

Ionut DANAILA

Full Professor in Applied Mathematics

Research: Scientific Computing, Numerical Analysis

- *Numerical analysis, implementation in 2D/3D codes of:*
 - **Numerical methods for fluid flow simulation:**
Navier-Stokes-Boussinesq equations.
High-order finite difference schemes, finite elements, etc.
Applications: vortex flows, jets, internal combustion engines, phase-change materials.
 - **Numerical methods for superfluid systems:**
Gross-Pitaevskii (Schrödinger) equations.
Finite differences, finite elements, spectral methods.
Minimization methods based on Sobolev gradients.
Applications: rotating Bose-Einstein condensates, Quantum turbulence.
- *Numerical analysis of Sobolev gradient methods.*
- *Mathematical models for vortex rings.*
- *Numerical algorithms for object-oriented languages.*
- *Evaluation of industrial codes.*

Research accomplishments

- Head of the project ANR QUTE-HPC (2019-2023).
Quantum Turbulence Exploration by HPC.
Group of 10 mathematicians and physicists.
 - Head of the project ANR BECASIM (2013-2017).
Bose-Einstein Condensate Advanced Simulation.
Group of 25 mathematicians (9 different laboratories).
 - Head of projects PEPS AMIES (2022-23, 2015-16).
Agency for Interaction of Mathematics with Industry and Society. Group of 10 researchers.
 - Head of the project PEPS CNRS (2010).
Work with FT-Orange (contract and PhD grant).
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- Invited speaker in 33 conferences/workshops.
 - Author of 5 books and 50 scientific articles, 77 presentations in conferences and 40 invited seminars.
 - Advisor of 9 PhD thesis, 9 Post-docs.

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- Director of the Laboratory LMRS since 2020.
Member (2012-16) of the Administration Board of
University Science Section (464 faculty, 3000 students).

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- Reviewer for SIAM Journals (SIAP, SINUM, SISC), J. of Computational Physics, Applied Numerical Mathematics, Physics of Fluids, J. Fluid Mechanics, etc.
 - Organizer of: Program at National University of Singapore (2019-20), Thematic program at the Fields Institute, Toronto (2016); International Workshops: Fields, 2019, Rouen, 2022, 2017; CIRM, 2016; FreeFem Days.

Collaborations with industry

- Initiator and Head of 6 research contracts with industry (France-Télécom-Orange, French Institute of Petroleum, Siemens Automotive, Continental Automotive).

Born: October 25, 1968, Married, two children.
Nationality: French.

✉ Université de Rouen Normandie
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Education and Work Experience

- 2020 **Director,**
➔ Department of Mathematics Raphaël Salem.
- 2011 **Full Professor in Applied Mathematics,**
➔ University of Rouen Normandy.
- 2008 **Habilitation in Applied Mathematics,**
Habilitation à diriger des recherches,
Disertation: *Vortices in fluids and superfluids: a numerical exploration,*
Université Pierre et Marie Curie, Paris.
- 1999 **Associate Professor** (1999-2011),
➔ Laboratoire Jacques-Louis Lions,
➔ Université Pierre et Marie Curie (Paris 6).
- 1998 **Post-doctoral Research Associate** (1998-1999)
➔ French Institute of Petroleum (IFP)
➔ research visit to CTR, Stanford University.
- 1997 **PhD in Fluid Mechanics** (1995-1997),
Disertation: *Numerical and theoretical study of jet flow instabilities,*
➔ Université Aix-Marseille II, France.
➔ Research performed at IRPHE, *with Honors.*
➔ **Research Associate** (PhD grant 1995-1997),
National Institute of Environment and Industrial Risks (INERIS)
- 1994 MSc (*DEA*) in Fluid Mechanics
➔ Ecole Nationale de l'Aéronautique et de l'Espace (Sup'Aéro), France.
rank 1/55, with Honors.
- 1993 Undergraduate studies
➔ Ecole Polytechnique, France,
Program for top European students, with Honors.
- 1993 Engineer in Aeronautics,
Undergraduate studies (1988-1993),
➔ Faculty of Aeronautical Engineering,
➔ University Politehnica, Bucharest, Romania,
rank 1/104, with Honors.

Recent invited conference talks

- ➡ (2023) *Workshop on Multiscale analysis and methods for PDEs: fluids and active matter dynamics*, National University of Singapore, Institute for Mathematical Sciences, Singapore.
- ➡ (2023) *Workshop on Mathematical Structures in Quantum Fluids*, Osaka City University, Japan (virtual).
- ➡ (2019) *Workshop on Modeling and Simulation for Quantum Condensation, Fluids and Information*, National University of Singapore, Institute for Mathematical Sciences.
- ➡ (2018) Conference on *Mathematical Models and Computation of Nonlinear Problems*, Tsinghua Sanya International Mathematics Forum, China.
- ➡ (2017) Conference *Focus Activity on Mathematical and Computational methods for Quantum and Kinetic Problems*, Beijing Computational Science Research Center.
- ➡ (2017) *27th Biennial Conference on Numerical Analysis*, Symposium *Numerical Modelling with Freefem++*, University of Strathclyde, Glasgow, UK.
- ➡ (2016) Conference on *Novel Developments in Evolutionary Partial Differential Equations*, King Abdullah University of Science and Technology, Saudi Arabia.
- ➡ (2016) Conference on *Nonlinear Partial Differential Equations and Scientific Computing*, Beijing Computational Science Center.
- ➡ (2015) Workshop on *Numerical Approximation of PDEs. Honoring the 60th birthday of Frédéric Hecht*, Malaga.
- ➡ (2015) Workshop on *High Performance and Parallel Computing for Materials Defects*, Singapore.
- ➡ (2014) Symposium on *Vortices and Wall Turbulence : Paolo Orlandi, a vortical and turbulent life*, Roma.
- ➡ (2014) 10th AIMS (American Institute of Mathematical Sciences) Conference, Madrid, Spain.
Session: *Advances in the numerical solution of nonlinear evolution equations*.
- ➡ (2013) The Symposium on *Frontiers of Fluid Dynamics-A Legacy: in honor of Prof. F. Hussain*, Puerto-Rico.
- ➡ (2013) Workshop on *Quantized vortices in superfluidity and superconductivity and related problems*, Wolfgang Pauli Institute (WPI), Vienna, Austria.
- ➡ (2013) SIAM Conference on Computational Science and Engineering, Boston, USA.
Session: *Numerical Methods and Analysis for Nonlinear Dispersive Equations and Applications*.
- ➡ (2013) Conference *Non-linear optical and atomic systems: deterministic and stochastic aspects*, CEMPI, Lille.

Books

- (to appear) I. Danaila, P. Joly, S. M. Kaber, M. Postel.
An Introduction to Scientific Computing. Fifteen computational projects solved with Matlab, **Springer**, 2023.
- ➡ I. Danaila, F. Kaplanski, S. S. Sazhin, *Vortex Ring Models*, **Springer**, 2021.
- ➡ I. Danaila, P. Joly, S. M. Kaber, M. Postel.
An Introduction to Scientific Computing. Twelve computational projects solved with Matlab, **Springer**, 2007.
- ➡ I. Danaila, P. Joly, S. M. Kaber, M. Postel.
Introduction au calcul scientifique par la pratique, Dunod, Collection Sciences Sup, 2005.
- ➡ I. Danaila, F. Hecht, O. Pironneau.
Simulation numérique en C++, Dunod, Collection Sciences Sup, 2003.

Recent publications

- ➡ I. Danaila and L. Danaila, *From Classical to Quantum Turbulence: Basic Concepts and Models*, p. 203-270, in *Models and Methods for Quantum Condensation and Fluids*, **World Scientific**, January 2023.
- ➡ Z. Zhang, I. Danaila, E. Lévêque and L. Danaila: *Higher-order statistics and intermittency of a two-fluid HVBK quantum turbulent flow*, **Journal of Fluid Mechanics**, **962**, p. A22(1-28), 2023.
- ➡ M. E. Brachet, G. Sadaka, Z. Zhang, V. Kalt and I. Danaila: *Coupling Navier-Stokes and Gross-Pitaevskii equations for the numerical simulation of two-fluid quantum flows*, **J. of Computational Physics**, **488**, p. 112193(1-17), 2023.
- ➡ V. Kalt, G. Sadaka, I. Danaila and F. Hecht: *Identification of vortices in quantum fluids: Finite element algorithms and programs*, **Computer Physics Communications**, **284**, p. 108606(1-15), 2023.
- ➡ A. Papoutsakis, I. Danaila, F. Luddens and M. Gavaises: *Droplet nuclei caustic formations in exhaled vortex rings*, **Scientific Reports**, **12**, Article number: 3892, <https://www.nature.com/>, 2022.

- ➡ V. Barbu, I. Ciotir and I. Danaila: *Existence and uniqueness of solution to the two-phase Stefan problem with convection*, **Applied Mathematics & Optimization**, <https://doi.org/10.1007/s00245-021-09764-w>, 2021.
- ➡ M. Kobayashi, Ph. Parnaudeau, F. Luddens, C. Lothodé, L. Danaila, M. Brachet and I. Danaila: *Quantum turbulence simulations using the Gross-Pitaevskii equation: high-performance computing and new numerical benchmarks*, **Computer Physics Communications**, **258**, p. 107579(1-26), 2021.
- ➡ G. Sadaka, A. Rakotondrandisa, P.-H. Tournier, F. Luddens, C. Lothodé, I. Danaila: *Parallel finite-element codes for the simulation of solid-liquid phase-change systems with natural convection*, **Computer Physics Communications**, **257**, p. 107492(1-26), 2020.
- ➡ A. Rakotondrandisa, G. Sadaka, I. Danaila: *A finite-element toolbox for the simulation of solid-liquid phase-change systems with natural convection*, **Computer Physics Communications**, **253**, p. 107188(1-20), 2020.
- ➡ A. Rakotondrandisa, I. Danaila, L. Danaila: *Numerical modelling of a melting-solidification cycle of a phase-change material with complete or partial melting*, **International Journal of Heat and Fluid Flow**, **76**, p. 57-71, 2019.
- ➡ A. Papoutsakis, S. S. Sazhin, S. Begg, I. Danaila, F. Luddens: *An efficient Adaptive Mesh Refinement (AMR) algorithm for the Discontinuous Galerkin method: applications for the computation of compressible two-phase flows*, **Journal of Computational Physics**, **363**, p. 399-427, 2018.
- ➡ I. Danaila, B. Protas: *Computation of Ground States of the Gross-Pitaevskii Functional via Riemannian Optimization*, **SIAM Journal on Scientific Computing**, **39**, p. B1102-B1129, 2017.
- ➡ I. Danaila, F. Kaplanski and S. Sazhin: *A model for confined vortex rings with elliptical core vorticity distribution*, **Journal of Fluid Mechanics**, **811**, p. 67-94, 2017.
- ➡ G. Vergez, I. Danaila, S. Auliac and F. Hecht: *A finite-element toolbox for the stationary Gross-Pitaevskii equation, with rotation*, **Computer Physics Communications**, **209**, p. 144–162, 2016.
- ➡ I. Danaila, M. A. Khamsehchi, V. Gokhroo, P. Engels and P. G. Kevrekidis: *Vector dark-antidark solitary waves, in multicomponent Bose-Einstein condensates*, **Physical Review A**, **94**, p. 053617 (1-8), 2016.
- ➡ I. Danaila and B. Protas: *Optimal reconstruction of inviscid vortices*, **Proceedings of the Royal Society A: Mathematical, Physical & Engineering Sciences**, **471**, p. 0323, 2015.
- ➡ I. Danaila, F. Kaplanski and S. Sazhin: *Modelling of confined vortex rings*, **Journal of Fluid Mechanics**, **774**, p. 267–297, 2015.

Organization of Scientific Conferences/Workshops/Symposia:

- (Sept. 2019-March 2020, member of the Organizing Committee) Program *Quantum and Kinetic Problems: Modeling, Analysis, Numerics and Applications*, National University of Singapore. Lead organizer: W. Bao.
- (April 2019, Organizer) Workshop *Scientific Computing across Scales: from Quantum Physics and Chemistry to Fluid Mechanics. Computation of Quantum Systems in Cold-matter Physics and Chemistry*, Fields Institute, Toronto.
- (July 2018, Organizer) Mini-symposium *Mathematical modelling and numerical simulation of superfluids*, *The 12th American Institute of Mathematical Sciences Conference*, July 5-9, 2018, Taipei, Taiwan.
- (August 2017, Organizer) Workshop on *Advances in mathematical modelling and numerical simulation of superfluids*, University of Rouen Normandy (LMRS), Rouen.
- (July 2016, Organizer) Workshop on *New challenges in mathematical modelling and numerical simulation of superfluids*, CIRM (Centre International de Rencontres Mathématiques), Marseille.
- (February 2016, Organizer) Workshop on *Computation of quantum systems in cold-matter physics and chemistry*, Fields Institute, Toronto.

Courses taught abroad

- (2019) ➡ Tutorial at National University of Singapore, Institute for Mathematical Sciences (2 days): *Solving PDEs with finite elements* (Program Modelling and Simulation for Quantum Condensation, Fluids and Information), pdfs and videos available online.
- (2017) Graduate Course at University of Strathclyde, Glasgow, UK:
An introduction to FreeFem++. (1 day, satellite of the 27th Biennial Conference on Numerical Analysis).
- (2016) ➡ Graduate Course at the Fields Institute and University of Toronto:
An introduction to scientific computing using free software FreeFem++. (2 weeks)

Post-doctoral and PhD Supervision:

Georges Edde	PhD student	2023-
Bahae-Eddine Madir	PhD student	2022-
Cyril Tain	PhD student	2020-
Cécile Legrand	PhD student	2019-
Dr. Victor Kalt	PhD student	2019-2023
Dr. Zhengtong Zhang (PhD Toulouse & Tianjin, China)	Post-doctoral fellow	2020-2023
Dr. Georges Sadaka (PhD Amiens)	Post-doctoral fellow	2021-2022
Dr. Aina Mandresy Rakotondrandisa	PhD student	2015-2019
Dr. Bian Lei (PhD Peking University, China)	Post-doctoral fellow	2017-2018
Dr. Guillaume Vergez	PhD student	2013-2017
Dr. Raluca Moglan	PhD student	2010-2013
Dr. Yan Zhang (PhD Xi'an, China)	Post-doctoral fellow	2010-2012
Dr. Parimah Kazemi (PhD U. Texas)	Post-doctoral fellow	2008-2009
Dr. Sonia Benteboula	PhD student	2003-2006
Dr. O. EL Guanaoui	Post-doctoral fellow	2003-2004

Research funding

Agency/Topic	Role	Amount	Time
Regional Research Agency: Normandy (ELBA) <i>Exploration of Lattice Boltzmann methods and Applications</i>	PI	130,000 €	2022-2023
International Emerging Actions France-Japan (CNRS) <i>Models for Superfluids and Superconductors</i>	PI	8,000 €	2022-2023
ANR (National Agency for Research) <i>HPC of Quantum Turbulence</i>			2019-2022
Total funding of the National Project	PI/national	581,000 €	
Part of the Partner Rouen-Paris	PI/local	320,000 €	
Orange (industrial contract) <i>Modelling and Simulation of a data-centre</i>	PI	12,000 €	2017-2018
ANR (National Agency for Research) <i>Mathematics and Simulations of Bose-Einstein condensates</i>			2013-2017
Total funding of the National Project	PI/head of the project	780,000 €	
Part of the Partner Rouen-Paris	PI/local coordinator	275,000 €	
GRR (Regional Research Agency: Normandy) <i>Mathematics and Simulations of Phase-Change Materials</i>	Co-PI	125,000 €	2015-2018
AMIES (Agency for Interaction of Mathematics with Industry) <i>Industrial applications of Phase-Change Materials</i>	PI/head of the project	6,000 €	2015-2016
EPSRC (Engineering and Physical Sciences Research Council, UK) <i>Vortex ring-like structures in internal combustion engines</i>	Visiting Professor	14,000 £	2015-2018
Orange (industrial contract) <i>Simulation of outdoor telecommunication cabinets</i>	PI	130,000 €	2010-2013
FUI (Research Funds with Industry) <i>Modelling the direct gasoline injection</i>	PI	150,000 €	2009-2013
CNRS-PEPS (National Research Centre) <i>Collaboration with France-Télécom</i>	PI	6,000 €	2010
Continental Automotive France (industrial contract) <i>Vortex rings in internal combustion engines</i>	PI	10,000 €	2010-2013

Web sites:

Personal Web page (ionut.danaila.perso.math.cnrs.fr).

Head of the LMRS Numerical Methods and Applications Group (lmrs-num.math.cnrs.fr).

Head of the ANR Project QUTE-HPC (quite-hpc.math.cnrs.fr).