

# Research Report

Emmanuel Lorin de la Grandmaison

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# 1 Research Topics

List of research topics: partial differential equations, numerical analysis, mathematical and computational physics.

- Microlocal and pseudodifferential analysis of domain decomposition methods for quantum wave linear and nonlinear equations. Analysis of Schwarz Waveform Relaxation methods: [A34], [A39], [A40], [A41], [A43], [A44], [A46], [A48].
- Microlocal analysis-based Absorbing Boundary Conditions for relativistic and nonrelativistic wave equations (Schrödinger, Dirac): [A33], [A13], [A42].
- Mathematical relativistic quantum physics and Weyl-Titchmarsh-Kodaira theory : pair-production, Schwinger's effect, Dirac equations: [A27], [A26], [A24], [A22]. Gauge theory: [29].
- Mathematical modeling in multiscale nonperturbative nonlinear optics, filamentation-laser and attosecond science, Maxwell-Schrödinger and Liouville equations, applied spectral theory: [A38], [A36], [E2], [A35], [A28], [A21], [A23], [A17], [A11], [A9], [A7].
- High order and parallel methods in quantum physics for Dirac, Schrödinger equations: Galerkin methods, high order B-splines, balanced-operators, High order splitting methods. [A37], [A31], [A20], [A19], [A18], [A45].
- Nonconservative hyperbolic systems of conservation laws, LeFloch-DalMaso-Murat path-theory: [A25], [A15].
- Derivation and analysis of non-diffusive finite volume methods for hyperbolic systems of conservation laws: reservoir technique. [A12], [A10], [A1].
- High performance Computing in computational physics, MPI/C++, Distributed parallel computing. [A37], [P10], [P7], [A9]

## 2 Research Contributions

### 2.1 Articles

- [A45] E. Lorin. Computational performance of simple and efficient sequential and parallel Dirac equation solvers. Accepted in *Comput. Phys. Comm.*, **2017**.
- [A44] X. Antoine, E. Lorin. Two-dimensional asymptotic estimates of the convergence of SWR-DDM for stationary classical and quantum waves. Revision *ESAIM: Numerical Analysis and Mathematical Modeling (M2AN)*, **2017**.
- [A43] X. Antoine, E. Lorin. An analysis of Schwarz waveform relaxation domain decomposition methods for the imaginary-time linear Schrödinger and Gross-Pitaevskii equations. Accepted *Numerische Mathematik*, **2017**.

- [A42] X. Antoine, E. Lorin, Q. Tang. A Friendly Review to Absorbing Boundary Conditions and Perfectly Matched Layers for Classical and Relativistic Quantum Wave Equations. *Molecular Physics.*, To appear **2017**.
- [A41] E. Lorin, X. Yang. Frozen Gaussian Approximation-Based Two-level Methods for Multi-frequency Time Dependent Schroedinger Equation. *Comput. Phys. Comm.*, **207**, **2016**.
- [A40] E. Lorin, X. Yang, X. Antoine. Frozen Gaussian Approximation based Domain decomposition methods for the linear Schrödinger equation beyond the semi-classical regime. *J. Comput. Phys.*, **315**, **2016**.
- [A39] X. Antoine, E. Lorin. Lagrange-Schwarz Waveform Relaxation Domain Decomposition Methods for Linear and Nonlinear Quantum Wave Problems. *Applied Math. Lett.*, **57**, **2016**.
- [A38] M. Lytova, E. Lorin, A. Bandrauk. Propagation of intense and short circularly polarized pulses in molecule gas. From multiphoton ionization to nonlinear macroscopic effects. *Phys. Rev. A*, **94**, 013421, **2016**.
- [A37] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. Galerkin method for unsplit 3-D Dirac equation using atomically/kinetically balanced B-spline basis. *J. Comput. Phys.*, **307**, **2016**.
- [A36] Book chapter for *Mathematical methods and models in Laser Filamentation. Springer, CRM Series in Mathematical Physics.*, **2015**.
- [A35] E. Lorin, M. Lytova, A. Memarian, A. Bandrauk. Nonperturbative nonlinear optics models. *J. Phys. A. Math & Theo. Phys.*, **10**(48), **2015**.
- [A34] X. Antoine, E. Lorin, A. Bandrauk. Domain Decomposition Methods and High-Order Absorbing Boundary Conditions for the Numerical Simulation of the Time Dependent Schrödinger Equation with Ionization and Recombination by Intense Electric Field. *J. of Sc. Comput.*, **64**(3), **2015**.
- [A33] X. Antoine, E. Lorin, A. Bandrauk. Absorbing boundary conditions for quantum and relativistic mechanics equations. A microlocal approach. *J. Comput. Phys.*, **277**, **2014**.
- [A32] E. Lorin, A. Cournoyer. Stochastic optimization of laser temporal shape for ablation. *Applied Mathematics Research eXpress (Oxford)*, **2**, **2014**.
- [A31] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. A Split-Step Numerical Method for the TDDE in 3-d Axisymmetric Geometries. *J. Comput. Phys.*, **272**, **2014**.

- [A30] D. Chakraborty, J.-H. Jung, E. Lorin. Efficient determination of critical parameters of nonlinear Schrödinger equation with pointlike potential using generalized polynomial chaos methods. *Applied Num. Math.*, **72**, **2013**.
- [A29] A. Bandrauk, F. Fillion, E. Lorin. Gauge theory for laser-molecule interaction. Invited review paper. *J. of Phys B.*, **46**(153001), **2013**.
- [A28] C. Köhler, R. Guichard, E. Lorin, A. Bandrauk, S. Skupin. Saturation of nonlinear refractive index. *Phys. Rev. A*, **87**(4), **2013**.
- [A27] F. Fillion, E. Lorin, A. Bandrauk. Enhanced Schwinger's pair production in many-center systems. *J. of Phys B.*, **46**(175002), **2013**.
- [A26] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. Resonantly enhanced pair production in a simple model. *Phys. Rev. Lett.*, **110**(1), **2013**.
- [A25] N. Chalmers, E. Lorin. On the numerical approximation of one-dimensional nonconservative hyperbolic systems. Accepted to a special issue on computational hyperbolic systems, *J. of Comput. Sc.*, **4**(1-2), **2013**.
- [A24] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. Relativistic Stark resonances in a simple exactly soluble model for diatomic molecule. *J. Phys. A: Math. Theor.*, **45**(21), **2012**.
- [A23] E. Lorin, A. Bandrauk. Fast and accurate numerical computation of a micro-macro nonlinear optics model for intense and short laser pulses. *J. of Comput. Sc.*, **3**(3), **2012**.
- [A22] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. Pair production from counterpropagating lasers. *Phys. Rev. A.*, **86**(3), **2012**.
- [A21] E. Lorin, E. Zaoui, S. Chelkowski and A.D. Bandrauk. Maxwell-Schrödinger-Plasma model for laser-molecule interactions: towards quantum filamentation with intense ultrashort pulses. *Physica D*, vol. **241**(12), pp1059-1071, **2012**.
- [A20] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. Numerical solution of the time-dependent Dirac equation in Coordinate Space without Fermion Doubling. *Comput. Phys Comm.*, vol. **183**(7), pp1402-1415, **2012**.
- [A19] F. Fillion-Gourdeau, E. Lorin, A. Bandrauk. Comparison of two methods using B-splines to compute the relativistic spectrum of diatomic molecules without spurious states. *Phys. Rev. A*, **85**(2), **2012**.
- [A18] E. Lorin, A.D. Bandrauk. A simple and accurate mixed  $P_0$ - $Q_1$  solver for Maxwell-Dirac equations. *Nonlin. Anal. B: Real World Applications*, vol. **12**(1), pp190-202, **2011**.
- [A17] E. Lorin, S. Chelkowski and A.D. Bandrauk. The WASP model: A micro-macro system of Wave-Schrödinger-Plasma equations for filamentation. *Comm. in Comput. Phys.*, vol. **9**(2), pp406-440, **2011**.

- [A16] E. Lorin, A.D. Bandrauk. Multiresolution scheme for time dependent Schrödinger equation, *Comput. Phys. Comm.*, vol. **181**(3), pp626-638, **2010**.
- [A15] N. Chalmers, E. Lorin. Approximation of nonconservative hyperbolic systems based on different shock curve definitions. *C. Applied Math. Q.*, vol. **17**(3), pp447-486, **2009**.
- [A14] S. Labbé, E. Lorin. On the reservoir technique convergence for nonlinear hyperbolic conservation laws. *J. of Math. Anal. Appl.*, vol. **356**(2), pp477-497, **2009**.
- [A13] E. Lorin, S. Chelkowski and A.D. Bandrauk. Mathematical modeling of boundary conditions for laser-molecule TDSE and some aspects of their numerical computation. 1-D case. *Num. Meth. for Partial Differential Equations*, vol. **25**(1), pp110-136, **2009**.
- [A12] F. Alouges, F. de Vuyst, G. LeCoq, E. Lorin. The reservoir technique: a way to make usual first order flux difference splitting methods zero or low-diffusive. *Eur. J. Mech. B Fluids*, vol. **27**(6), pp643-664, **2008**.
- [A11] E. Lorin, S. Chelkowski and A.D. Bandrauk. Attosecond pulse generation from aligned molecules - Dynamics and propagation in  $H_2^+$ . *New J. of Physics*, vol. **10**(2), **2008**.
- [A10] F. Alouges, G. LeCoq and E. Lorin. Two-dimensional extension of the reservoir technique. *J. of Sci. Comput.*, **31**(3), pp419-458, **2007**.
- [A9] E. Lorin, S. Chelkowski and A.D. Bandrauk. Numerical Maxwell-Schrödinger model for laser-molecule interaction and propagation. *Comput. Phys. Comm.*, vol. **177**(12), pp908-932, **2007**.
- [A8] E. Lorin, A. Ben Haj Ali and A. Soulaïmani. Accurate positivity preserving finite element - finite volume scheme for the Spalart-Allmaras turbulence model. *Comput. Methods Appl. Mech. Engrg.*(CMAME), vol. **196**(17-20), pp2097-2116, **2007**.
- [A7] E. Lorin, S. Chelkowski and A.D. Bandrauk. A Maxwell-Schrödinger model for non perturbative laser-molecule interaction and some methods of numerical computation. *CRM Proceedings and Notes (A.M.S.)*, vol. **41**, pp161-182, **2007**.
- [A6] E. Lorin, S. Gowda, Y. Saad, M. Tiago and J.R. Chelikowsky. A fast Fourier-based computation of the coupling matrix in time dependent density functional theory. *Comput. Phys. Comm.*, **167**(1), pp7-22, **2005**.
- [A5] E. Lorin, G. Zérah. A recursion method for the electronic structure calculation. *Comput. Phys. Comm.*, **158**(1), pp39-46, **2004**.
- [A4] E. Lorin. Existence of viscous profile for the compressible Navier-Stokes equations. *Appl. Anal.*, **82**(7), pp645-654, **2003**.
- [A3] P. Godillon, E. Lorin. A Lax shock profile satisfying a sufficient condition of spectral instability. *J. Math. Anal. Appl.*, **282**(1), pp12-24, **2003**.

- [A2] E. Lorin. V. Seignole. Convection systems with stiff source terms. *Math. Models Methods Appl. Sci.*, **13**(7), pp971-1018, **2003**.
- [A1] F. Alouges, F. de Vuyst, G. LeCoq, E. Lorin. Un procédé de réduction de la diffusion numérique pour les schémas à différence de flux d'ordre un pour les systèmes hyperboliques. *C. R. Math. Acad. Sci. Paris*, **335**(7), pp627-632, **2002**.

## 2.2 Submitted articles

- [A46] E. Lorin. Schwarz Waveform Relaxation Domain Decomposition Methodology for the  $N$ -body Time-Independent and Time-Dependent Schrödinger Equation. Submitted.
- [A47] F. Fillion-Gourdeau, E. Lorin. Simple digital quantum algorithm for some first order hyperbolic systems. Submitted.
- [A48] X. Antoine, E. Lorin. Multilevel preconditioning techniques for Schwarz waveform relaxation domain decomposition methods for real- and imaginary-time nonlinear Schroedinger equations. Submitted.

## 2.3 Other refereed contributions

- [P13] F. Fillion-Gourdeau, E. Lorin. Avoiding the coordinate singularity problem in the numerical solution of the Dirac equation in cylindrical coordinates. *Springer Proceedings in Mathematics & Statistics* **117**, **2015**.
- [P12] A. Cournoyer, D. Gay, P. Turbis, E. Lorin, Y. Taillon. Maximizing laser ablation efficiency of silicon through optimization of the temporal pulse shape. *The International Society for Optical Engineering (SPIE)* **414**(1), **2014**.
- [P11] F. Fillion-Gourdeau, E. Lorin and A. D. Bandrauk. New mechanism for the generation of electron-positron pairs in Laser-Matter Interaction: Resonantly Enhanced Pair Production in a molecular system. *Journal of Physics: Conference Series (JPCS)* **414**(1), **2013**.
- [P10] F. Fillion-Gourdeau, E. Lorin and A. D. Bandrauk. Relativistic Ground State of diatomic molecules from the numerical solution of the Dirac equation on parallel computers. Proceedings of the 25<sup>th</sup> *High Performance Computing Symposium*, Montréal. *Journal of Physics: Conference Series (JPCS)*: Conference Series Volume 341 conference 1, **2012**.
- [P9] F. Fillion-Gourdeau, E. Lorin and A. D. Bandrauk. Numerical Solution of the Dirac Equation and Applications in Laser-Matter Interaction. Proceedings of the *The International Conference on Applied Mathematics, Modeling and Computational Science*. AIP Conf. Proc. 1368, pp. 13-16; doi:10.1063/1.3663448, **2011**.

- [P8] E. Lorin, A.D. Bandrauk. A Maxwell-Schrödinger-plasma model and computing aspects for intense, high frequency and ultrashort laser-gas interaction. Proceedings of the 23<sup>th</sup> *High Performance Computing Symposium, Lecture Notes in Computer Science*, Springer, Kingston, Lecture Notes, pp70–75, 5976, **2010**.
- [P7] E. Lorin, A.D. Bandrauk. Efficient parallel computing for laser-gas quantum interaction and propagation. Proceedings of the 22<sup>th</sup> *High Performance Computing Symposium*, IEEE, pp4-8, Québec City, June **2008**.
- [P6] E. Lorin, S. Chelkowski and A.D. Bandrauk. Propagation effects on attosecond pulse generation. Proceedings of the Society of Photographic Instrumentation Engineers, *SPIE*, vol. 6733, Minsk, May **2007**.
- [P5] E. Lorin, A. Ben Haj Ali and A. Soulaïmani. Accurate positive scheme for the Spalart-Allmaras turbulence model. Application to aerodynamics. Proceedings of the 36<sup>th</sup> *AIAA Fluid Dynamics Conference and Exhibit 2006*. San Francisco, July **2006**.
- [P4] F. Alouges and G. LeCoq and E. Lorin. Extension of the reservoir technique to multi-dimensional linear equations. Proceedings of the *Fourth International Symposium on Finite Volume for Complex Applications*. Marrakech. Hermès Ed., pp413-422, July **2005**.
- [P3] E. Lorin, A. Ben Haj Ali and A. Soulaïmani. Positive scheme for the Spalart-Allmaras turbulence model. Proceedings of *ECCOMAS 2004*, European Comm. on Comput. Meth. in Appl. Science. Finland, July **2004**.
- [P2] G. Chabrier, E. Lorin, A. Windoerfored and G. Zérah. Orbital free simulations for warm dense matter physics. Proceedings of the *Fifth International Symposium of behavior of dense medias under high pressures*, Saint-Malo, May **2003**.
- [P1] F. Alouges, F. de Vuyst, G. LeCoq and E. Lorin. Reservoir scheme for the systems of conservation laws. Proceedings of the *Third International Symposium on Finite Volume for Complex Applications*, Porquerolles, Hermès Ed. pp261-268, June **2002**.

## 2.4 Research reports

- [R5] E. Lorin, S. Gowda, Y. Saad, M. Tiago, J.R. Chelikowsky. Technical report University of Minnesota Supercomputing Institute Research Report **UMSI 2005/96, 2005**.
- [R4] *Inclusion de Numerical Platon dans OVAP*. Technical report Commissariat à l’Energie Atomique (France). **CEA/Saclay/DM2S/SFME/LGLS/RT/01-013A, 2001**.
- [R3] *Implicitation en flux des schémas de flux*. Technical report Commissariat à l’Energie Atomique (France). **CEA/Saclay/DM2S/SFME/LGLS/RT/01-010, 2001**.
- [R1-R2] *Trends in Numerical & Physical Modeling for Industrial Multiphase Flows*, Corse, **2001, 2005**.

## 2.5 Editorial tasks

- [E3] Member of Editorial Board. *Advances in Mathematical Physics* (**2015**-to date)
- [E2] Editor (with A. Bandrauk, J. Moloney): Book on "Mathematical methods and models in Laser Filamentation" (~10 chapters). *Springer, CRM Series.*, **2016**.
- [E1] Edition of a special issue of the *Canadian Applied Mathematics Quarterly*, celebrating the 30th Anniversary of the CAIMS meeting, **2010/2011**.

## 2.6 Long term funded invitations (Since 2010)

- Invited Researcher at KITP (Kavli Institute for Theoretical Physics) at University of California at Santa Barbara (2 weeks), April **2015**.
- Invited Professor in the Mathematics department at the University of California at Santa Barbara (1 month), Jan. **2015**.
- Invited Researcher at the KITP at University of California at Santa Barbara (1 month), Sept. **2014**.
- Invited Professor in the Applied Mathematics department, Université de Grenoble, France (2 months), May-June **2011**.

## 2.7 Software

Some software that I have (co-)developed.

- [S0] Development of a parallel 2d/3d (MPI,C++) Time Independent and Dependent Dirac solver (**2013-2016**). Atomic balance, Finite element method with B-splines basis. ([www.ccs.usherbrooke.ca/mammoth](http://www.ccs.usherbrooke.ca/mammoth)).
- [S1] Development of a parallel 2d (MPI,C++) Maxwell-Dirac code (**2010-2012**) for relativistic laser-matter interactions and propagation ([www.ccs.usherbrooke.ca/mammoth](http://www.ccs.usherbrooke.ca/mammoth)).
- [S2] Development of a 3d-parallel (MPI,C++) Maxwell-Schrödinger-Plasma code (**2005-2014**) for laser-matter interactions and propagation ([www.ccs.usherbrooke.ca/mammoth](http://www.ccs.usherbrooke.ca/mammoth)).
- [S3] Development of a C++ parallel quantum chemistry simulation code at the University of Minnesota (**2002-2003**). The code is installed at the Minnesota Supercomputing Institute and computes optical spectra of molecules.
- [S4] Implementation of new numerical methods for electronic structure calculation in Abinit ([www.abinit.org](http://www.abinit.org)), (**2002**). We proposed a new  $\mathcal{O}(N)$  method particularly efficient at high temperatures and for big molecules, instead of usual  $\mathcal{O}(N^3)$  methods.



[S5] Participation in the development of the Oriented-Object code  $\text{TRIO}_U$  (**2001**), at the French Atomic Energy Center (CEA). I implanted a new 3d numerical implicit finite volume scheme for simulation of two phase flows inside the core of power stations.

## 2.8 Industrial Projects

- MITACS cluster-project (*granted*). Name of the company: **general fusion** (British Columbia). Modeling and computations for MTF-based nuclear reactor (HQP: 2 PDF, 1PhD), \$133,000 **2010-12**.
- Name of the company: **INO** (Québec). Optimization of laser-metal ablation. (HQP: 1 PDF), \$25,000, **2013**.

## 2.9 Seminars & Workshops since Aug. 2005 (Arrival to Canada)

- Workshop *High-dimensional partial differential equations in science and engineering*, CRM, Montréal, Aug. **2005**.
- Scientific Computing Days at the CRM, Montréal, Feb. **2006**.
- Seminar of Applied Mathematics at Carleton University, Ottawa, Feb. **2006**.
- Seminar of Applied Mathematics at Université de Montréal, Montréal, April **2006**.
- Seminar of Theoretical Chemistry, University of Sherbrooke, Sherbrooke, April **2006**.
- *36<sup>th</sup> AIAA Fluid Dynamics Conference and Exhibit*, San Fransisco, June **2006**.
- *1<sup>st</sup> International Symposium on lasers*. Laval University, Québec, Sept. **2006**.
- Seminar of Applied Mathematics at Ecole Polytechnique de Montréal, Oct. **2006**.
- Seminar of Applied Mathematics at Concordia University, Montréal, Dec. **2006**.
- Workshop on ultrafast lasers, Laval University, March **2007**.
- Applied Mathematics seminar, University of Ontario Institute of Technology, March **2007**.
- Mathematics seminar, University of Sherbrooke, May **2007**.
- Mathematics seminar, Laval University, June **2007**.
- *76<sup>th</sup> ACFAS conference*, Québec City, May **2008**.
- *2<sup>nd</sup> Canada-France Congress of Mathematics*, Montréal, June **2008**.

- *22<sup>nd</sup> Annual International Symposium on High Performance Computing Systems and Applications* (HPCS 2008), Québec City, Canada. IEEE Computer Society, June **2008**.
- *5<sup>th</sup> European Congress on Computational Methods in Applied Sciences and Engineering* (ECCOMAS 2008), Venise, July **2008**.
- Seminar of Applied Mathematics, Ottawa University, Nov. **2008**.
- CMS Winter Meeting: Session Applied PDEs, Ottawa, Dec. **2008**.
- CMS Winter Meeting: Session Numerical Analysis, Ottawa, Dec. **2008**.
- Seminar Mathematics, Carleton University, Dec. **2008**.
- Seminar Physics & Chemistry, Trent University, March **2009**.
- Workshop on Computational Hyperbolic Systems, Fields Institute, April **2009**.
- CAIMS Meeting 2009, University of Western Ontario, June **2009**.
- Workshop on Quantum Dynamic Imaging, CRM, Nov. **2009**.
- Seminar in Applied Mathematics, McGill, March **2010**.
- Physics Seminar, Commissariat à l’Energie Atomique (France), June **2011**.
- Applied Mathematics seminar, Ecole Normale Supérieure de Cachan (France), June **2011**.
- Applied Mathematics seminar, Université de Chambéry (France), June **2011**.
- Applied Mathematics, Modeling and Computational Science Conference, Session “Computational Methods for Hyperbolic Problems”, Waterloo, July **2011**.
- Applied Mathematics, Modeling and Computational Science Conference, Session “Computational Physics and Chemistry”, Waterloo, July **2011**.
- *4<sup>th</sup> Workshop on Industrial Mathematics*. Coordinator for INO project, Montréal, Aug. **2011**.
- Applied Mathematics seminar, State University of New York at Buffalo, Feb. **2012**
- Canadian Mathematics Society Meeting, Montréal. Session: applied mathematics, Dec. **2012**.
- Canadian Mathematics Society Meeting, Montréal. Session: quantum imaging, Dec. **2012**.

- Canadian Applied and Industrial Mathematics Society Meeting, Québec City. June **2013**.
- Applied Mathematics, Modeling and Computational Science Conference, Session “Computational Methods for Hyperbolic Problems”, Waterloo, Aug. **2013**.
- International Workshop on mathematical methods and models in laser-filamentation, Montréal, March **2014**.
- Applied Mathematics seminar, University of Ontario Institute of Technology, April **2014**.
- KITP at University of California Santa Barbara, Aug. **2014**.
- University of Ottawa, Physics Seminar, January **2015**.
- Applied Mathematics seminar, University of California Santa Barbara, Jan. **2015** (2 talks).
- Applied Mathematics, Modeling and Computational Science Conference, Session “Numerical Analysis”, Waterloo, Aug. **2015**.
- CRM Networking Industrial Workshops - Photonics, Centre de Recherches Mathématiques, Montréal, Sept. **2015**.
- Workshop on Math.&Comput. Methods in Quantum Chemistry, Fields Institute, Feb. **2016**.
- Symposium Molecules & Laser Fields, Orford, May **2016**.
- AIMS-2016, Orlando, June **2016**.
- KI-NET conference, University of California Santa Barbara, Nov. **2016**.

### 3 Other Evidence of Impact and Contributions

#### Co-organizer of Conferences and Workshops

- Annual Congress of the French Society of Applied and Industrial Mathematics SMAI2005, France, June **2005**.
- Fourth Montréal Scientific Computing Days, Montréal, April **2007**.
- Durham Regional Youth Science Foundation Science Fair (chair), Oshawa, April **2008**.
- Special Session *Numerical Analysis for Hyperbolic Systems of Conservation Laws* at Canada-France Congress of Mathematics (14 invited speakers), Montréal, June **2008**.

- Durham Regional Youth Science Foundation Science Fair (chair), Oshawa, April **2009**.
- SHARCNET Research Day 2009, Waterloo University, May **2009**.
- Seventh Montréal Scientific Computing Days, Montréal, May **2013**.
- Fields Workshop on Numerical Methods for Fluid Dynamics, Aug. **2013**.
- International Workshop on Mathematical Modeling and Analysis of Filamentation (Centre de Recherche Mathématiques, Montréal), March **2014**.
- Eighth Montréal Scientific Computing Days, Montréal, May **2015**.
- Program committee member: Conference on Lasers and Electro-Optics/Europe and the European Quantum Electronics Conference (CLEO 2015), June **2015**.
- Program committee member: Conference on Lasers and Electro-Optics/Europe and the European Quantum Electronics Conference (CLEO 2017), June **2017**.
- Banff/CMO. From Quantum Dynamics to Quantum Information Theory, August **2017**.
- DDM-25: International Conference on Domain Decomposition Methods, St-John, Canada, **July 2018**.

### Referee tasks

- Referee for: *Ann. Math. Québec, Appl. Math. and Comput., Appl. Num. Math., Comput. Methods Appl. Mech. Engrg., J. of Comp. and Applied Math., Comput. Phys. Comm., Eur. J. Mech. B Fluids, Comm. Partial Differential Equations, J. of the Optical Soc. of America B, Proceedings of Royal Society A, J. Phys. B, Physica D, Chemical Physics, Appl. Math. Lett., International Journal of Computer Mathematics, J. Comput. Phys., Optics Lett.*, International conferences.
- Selection Committee Member: Fonds de Recherche du Québec - Nature et Technologies (FQRNT), **2012/2015**. Math. Committee B2 (Scholarship for MSc/PhD).
- Reviewer for NSERC (Collaborative Research and Development program), **2013**.
- Review for The Mathematics of Information Technology and Complex Systems (MITACS), **2015**.
- Review for US-Department of Energy (DOE), **2016**.
- Reviewer for NSERC (I2I program), **2017**.

### Defense committee: Reviewer

- Master thesis defense of M. McLeod at Ottawa University. Mixed finite element methods for Stefan-Maxwell equations, September 2013.

- Master thesis defense of L. Charette at Ottawa University. Lattice symmetry breaking perturbation for spiral waves, June 2013.
- Master thesis defense of J. Pellerin at Ecole Polytechnique de Montréal. Un potentiel d'interaction pour les lois de conservation non classiques, March 2011.
- PhD thesis defense of A. Ben Haj Ali at Ecole de Technologie Supérieure (University of Québec). High performance computing in aeroelasticity and 3d turbulent flows, Aug. 2008.
- Master thesis defense of C.Y. Liu at Ecole Polytechnique de Montréal (University of Montréal). Adjoint-based error estimation for the front-tracking method, Aug. 2007.
- PhD thesis defense of M. Rioux at Ottawa University. Numerical computations of action potentials for the heart-torso coupling problem. Nov. 2011.
- PhD thesis defense of D. MacLaren at Ottawa University. Sequential and localized implicit wavelet-based solvers for stiff partial differential equations. Feb. 2012.
- PhD thesis defense of H. Beauchesne at Carleton University. Possible avenues in supersymmetry and naturalness. August 2016.
- PhD thesis defense of E. Kardashi at University of Montréal. Stabilité des chocs non classiques pour des lois de conservation non convexes. April 2017.
- MSc thesis defense of X. Chen at Carleton University. Cooperative Linear-Quadratic Mean Field Game Control and Hamiltonian Matrix Analysis. April 2017.
- PhD thesis defense of J. Bramburger at Ottawa University. On the existence and stability of rotating wave solutions to lattice dynamical systems. June 2017.
- PhD thesis defense of K. Choon Loy at Ottawa University. Semi-implicit schemes incompressible Navier-Stokes equations. June 2017.

### Research Grants and Fellowship

- NSERC Discovery Grant : \$15,000/year, GSC Pure and Applied Maths B 337, 2013-2018.
- Co-applicant (with 6 others) of a granted Research Tools Instruments (NSERC), \$46,068, (2012).
- Fields Institute Funds for Post-Doc. Fellowship (\$12,500) (2011-2012).
- CRM/ISM Funds to hire a Post-Doc. Fellowship (\$7,500 shared with Prof. A. Bandyopadhyay), (2012)

- Invited Professor (May-June 2011). Applied Mathematics Department at Université Joseph Fourier - Grenoble I (France). €7,500.
- P.I. of a *granted* MITACS Project (**cluster**): 2 post-docs, 1 PhD, Travel Subsidy Award. Collaboration with the company *General Fusion* (Vancouver), and Prof. M. Laforest (*Ecole Polytechnique de Montréal*), \$133,000 over 2 years, 2010/2012.
- Research Grant as SHARCNET siteleader: \$8,000 / year, 2008/09.
- CRM/ISM Funds to hire a Post-Doc. Fellowship (\$20,000 shared with Prof. A. Bandrauk).
- Participation (P.I. in Ontario) to a *granted* \$2,377,000 CFI/NFI project on Dynamic Imaging and Visualization: iMOVI, 2009 (Participation withdrawn due conflict with Compute Canada policy).
- CRM-ISM Postdoctoral Fellowship (Montréal), 2005-2007.
- AUF (Agence universitaire de la Francophonie) *Granted* project on the Shallow Water Equations (collaboration Canada/France/Maroc): €20,000, 2006.
- Supercomputing Institute Research Scholarship (Minnesota Supercomputing Institute, University of Minnesota), 2002.
- Research Contract, Commissariat à l’Energie Atomique, Service de Mécanique de Fluides, Saclay 2000.

### Current Students

- M. Lytova, PhD.
- D. Charles, Honours.

### Past Students

- T. Hof McNeil, MSc.
- F. Fillion-Gourdeau, Post-Doc., co-supervision with A. Bandrauk.
- F. Hou, Research Assistant.
- F. Albeshree, MSc in Applied Maths (Course).
- A. Capuano, Honours Student (Thesis not defended).
- A Memarian, Honours Student. Defense Jan. 2014.
- J. Sater, MSc in Applied Maths (Thesis). Defense Oct. 2012

- K. Lyon, Summer Student (2012).
- R. Arteaga, Research Assistant/ Honours Student (2011-2012).
- H. Rizq, MSc in Applied Maths (2014).
- M. Kazemina, PhD Student (registred at Ecole Polytechnique de Montréal), co-supervision with Prof. M. Laforest (2010-2012).
- P. Turbis, Post-Doc., co-supervision with Prof. M. Laforest (2011-2012).
- X. Lavocat-Dubuis, Post-Doc. (2010-2011)
- E. Zaoui, CRM/ISM Post-Doc., partially funded (50%) by the *Centre de Recherches Mathématiques* (2009-2010).
- N. Chalmers, Honours/MSc Student then Research Assistant, *Carleton University* (2010).
- +3 Honours students at UOIT (2008,2009).
- +3 Master students, Université Paris-Sud-Orsay (2002-2005).