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Citizenship

Canadian.

Languages

English and French.

Degrees

Ph.D. in mathematics, University of New Mexico–Albuquerque, May 2002. Thesis title: *Numerical solution of the steady diffusion equation with discontinuous coefficients.*

B.Sc. spécialisé bidisciplinaire en mathématiques et physique, Université de Montréal, May 1984.

D.E.C. (Diplôme d'Études Collégiales) en sciences pures, Collège Bois-de-Boulogne, May 1981.

Refereed publications

[**1**] A. Kitson, R. I. McLachlan and N. Robidoux. *Skew-adjoint finite difference methods.* Accepted for publication with modifications in the ***New Zealand Journal of Mathematics***. 20 pages.

[**2**] P. M. Knupp and N. Robidoux. *A framework for variational grid generation: conditioning the Jacobian matrix with matrix norms.* ***SIAM Journal on Scientific Computing*** 21, no. 6 (2000), 2029–2047.
(Cited by W. W. Cao, R. Carretere-Gonzalez, R. Gadh, W. M. Huang, Y. Lu, L. G. Margolin, R. D. Russell, M. Shashkov, W. Sun, T. J. Tautges and O. V. Ushakova.)

[**3**] R. I. McLachlan and N. Robidoux. *Antisymmetry, pseudospectral methods, and conservative PDEs.* In ***EQUADIFF 99, Proceedings of the International Conference on Differential Equations, Berlin, Germany 1–7 August 1999***, B. Fiedler, K. Gröger and J. Sprekels, eds., World Scientific, Singapore (2000), 994–999. (Cited by E. Celledoni, A. Iserles, G. R. W. Quispel and N. Trefethen.)

[**4**] R. I. McLachlan, G. R. W. Quispel and N. Robidoux. *Geometric integration using discrete gradients.* ***Royal Society of London Philosophical Transactions, Series A, Mathematical, Physical and Engineering Sciences*** 357, no. 1754 (1999), 1021–1045. (Cited by P.B. Bornemann, C. Budd, E. Celledoni, K. Engo, S. Faltinsen, U. Galvanetto, T. Ide, A. Iserles, A. Kitson, R. Kozlov, J. E. Marsden, T. Matsuo, S. P. Nørsett, M. Okada, P. J. Olver, B. Orel, M. Perlmutter, A. San Miguel, S. Sieniutycz and M. West.)

[**5**] R. I. McLachlan, G. R. W. Quispel and N. Robidoux. *Unified approach to Hamiltonian systems, Poisson systems, gradient systems, and systems with Lyapunov functions or first integrals.* ***Physical Review Letters*** 81, no. 12 (1998), 2399–2403. (Cited by P. Betsch, F. Bullo, A. Figueiredo, I. M. Gleria, A. Kitson, R. Kozlov, J. E. Marsden, M. Perlmutter, T. M. Rocha, P. Steinmann and M. West.)

[**6**] N. Robidoux. *Computer algebra and interpolation: a lesson plan.* ***Journal of Symbolic Computation*** 23 (1997), 551–576.

[**7**] N. Robidoux. *A new method of construction of adjoint gradients and divergences on logically rectangular smooth grids.* In ***Finite Volumes for Complex Applications, Problems and Perspectives***, F. Benkhaldoun and R. Vilsmeier, eds., Hermès, Paris (1996), 261–272. (Cited by S. Steinberg.)

Selected other publications

[**8**] N. Robidoux. *Numerical Solution of the Steady Diffusion Equation with Discontinuous Coefficients*, Ph.D. thesis, U. New Mexico, Albuquerque, NM (2002), xxiv+131. (Cited by J. M. Hyman and S. Steinberg.)

[**9**] H. Hong, R. Liska, N. Robidoux and S. Steinberg. *Elimination of variables in parallel.* ***SIAM News*** 33, no. 8 (2000), in the column *Applications on Advanced Architecture Computers*, G. Astfalk, ed., 1 and 12–13.

[**10**] N. Robidoux. *Does AXIOM Solve Systems of O.D.E.'s Like* Mathematica*?* Technical Report LA-UR-93-2235, Los Alamos National Laboratory, Los Alamos, NM (1993), 13 pages. (Cited by F. Postel, M. Wester and P. Zimmermann.)

Software

[**11**] N. Robidoux. Stanza for the modem identification component of the Linux PCMCIA module (1997; in standard Linux PC distributions since 1998).

[**12**] H. Hong, R. Liska, N. Robidoux and S. Steinberg. PQEPCAD (Parallel Quantifier Elimination by Partial Cylindrical Algebraic Decomposition), the message passing implementation of the QEPCAD computer algebra software package for quantified systems of polynomial inequalities (1995, 1997). Home page: `http://www.cs.usna.edu/~qepcad/B/...QEPCAD.html`.

Selected conference and workshop presentations

(“*” = presenter.)

[**13**] N. Robidoux*. *Superconvergent discrete Hodge star operators.* ***Mimetic Discretizations of Continuum Mechanics*** (July 2003), San Diego CA.

[**14**] S. Steinberg* and N. Robidoux. *A discrete vector calculus in tensor grids.* ***Mimetic Discretizations of Continuum Mechanics*** (July 2003), San Diego CA.

[**15**] S. Steinberg* and N. Robidoux. *A discrete vector calculus in tensor grids.* **IEEE International Symposium on Antennas and Propagation** (Institute of Electrical and Electronics Engineers) (June 2003), Columbus OH.

[**16**] S. Steinberg* and N. Robidoux. *A discrete vector calculus in tensor grids.* **Second M.I.T. Conference on Computational Fluid and Solid Mechanics** (June 2003), Cambridge MA.

[**17**] N. Robidoux*. *Discrete Hodge star operators.* **Workshop on Group Theory and Numerical Analysis** (May 2003), Montreal QC.

[**18**] S. Steinberg* and N. Robidoux. *A discrete vector calculus in tensor grids.* ***Sixth New Mexico Analysis Seminar*** (March 2003), Albuquerque NM.

[**19**] N. Robidoux*. *Finite volume difference solutions of the Poisson equation with non-smooth diffusion coefficient, source term, and grids.* ***2002 SIAM Annual Meeting*** (Society for Industrial and Applied Mathematics) (2002), Philadelphia PA.

[**20**] T. Myers, N. Dubash*, N. Robidoux*, and seven others. *The flow of an evaporating thin film liquid.* ***Fifth PIMS Graduate Mathematics Modelling Camp*** (2002), Burnaby BC.

[**21**] N. Robidoux* and P. M. Knupp. *A framework for variational grid generation: conditioning the Jacobian matrix with matrix norms.* ***SciCADE 01*** (International Conference on Scientific Computation And Differential Equations) (2001), Vancouver BC.

[**22**] P. Read*, A. Parshotam and N. Robidoux. *A multi region development of the FLAMES model to simulate trade in biofuel and conventional timber products resulting from policy driven land use change.* ***Joint meeting of the Energy Modeling Forum, the International Energy Agency, and the International Energy Workshop*** (2000), Stanford CA.

[**23**] P. Read*, A. Parshotam and N. Robidoux. *Using GIS data for country level carbon absorption curves under pro-active land use change policies in a market driven environment: the New Zealand case.* ***Conference on Sustainable Energy: New Challenges for Agriculture and Implications for Land Use*** (2000), Wageningen, The Netherlands.

[**24**] A. Parshotam*, P. Read and N. Robidoux. *Modelling biofuels.* ***ANZIAM 2000*** (Australia New Zealand Industrial and Applied Mathematics Society) (2000), Waitangi, New Zealand.

[**25**] N. Robidoux* and R. I. McLachlan. *Conservative, Hamiltonian pseudospectral methods.* ***SciCADE 99*** (1999), Fraser Island, Australia.

[**26**] R. I. Mclachlan* and N. Robidoux. *Symmetry, pseudospectral methods, and conservative PDEs.* ***EQUADIFF 99*** (International Conference on Differential Equations) (1999), Berlin, Germany.

[**27**] N. Robidoux*. *Discretizing compositions of differential operators.* ***ANODE 99*** (Auckland Numerical Ordinary Differential Equations) (1999), Auckland, New Zealand.

[**28**] H. Hong*, R. Liska, N. Robidoux and S. Steinberg. *Eliminating variables in parallel.* ***MSRI Workshop on Parallel Symbolic Computation*** (Mathematical Sciences Research Institute) (1998), Berkeley CA.

[**29**] N. Robidoux*. *Natural discretizations of Div K Grad.* ***ANODE 97*** (1997), Auckland, New Zealand.

[**30**] H. Hong*, R. Liska*, N. Robidoux* and S. Steinberg*. *Parallel quantifier elimination* ***IMACS-ACA 97*** (International Association for Mathematics and Computers in Simulation Conference on Applications of Computer Algebra) (1997), Maui HI.

[**31**] N. Robidoux*. *User friendly reviews of computer algebra systems.* ***IMACS-ACA 96*** (1996), Hagenberg, Austria.

[**32**] N. Robidoux*. *Adjoint high order numerical gradient and divergence operators on non-uniform grids.* ***Finite Volumes for Complex Applications 96*** (1996), Rouen, France.

[**33**] P. M. Knupp* and N. Robidoux. *A framework for variational grid generation.* ***1996 SIAM Annual Meeting*** (1996), Kansas City MO.

[**34**] H. Hong*, M. Jahn, R. Liska, N. Robidoux and S. Steinberg, S. *Parallel quantifier elimination on the IBM SP2.* ***IMACS-ACA 95*** (1995), Albuquerque NM.

[**35**] N. Robidoux*. *Investigating interpolation and numerical differentiation with a computer algebra system: examples using AXIOM.* ***A Workshop on New Technology for Symbolic Computational Mathematics and Applications in Research and Education*** (1994), New Brunswick NJ.

Poster

[**36**] T. Myers, L. Barannyk*, and eight others including N. Robidoux. *The flow of an evaporating thin film liquid.* ***MITACS Third Annual General Meeting*** (Mathematics of Information Technology and Complex Systems) (2002), Vancouver BC.

Drafts at an advanced stage of writing

[**37**] N. Robidoux. *Polynomial histopolation, superconvergent degrees of freedom, and pseudospectral discrete Hodge operators*, 33 pages. `http://www.cs.laurentian.ca/robidoux/...prints/super/histogram.pdf`.

[**38**] N. Robidoux and S. Steinberg. *A discrete calculus in tensor grids*, 59 pages. `http://www.cs.laurentian.ca/robidoux/...prints/discrete_intro/discrete_intro.ps`.

[**39**] R. McLachlan and N. Robidoux. *Anti-symmetry, pseudospectral methods, weighted residual discretizations*, 37 pages. `http://www.cs.laurentian.ca/robidoux/...prints/skew/skew.ps`.

Current research interests

Numerical analysis

- Discrete Hodge-Helmholtz decomposition.
- Spectrally convergent methods for div-grad systems with discontinuous coefficients.
- Conservative mixed finite difference discretizations of div-grad and curl-curl systems with discontinuous, non-isotropic, degenerate or unbounded coefficients.
- Discrete Hodge star operators. Discrete Dirichlet to Neumann maps. Superconvergent geometric degrees of freedom for discrete Hodge star operators based on higher order tensor elements.
- "Natural" finite volume difference numerical discretizations of exterior differential operators (div, grad and curl) based on the generalized Stokes' Theorem and the deRham map. Consistent numerical discretizations of constitutive relations (material properties).
- Structural factorizations (in terms of incidence matrices/coboundary operators) of numerical differential operators.
- Modelling of diffusion through heterogeneous non-isotropic media.
- Modelling of eddy currents in systems with large coefficient jumps.

Mathematical physics

- Smooth "linear-gradient" factorizations of vector fields with conserved quantities and/or Lyapunov functionals.

Main contributions to R&D

Linear-gradient factorizations of systems of ODEs with an integral/Lyapunov function, and discrete gradient factors of conservative/monotone numerical integrators

R. I. McLachlan, G. R. W. Quispel and N. Robidoux. *Geometric integration using discrete gradients.* Royal Society of London Philosophical Transactions, Series A, Mathematical, Physical and Engineering Sciences 357, no. 1754 (1999), 1021–1045.

R. I. McLachlan, G. R. W. Quispel and N. Robidoux. *Unified approach to Hamiltonian systems, Poisson systems, gradient systems, and systems with Lyapunov functions or first integrals.* Physical Review Letters 81, no. 12 (1998), 2399–2403.

These articles have appealed to researchers outside of the numerical analysis community and have been cited in geometric integration, dynamical systems and control theory papers.

An unusual feature of these papers is that new, elementary, results about factorizations of systems of ODEs came out of "taking limits" of correspondingly factored generic numerical integrators. (One referee was surprised that such converses to standard classical mechanics and ODE stability theory results had not been discovered before.) The following theorem is representative of the "continuum" component of the articles:

Theorem *Suppose that the flow of an analytic vector field $f(x)$ has an analytic first integral (constant of motion) $V(x)$. Suppose also that the critical points of V are non-degenerate. Then, there exists a C^∞ antisymmetric matrix function $A(x)$ such that*

$$f(x) = A(x)\nabla V.$$

The articles also contain factorization results for C^r vector fields, multiple first integrals, and Lyapunov functionals (functions which do not increase on solutions of the ODEs). Such factorizations make obvious the fact that V is a constant of motion, and can be used to build conservative integrators by replacing the gradients by so-called "discrete gradients."

Reinout Quispel (one of the authors) had previously identified $(f \wedge \nabla V) / |\nabla V|^2$ as a suitable $A(x)$ away from critical points, where unfortunately it may blow up. An observation of mine—that the Morse lemma allows one to choose local coordinates with respect to which $V(x)$ is a constant bilinear form—was the key to regularity results.

Analogous issues arise in the discrete case. Drawing on my doctoral work on cochain-based numerical schemes for div-grad systems, I discovered an alternate characterization of discrete gradients based on the Potential Theorem. This characterization in terms of path integrals, which emphasizes the archetypal nature of the mean value discrete gradient of Harten, Lax and van Leer, led to reformulations of existing discrete gradients free of 0/0 quotients.

Robert McLachlan, of the Institute for Fundamental Sciences of Massey University, New Zealand, my postdoctoral supervisor at the time, Reinout Quispel, of the Department of Physics of LaTrobe University in Melbourne, Australia, and myself each contributed many other ideas and results, which Robert assembled.

A general framework for variational grid generation

P. M. Knupp and N. Robidoux. *A framework for variational grid generation: conditioning the Jacobian matrix with matrix norms.* SIAM Journal on Scientific Computing 21, no. 6 (2000), 2029–2047.

This article fits most commonly used grid generators under an intuitive conceptual framework, and provides heuristics for the characterization of the local and global features of the corresponding grids. The main idea is that globally minimizing the norm of a matrix derived from the Jacobian matrix of the mapping implied by the grid is a very flexible way to build variational grid generators. For example, the popular harmonic mapping generator arises from minimizing the L^2-norm of the Frobenius norm of the inverse of the Jacobian matrix.

Patrick Knupp—then a senior researcher at at Ecodynamics Research Associates in Albuquerque, New Mexico—contributed the main idea, the numerical examples and the more complicated derivations. I—a graduate student at the University of New Mexico at the time—contributed a more structured and general version of the framework, several building blocks, and a systematic exploration of the properties of functionals based on the framework. Patrick has coded several of these ideas for the CUBIT grid generation group of Sandia National Laboratories (Albuquerque, NM). Writing wise, I contributed the notation and exposition, Patrick contributed the examples, numerics and links to the literature, and we edited together.

Cochain/discrete Hodge star operator numerical methods

N. Robidoux. *Numerical Solution of the Steady Diffusion Equation with Discontinuous Coefficients*, Ph.D. thesis, U. New Mexico, Albuquerque, NM (2002), xxiv+131.

I performed a thorough study of a cochain-based discretization of the steady diffusion equation on the interval. Specifically, I analysed and implemented a discrete Hodge star operator-based numerical solver for the 1D version of the div-grad system

$$-\nabla\cdot\left(\mu^{-1}\nabla d\right) \;=\; g,$$

on the interval, with consistent combinations of Dirichlet, Neumann and Robin (mixed) boundary conditions, where μ, a non-negative integrable function, is the inverse of the diffusion coefficient; g, a Borel measure, is the source term; d is the temperature; and $\mu^{-1}\nabla d$ is the heat flux.

Necessary and sufficient conditions for the existence and uniqueness of solutions of discrete analogs of the steady heat equation with "$\nabla\cdot\mu^{-1}\nabla$" terms equal to products of two full rank rectangular matrices with one dimensional nullspaces were presented. The computed point values of the temperature and flux was shown to converge in max norm to the point values of the exact solution as the diameter of the largest cell goes to zero if g is integrable, converge (at least) at first order if μ and g are square integrable, and converge at second order if the restriction of g to every grid cell has a square integrable derivative. If, on the other hand, g is a Borel measure, then the computed point values of the temperature converge in max norm at half order provided the Lax-Milgram Theorem applies to the continuum problem. (Some of the above convergence rates are improved versions derived after publication.) It was also shown that a symmetric positive definite discrete Hodge star operator matrix is obtained by adapting the secondary grid to the intra-cell variations of μ. A very cheap solver (12 to 15 flops per grid cell, depending on the boundary conditions) was documented.

Thus, the thesis established that such numerical schemes are competive for 1D div-grad systems, that they preserve the structure of the continuum problem, and that they robustly handle problems with very rough coefficients.

General formulas for normal flux and circulation interpolants for hexahedral cells, and the corresponding 3D discrete Hodge star operator matrices, were also presented.

Research plan

Cochain-based numerical methods for the solution of partial differential equations and scientific visualization

Consider a computational grid which defines cells, faces, edges and vertices. If one assigns to every grid cell the total charge contained in the corresponding volume, one defines a cochain; likewise if one assigns to every face the total heat flux through it, or if one assigns to every edge the tangential integral of the electric field along it. An important feature of cochain-based methods is that incidence matrices provide discretizations of the gradient, divergence and curl operators which are free of truncation error. This follows from the fact that the discrete unknowns are chosen so as to be consistent with the Potential, Divergence and Stokes' theorems A more sophisticated explanation is that incidence matrices can be identified with the coboundary operator of deRham cohomology This connection with algebraic topology leads to discrete analogs of key theorems of vector calculus hold (à la "The curl of a gradient always vanishes;" more pointedly, those implied by the Hodge-Helmholtz decomposition) and leads to characterizations of the solution spaces of cochain-based numerical discretizations of div-grad (diffusion) and curl-curl (Maxwell's equations) systems.

In cochain-based methods, it is typical for constitutive relations to be discretized by way of so-called discrete Hodge operators. For example, diffusion, electric permittivity and magnetic permeability tensors lead to discrete Hodge operators which reconstruct face fluxes from edge tangential integrals (hence the analogy with the Hodge operator of differential forms theory). A major component of the proposed research concerns the development of better—higher order, or more robust with respect to material and grid discontinuities—discrete Hodge operators.

Short term objectives

Implement and test first and second order (with non-diagonal discrete Hodge star operators) discrete Hodge-Helmholtz decomposition software for triangular and tetrahedral grids.

Implement and test second order and piecewise pseudospectral discrete Hodge-Helmholtz decomposition software for grids with quadrilateral and hexahedral cells.

Implement and test cochain-based methods for div-grad systems based on piecewise pseudospectral discrete Hodge star operators, applicable to logically rectangular grids.

Develop efficient solvers for the various numerical schemes.

Long term objectives

Flexible, robust, second order accurate and fast discrete Hodge-Helmholtz decomposition software packages for numerical modelling and computer graphics.

Accurate and flexible solvers for div-grad and curl-curl systems on hexahedral and tetrahedral grids aligned with material discontinuities, based on second order discrete Hodge star operators.

Superconvergent high order polynomial and pseudospectral cochain-based methods for sufficiently smooth div-grad and curl-curl systems.

Understanding of the relative merits of the three main approaches for constructing discrete Hodge star operators: Galerkin using Whitney elements, Whitney/deRham (field reconstruction and projection), and generalized collocation (e.g., diagonal stars based on circumcentric dual grids).

The two main components of the research project

The proposed research, on cochain-based methods which use discrete Hodge star operators, and applications, has two main components: discrete Hodge-Helmholtz decomposition, and superconvergent piecewise pseudospectral discrete Hodge star operators.

Discrete Hodge-Helmholtz decomposition

This is a collaborative project with Mathieu Desbrun of the Department of Computer Science of the University of Southern California (Los Angeles, CA) and his graduate student Yiying Tong, whose interest in discrete Hodge-Helmholtz decomposition comes from its applications to computer graphics and scientific visualization.

The Hodge-Helmholtz decomposition of a vector field is a splitting of the field as a sum of a curl-free component (typically written as the gradient of a potential), a divergence-free component (typically, the curl of a vector potential), with a third component, the harmonic part, only present when the topology of the domain is non-trivial. What discrete Hodge-Helmholtz decomposition software aims to accomplish is such a splitting when only finitely many values of the field are known. Cochain-based methods are appealing because the discrete divergence can be made error free when using cochains as discrete unknowns.

Recent progress in research activities related to the proposal

Following a suggestion of mine, Mathieu and a graduate student are currently programming a tetrahedral grid Hodge-Helmholtz decomposition which uses the cochains determined by the deRham projection. The prototype uses a first order diagonal discrete Hodge star operators based on circumcentric dual grids (this discrete Hodge star operator is second order in the interior of the domain when the grid is uniform and the material properties trivial), and second order Galerkin discrete Hodge star operators based on Whitney elements.

I have shown that cochain/discrete Hodge star operator based discrete Hodge decompositions are unique if and only if the corresponding discrete div-grad system defines a unique flux cochain. I have also shown that there is an underlying variational principle if the matrix representation of the discrete Hodge star operator is symmetric positive definite, in which case the Euler-Lagrange equations can be tackled with a conjugate gradient solver. This result applies to quite general discrete Hodge star operators, and indicates that the decomposition can be easily extended to fluxes arising from non-isotropic material properties.

In a parallel development, I have shown that averaging low order interpolatory ("Whitney-deRham") discrete Hodge operators over local grids parameterized by the nodal positions yields the Galerkin Hodge operator. This links the main two approaches used to build discrete Hodge star operators.

Methodology

Because we now have a fairly generic discrete Hodge-Helmholtz decomposition framework, which in every case involves incidence matrices as key factors, we can try various discrete Hodge star operators—Galerkin, Whitney/deRham, based on circumcentric or barycentric dual grids, with or without diagonal lumping, ...—and compare their accuracy through numerical testing.

Anticipated significance of the work

Discrete Hodge-Helmholtz decomposition software can be used to identify vertices, sources and sinks in 2 and 3D vector fields and to filter out "spurious modes" numerical computations. In computer animation, the decomposition can be used to simulate fluid flow or the deformation of a solid body in a more realistic way.

Independently of the usefulness of the software, this project is a perfect testing ground for various discrete Hodge star operators. The results should be of interest to those developing discrete differential forms theories with an eye to numerical modelling.

Superconvergent piecewise pseudospectral discrete Hodge star operators

Recent progress in research activities related to the proposal

I have constructed superconvergent “interpolatory” discrete Hodge operators of all orders for grids with cells which are affine images of cubes. Besides improved accuracy, the degrees of freedom which define the superconvergent discrete Hodge operators have been found to lead to key matrix factors with condition numbers bounded independently of the order (which is far from being expected given that the construction of the discrete Hodge operators involves high order piecewise polynomials).

Methodology

What needs to be verified is whether this leads to superconvergent solutions of div-grad and curl-curl systems in 2 and 3D when discontinuous coefficients are involved (one only expects spectral convergence when the coarse level grid is aligned with discontinuities). This can be checked with numerical tests.

A number of open questions remain, not the least of which is whether such superconvergent discrete Hodge operators can be devised for grids with triangular and tetrahedral cells, and whether solvers for mixed finite element methods for div-grad and curl-curl systems benefit from using the optimal degrees of freedom. Preliminary investigations of these questions can be done with a computer algebra system.

Anticipated significance of the work

We hope that these ideas will lead to high order and spectrally convergent numerical solvers for div-grad and curl-curl systems with mild singularities located at the coarse cell boundaries. Also, the low condition numbers of rescaled discrete Hodge star operators suggest that using the corresponding degrees of freedom when computing with high order Galerkin finite element methods may decrease the costs associated with inverting mass matrices. “Interpolatory” high order discrete Hodge star operators, which are far from being symmetric (and even farther from being diagonal), also question the common assumption that matrix representations of discrete Hodge star operators should be symmetric.

Research employment

Posdoctoral Fellow 5/01–6/03
Mathematics Department, Simon Fraser University, Burnaby BC.
Under the supervision of Profs. R. Russell and M. Trummer, developed mimetic methods for elliptic problems with very rough, degenerate or unbounded coefficients, piecewise pseudospectral mimetic methods for elliptic problems with piecewise smooth coefficients, and formulated discretizations of eddy current problems without spurious nullspaces. Discovered superconvergent degrees of freedom for discrete Hodge star operators. Formulated algorithms for discrete Hodge-Helmoltz decompositions. Investigated the convergence rates and properties of radial basis function expansions.

Researcher 1/00–6/00
Landcare Research (NZ) Ltd., Massey University Campus, Palmerston North, New Zealand.
Under the supervision of Dr. A. Parshotam of Landcare Research (NZ) Ltd. and Dr. P. Read of the International and Applied Economics department of Massey University, Palmerston North, formulated a GIS (Geographical Information System) based model of land use switch to biofuel forestry driven by subsidy and market price of biofuel, and analysed a model of the international trade of biofuel.

Marsden Postdoctoral Research Fellow 9/97–8/99
Mathematics, Institute of Fundamental Sciences, Massey University, Palmerston North, New Zealand.
Under the supervision of Dr. R. McLachlan, studied structural—basis and grid independent—factorizations of spectral and pseudospectral discretizations of d/dx. Formulated a conservative semi-discretization method for Hamiltonian (Lie-Poisson) partial differential equations.
With Dr. R. McLachlan and Prof. R. Quispel of the Department of Mathematics of LaTrobe University, Melbourne, Australia, discovered a universal formula for systems of ordinary differential equations with conserved quantities and/or Lyapunov functionals, which makes the properties explicit. Formulated a discrete analog fitting several established conservative discretizations into a single framework.

Research Assistant 9/94–9/96 and 1/97–8/97
Albuquerque High Performance Computing Center, University of New Mexico, Albuquerque NM.
Under the supervision of Prof. S. Steinberg of the Mathematics and Statistics Department, developed and tested a new discretization of the diffusion operator.
With Prof. H. Hong of the Research Institute for Symbolic Computation in Hagenberg, Austria, and Dr. R. Liska of the Czech Technical University in Prague, Czech Republic, parallelized the software package QEPCAD (Quantifier Elimination by partial Cylindrical Algebraic Decomposition), and worked on the solution of control theory problems as well as on fundamental algorithmic improvements.
With Dr. P. Knupp, of Ecodynamics Research Associates, Inc., in Albuquerque, formulated a new framework for the variational generation of structured grids.
With Dr. T. Robey of Spectra Research Institute in Albuquerque, studied the regularization of grids generated by minimizing coefficient heterogeneity within cells for a Sandia National Laboratory ground flow model.
With the User Services Group of the Maui High Performance Computing Center, performed supercomputer system administration.

Graduate Research Assistant 11/92–9/94
Center for Nonlinear Studies and Division T-7, Los Alamos National Laboratory, Los Alamos NM.
Under the supervision of Dr. J. M. Hyman of Division T-7, developed the periodic uniform grid version of local high order numerical differentiation operators which satisfy the basic equations of vector calculus. Rewrote

FORTRAN quadrature subroutines. Investigated the internal singularities of elliptic equations with discontinuous coefficients and applications to porous media flow modelling.
Did theoretical physics work with Dr. M. Mineev of Division T-12, on the existence of solutions Laplacian Growth Equations model of finger growth in two-phase flow, using complex analysis.

Research Assistant 5/82–4/84 and 8/84–9/84
Centre de recherche nucléaire de l'Université de Montréal, Montréal QC.
Under the supervision of Prof. P. Taras, ported, customized and developed FORTRAN data analysis and modelling software and calibrated and customized instruments for research on heavy nuclei with high angular momentum.

Research Assistant 5/84–8/84
Mathematics Department, Simon Fraser University, Burnaby BC.
Investigated the relationship between the linearized curvature and Ricci tensors under the supervision of Prof. E. Pechlaner.

Teaching employment

Assistant professor 7/03–
Department of Mathematics and Computer Science,
Laurentian University,
Sudbury ON
Taught Discrete Mathematics II (in French) and Analysis I (in English) to small classes (five and four students; all but one finished the course). Supervising a mathematics honours thesis. In the Spring of 2004, will teach Linear Algebra I (in French) and Discrete Mathematics II (in English), supervising two graders.

Sessional Lecturer
8/01–12/01 and 1/03–4/03
Mathematics Department, Simon Fraser University, Burnaby BC.
Taught Algebra and Trigonometry (precalculus) to 108 undergraduates (103 completed the course), and Complex Variables to 97 undergraduates (86 completed the course) and supervised a teaching assistant.
Class management and distribution of handouts, grades, and announcements with WebCT, a web-based software package. (This positive experience with WebCT led to my giving WebCT seminars at the University of New Mexico in April 2002.)

Research Assistant
9/94–9/96 and 1/97–8/97
Albuquerque High Performance Computing Center, University of New Mexico, Albuquerque NM.
Wrote and published (in the Journal of Symbolic Computation) an introduction to computer algebra [**6**].
Gave workshops on using computer algebra systems to construct and program numerical schemes, parallelization using message passing, and grant proposal writing.
With the User Services Group of the Maui High Performance Computing Center, answered users' queries on parallel computing and scientific computation.

Private Tutor 9/88–2/93
Albuquerque NM and Los Alamos NM.
Individual and group tutoring: algebra, trigonometry, calculus, partial differential equations, applied mathematics, statistics, physics, ground water engineering, economics and quantitative management.
Diverse student clientele: mature students, veterans, Native Americans and recent immigrants completing undergraduate and graduate degrees in management, business, engineering, nursing, mathematics, computer science, dentistry...

Teaching Assistant 8/91–8/92
Department of Mathematics and Statistics, University of New Mexico, Albuquerque NM.
Taught trigonometry and calculus courses to groups of 20 to 30 students.

Physics Consultant 1/90–5/90
Office of Graduate Studies, University of New Mexico, Albuquerque NM.
Physics tutoring.

Teaching Assistant
8/85–5/87 and 1/88–5/88
Mathematics Department, University of Wisconsin, Madison WI.
Spring 1987 teaching performance rated “outstanding” by the departmental evaluation committee.
Taught and managed business calculus and trigonometry courses, and conducted calculus tutorial sessions, to groups of 20 to 30 students.

Teaching interests and philosophy

• I am qualified to teach a wide variety of introductory and advanced classes in pure and applied mathematics, including algebra and trigonometry, calculus, vector calculus, linear algebra, ordinary and partial differential equations, complex variables, mathematical physics, applied mathematics, real and complex analysis, measure theory, computer algebra, numerical analysis, introductory topology, elementary graph theory, and parallel computing.

• I do not regard teaching an elementary class as a "lesser" assignment. The challenge of making the material accessible and intuitive to students with less mathematical maturity makes up for the less interesting material.

• "Why?" "What does this mean?" and "Why do we care?" are the most important questions: Why do we complete the square? What does it mean for a mapping to be conformal? Why do we care about complex values when considering the stability of a real numerical algorithm? Half of knowing how is knowing why.

• No single teaching approach fits all students, all topics, or all teaching situations.

• I try to ensure that every part of a lecture, every reading assignment and every homework and exam question has a clear purpose.

• To accomodate the various learning styles, I try to break my lectures into differently themed and paced parts, targeted to the slow/fast/best/worst/confused/curious.

• All students deserve respect, and I go out of my way to make non-mathematics majors feel welcome in my classroom.

• Wishing the students were better prepared or more interested is pointless: My job is to inspire students—the actual students sitting in my class—to learn and grow in mathematical maturity.

• Answering a question involves active listening: I try to get a clear idea of what the asking student does and does not understand before I formulate answers.

• I encourage students to point out typos and mistakes in my lectures or handouts by rewarding them with extra credit points. Besides the obvious, "finding me wrong" keeps the better students awake during less challenging lectures, and sometimes exposes subtle misunderstandings. (Once students have earned a certain number of such bonus points, they are promoted to the "Count to Ten Club" so as to give others a chance.)

• An exam question which a typical student can only be expected to answer by memorization ("State and prove the Cauchy-Goursat Theorem.") is not ideal. I prefer questions which require a little bit of creative problem solving in addition to understanding the concepts ("Give me a formula for a function which is differentiable somewhere, but analytic nowhere.").

• A typical homework assignment contains a number of routine problems from both recent and earlier material, as well as one or two very easy problems about material yet to be coveredq, to encourage students to read the textbook ahead of time and familiarize themselves with the topic before I lecture on it. In advanced classes, homework assignments also contain one or two challenging problems which may be out of reach of the weaker students. Thus, a specific type of problem lingers for three or four assignments: as a preview in an easy version, twice in "standard strength," and possibly once in challenging form.

• Solutions should be posted (on the web and my office door) when homework is collected; grading keys, when it is returned.

• I rely on a web-accessible calendar to make announcements and distribute lecture notes, homework assignments, grades, solutions, etc. Students quickly learn to check the class site for grades, announcements and class material (the only documents I print are the syllabus and exams). Keeping announcements out of the classroom and minimizing document handling focuses class time on lecturing and answering questions.

Teaching evaluations highlights

Following is a discussion of the most recent teaching evaluations available. Copies of the "numerical" summaries are stapled at the end of this resume.

Algebra and Trigonometry at Simon Fraser University 1/03–4/03

The students gave me an overall "grade" of 3.14. Following are comments copied from the evaluation forms. (Copies of the full set of student evaluations are available on request, as are copies of the exams and their solutions.)

- *"Extremely engaging, very informational. An excellent teacher. He is absolutely 100% focused on the student's grasp of the material. He supports us completely and does everything he can to help us understand this. He's the best prof! This is the first time I've ever taken a math course that I love! I love math now and it's thanks to this professor."*
- *"One of the best professors I have ever had!!! Great sense of humour and an amazing ability to teach difficult material. It definitely made math fun and a lot easier. Professor is extremely flexible in regard to getting extra help and very receptive to student needs. Questions always encouraged in class with the attitude that no question is a stupid question. We need more great teachers like these!"*
- *"Stongest: Always making sure everyone knows how to do the material. Interest in the course..."*
- *"Good pace, didn't rush, catered to everyone's needs."*
- *"Job well done. He answered queries as they were asked, and ensured that everyone in the class understands material before moving on. Great sense of humour."*
- *"Excellent communication towards students and a great passion and high interest in mathematics."*
- *"Excellent attitude and sense of humour."*
- *"He made the class more interesting by using everyday analogies and making jokes too..."*
- *"He makes math fun. Very interesting teaching approach."*
- *"Energetic, knowledgeable."*
- *"Bonus points given out during lectures whenever the professor made small mistakes served as an incentive to pay more attention in class, as well as understanding the material during lectures. A unique approach to explaining course material, which made hard questions appear to be easy to solve."*
- *"Strongest: Very informative & highly interested in course material & was highly accessible for help & encouraged comments/questions & good communication of material & highly responsive to students. Weakest: nothing. Keep up the great work prof!*

Complex Variables at Simon Fraser University 8/01–12/01

The students gave me an overall "grade" of 2.98. Following are student comments copied from the evaluation forms:

- *"I loved this course. Nicolas' test writing is some of the best I've seen for a while since he tends to focus on concepts above all. He was always available to help and showed great concern that people understood. I'm sure the amount of time he has put into this course far exceeds the requirement. Most importantly, he is very clear, and has made me feel challenged by the material."*
- *"Dr. Robidoux was always willing to help me outside of his office hours and did a great job of explaining the more difficult concepts to me. He also listened to my ideas and allowed me to be a valuable participant in class."*
- *"Dr. Robidoux was really helpful and open to suggestions. His notes are great, but more numerical examples would've been helpful."*
- *"Quite concerned about student difficulties, comprehensive on homeworks, exams, etc. Prepares very well for the lectures, and has a very high interest on the subject. I appreciate the effort to bring the class moral up with jokes when needed..."*

- *"Tremendous effort in teaching this class! Your lectures tended to be quite theoretical whereas your assignments more applied. Perhaps doing more examples in class will help balance the content you taught."*
- *"Really enjoyed your class, don't lose your personality... it's a rare phenomenon in math."*
- *"Very fun class, never too dull to stay awake."*
- *"Strongest: Good assignments, fair midterms."*
- *"Assignments and midterms keys are detailed and accurate."*
- *"Excellent teaching, just a bad course."*
- *"Fun classes, but it would help if pinpoint what is going to be on exams, some times different."*
- *"The instructor was enthousiastic. I really enjoyed, but I suggest the instructor to prepare for lectures earlier so there's less typos on slides."*
- *"He listened to the students & made an effort to help us understand the material. Sometimes he wasn't prepared, but overall he was good..."*

Professional activities

- Referee for ***Applied Numerical Mathematics***, ***Numerical Algorithms***, ***SIAM Journal on Numerical Analysis***, and ***SIAM Journal on Scientific Computing***.
- Scientific committee of the NSF (US National Science Foundation) funded ***Mimetic Discretizations of Continuum Mechanics*** workshop (San Diego CA, July 2003). Home page: `http://www.sci.sdsu.edu/compscims/...MIMETIC/index.htm`.
- Author (with Stanly Steinberg) and webmaster of a bibliography on mimetic methods. Home page: `http://www.cs.laurentian.ca/robidoux/...mimetic/mimetic.html`.
- Organizer (with Bob Russell) of the Center for Scientific Computing seminar series (Burnaby BC, September 2002–May 2003).
- Local arrangements committees of ***IMACS-ACA 97*** (Conference on Applications of Computer Algebra) (co-chair), ***ISSAC 97*** (International Symposium on Symbolic and Algebraic Computation), ***PASCO 97*** (Second International Symposium on Parallel Symbolic Computation), and a ***Workshop on Parallel Quantifier Elimination*** (Maui HI, July 1997).
- Author of an article about intellectual property issues for academic software developers which appeared in ***Concerns of Young Mathematicians*** 5, No. 11, April 1997. A summary of this article appeared in ***NA Digest*** 97, No. 17, April 1997.
- Student coordinator of a successful $10000 grant proposal to equip the University of New Mexico Mathematics and Statistics Graduate Computing Laboratory (Albuquerque NM, 1994).

Selected fellowships, scholarships, grants, prizes, travel funding, etc.

Organization	Name	Type	Dates	Total value
CIMMS, Caltech		workshop travel	10/03	$1800
CIMMS, Caltech		speaker travel	7/03	$275
U.S. National Science Foundation		workshop travel	7/03	$1800
Centre de recherches mathématiques		conference travel	5/03	$500
Dept of Mathematics, Simon Fraser U.	Postdoctoral Fellowship		5/01–8/03	$81000*
WebCT Faculty Forum, U. New Mexico		speaker travel	2/02	$400
Dept of Mathematics, U. Auckland		speaker travel	12/97, 10/98 and 8/99	$400
Royal Society of New Zealand	Marsden Postdoc. Fell.		9/97–8/99	$82000*
Numerical Algorithms Group Inc.	NAG Student Travel Award	conference travel	7/97	$1150
U. New Mexico	UNM RPT Grant	research travel	6/96–7/96	$2900
Albuquerque High Performance Computing Center, U. New Mexico	AHPCC Research Assistantship		1/97–8/97 and 9/94–9/96	$63000*
DIMACS, Rutgers U. (NSF)		workshop travel	7/94	$1350
Los Alamos National Laboratory	Graduate Research Assist.		11/92–9/94	$70000*
Dept of Math. & Stat., U. New Mexico	Teaching Assistantship		8/91–8/92	$14000*
Dept of Mathematics and Statistics, U. Wisconsin–Madison	Teaching Assistantship		1/88–5/88 and 8/85–5/87	$65000*
NSERC	NSERC USRA	summer R. A.	5/84–8/84	$3500*
NSERC	NSERC PGS A	scholarship (declined)	84	$19000*
FCAR	Bourse de maîtrise FCAR	scholarship (declined)	84	$11000*
Association mathématique du Québec	14ème prix, Concours de l'AMQ	CEGEP level math. contest (camp declined)	81	$15 + $500*
Association canadienne des physiciens	14ème prix, Concours de Physique du Québec	CEGEP level physics contest	81	$35

*: Amounts, converted to canadian dollars, include travel funds and other benefits.