and uniform integrability of its divided differences](#), The American Mathematical Monthly 122 (2015), no. 4, pp. 362-366
52. Patrick M. Fitzpatrick and James C. Alexander, [Spectral flow is a complete invariant for detecting bifurcation of critical points](#), Transactions of the American Mathematical Society, 368(2016), no. 2, 4439-4459
53. Patrick M. Fitzpatrick and Jacobo Pejsachowicz, [Bifurcation and Branching](#), Discrete and Continuous Dynamical Systems, Series 8, Volume 12, Number 7, Nov 2019, pp. 1-21

Book Reviews

1. [Featured Review of *Linear and Nonlinear Functional Analysis and its Applications*](#) by C.R. Ciarlet, Springer-Verlag, 2014, pp. 806: SIAM Rev. 58 (2016), 577-582
2. [Review of *Nonlinearity and Functional Analysis*](#) by M. S. Berger, Academic Press, 1977: Bulletin of the American Mathematical Society, Vol. 85 (1) (1979), pp. 210-217.
3. [Review of *Methods in Bifurcation Theory*](#) by S. N. Chow and J. Hale, Springer-Verlag, 1982: (written with J. Alexander) Bulletin of the American Mathematical Society, Vol. 15 (2) (1986).
4. [Review of *Nonlinear Functional Analysis*](#) by Klaus Deimling, Springer-Verlag, 1986: Bulletin of the American Mathematical Society, Vol. 20 (2) 1989, pp. 277-280.

PhD Theses Directed

- Dennis Phillips, *The Existence of Determining Equations and Their Application to Finding Fixed Points of Compact Operators and Error Bounds for Eigenvalue Estimates of Compact Linear Operators*, UMd 1978
- Charles Fletcher, *Multiscale Periodic Homogenization of Certain Elliptic Equations Using Viscosity Solutions*, codirected with L.C. Evans, UMd 1990
- Maria Testa, *The Analytical Index of Families of Unbounded Linear Fredholm Operators and Bifurcation for Families of Nonlinear Operators*, UMd 1992

Selected Lectures

- Nine invited lectures at Oberwolfach conferences between 1978 and 2000
- Colloquia at various US Universities, including at Brown, Cornell and U. Chicago
- Jacques Lions Séminaire, College de France, January, 1983
- Seminar Lectures at the University of Paris- Orsay, February, 1983
- PDE Seminar, Universität Zürich, January, 1998
- Applied Mathematics Seminar, the Mathematics Institute, University of Oxford, January, 1998
- Several Analysis Seminars, Politecnico di Torino
- Conference on Topological and Variational Methods in PDE, Cuernavaca, Mexico, February, 1999
- Principal Speaker and Section Organizer, Third World Conference on Nonlinear Functional Analysis, Catania, Italy, July, 2000
- Inaugural of James Stewart Center Colloquium, McMaster University, September 2003
- Lecture, Conference on Variational Methods and the Nonlinear Schrödinger Equation, Ecole Polytechnique Fédérale de Lausanne, February 2004
- Lecture, SIAM Conference on Partial Differential Equations, Houston, November, 2004
- Plenary Speaker, SIDIM 2007, University of Puerto Rico, Ponce, July 2007
- Speaker, Complex Patterns in Nonlinear Systems, University of Torino, January, 2015
- Lectures at King Saud University of Science and Technology, January, 2016