

Frédéric Paquin-Lefebvre

Position

- Postdoctoral Fellow, Institut de Biologie de l'École Normale Supérieure, Université Paris Sciences & Lettres
 - Member of the Group of Applied Mathematics and Computational Biology lead by Prof. David Holcman
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Education

- Ph.D. in Applied Mathematics, The University of British Columbia, 2015-2020
 - Thesis: *On the Weakly nonlinear Analysis of Coupled Bulk-Surface Reaction-Diffusion Systems: Theory, Numerics and Applications.*
 - Advisors: Michael J. Ward and Wayne Nagata
- M. Sc. in Applied Mathematics, Université de Montréal, 2012-2014
 - Thesis: *Sur un Modèle d'Érythropoïèse Comportant un Taux de Mortalité Dynamique.*
 - Avisor: Jacques Bélair
- B. Sc. in Mathematics, Université de Montréal, 2009-2012

Publications

1. **Paquin-Lefebvre F**, Basnayake K, Holcman D. *Narrow Escape in Composite Domains Forming Heterogeneous Networks*. Physica D: Nonlinear Phenomena. 454, 133837, (2023).
2. **Paquin-Lefebvre F**, Toste S, Holcman D. *How Large the Number of Redundant Copies Should Be to Make a Rare Event Probable*. Phys. Rev. E 106, 064402, (2022).
3. **Paquin-Lefebvre F**, Holcman D. *Modeling and Asymptotic Analysis of the Concentration Difference in a Nanoregion Between an Influx and Outflux Diffusion Across Narrow Windows*. Proc. R. Soc. A. 477, (2021).
4. **Paquin-Lefebvre F**, Iyaniwura S, Ward MJ. *Asymptotics of the Principal Eigenvalue of the Laplacian in 2-D Periodic Domains with Small Traps*. Europ. J. Appl. Math., 1-28, (2021).
5. Gomez D, Iyaniwura S, **Paquin-Lefebvre F**, Ward MJ. *Pattern Forming Systems Coupling Linear Bulk Diffusion to Dynamically Active Membranes or Cells*. Phil. Trans. R. Soc. A. 379, (2021).
6. Kolokolnikov T, **Paquin-Lefebvre F**, Ward MJ. *Competition Instabilities of Pulse Patterns for the 1-D Gierer-Meinhardt and Schnakenberg Models are Subcritical*. Nonlinearity. 34(1), 273-312 (2021).
7. Kolokolnikov T, **Paquin-Lefebvre F**, Ward MJ. *Stable Asymmetric Spike Equilibria for the Gierer-Meinhardt Model with a Precursor Field*. IMA J. Appl. Math. 85(4), 605-634 (2020).
8. **Paquin-Lefebvre F**, Nagata W, Ward MJ. *Weakly Nonlinear Theory for Oscillatory Dynamics in a 1-D PDE-ODE Model of Membrane Dynamics Coupled by a Bulk Diffusion Field*. SIAM J. Appl. Math. 80(3), 1520-1545 (2020).
9. **Paquin-Lefebvre F**, Xu B, DiPietro KL, Lindsay AE, Jilkine A. *Pattern Formation in a Coupled Membrane-Bulk Reaction-Diffusion Model for Intracellular Polarization and Oscillations*. J. Theor. Biol. 497, 110242, 23 pages, (2020).
10. **Paquin-Lefebvre F**, Bélair J. *On the Effect of Age-Dependent Mortality on the Stability of a System of Delay-Differential Equations Modeling Erythropoiesis*, Acta Biotheor. 68, 5-19 (2020).
11. **Paquin-Lefebvre F**, Nagata W, Ward MJ. *Pattern Formation and Oscillatory Dynamics in a Two-Dimensional Coupled Bulk-Surface Reaction-Diffusion System*. SIAM J. Appl. Dyn. Syst. 18(3), 1334-1390 (2019).

Journals reviewed:

- Journal of Mathematical Biology (2)
- Journal of Physics A: Mathematical and Theoretical (1)
- SIAM Journal on Applied Dynamical Systems (1)
- Proceedings of the Royal Society A (1)
- Discrete and Continuous Dynamical Systems Series B (1)
- Nonlinear Dynamics (1)
- International Journal of Bifurcation and Chaos (1)

Research Interests

My scientific interests lie at the intersection of applied dynamical systems theory and mathematical biology. The overarching theme of my research is the analysis of bifurcations, which characterize the onset of qualitative changes in the overall dynamics resulting from parameters crossing through critical values, in mathematical models of biological systems using combined analytical and numerical approaches. During my PhD I have studied the stability of spatio-temporal patterns in certain coupled bulk-surface reaction-diffusion systems, a novel class of models motivated by the compartmentalization of intracellular proteins between membrane-bound and cytosolic species.

Keywords: Dynamical Systems Theory, Asymptotic and Perturbation Methods, Reaction-Diffusion Theory, Electrodiffusion Theory, Mathematical Biology, Scientific Computation and Numerical Continuation Methods.

Selected Conference and Seminar Talks

14. *How geometry affects ionic flow and voltage response in cellular nanodomains*. Neurosection IBENS internal seminar, Feb. 27, 2024.
13. *Problèmes d'échappée belle dans les microdomaines organisés en réseaux*.
 - Séminaire A3 du LAMFA, Université de Picardie Jules-Vernes, Oct. 2, 2023.
 - Séminaire du LJAD, Université Côte d'Azur, June 16, 2023.
12. *The narrow escape problem for diffusion*. Seminar at the Institut de Biologie de l'Université de Neuchâtel, Feb. 22nd, 2023.
11. *Asymptotic Analysis of the Concentration Difference Due to Diffusive Fluxes Across Narrow Windows*. Mathematical Biology Seminar, UBC (virtual). Feb. 9, 2022.
10. *Bulk-Surface Coupled Models: Coupling Passive Diffusion in Bounded Domains to Dynamically Active Boundaries*.
 - SIAM Conference on Nonlinear Waves and Coherent Structures, mini-symposium on Pattern Formation, Cell Polarity and Morphogenesis, University of Bremen. Aug. 30, 2022.
 - SIAM Conference on Mathematical Aspects of Material Science, session on Bulk and Surface Diffusion (virtual). May 27, 2021.
 - SIAM Conference on Applications of Dynamical Systems, session on Bulk and Surface Diffusion on Membranes (virtual). May 23, 2021.
 - Seminar Talk at ICQMB, UC Riverside (virtual). January 26, 2021.
 - Department Colloquium, UBC (virtual). November 27, 2020.
9. *A Study of Two-Spike Equilibria in the 1-D Gierer-Meinhardt Model*. Joint CAIMS-SIAM meeting (virtual). July 10, 2020.
8. *Pattern Formation in a Coupled Membrane-Bulk Reaction-Diffusion Model for Intracellular Polarization and Oscillations*. CRM Applied Mathematics Seminar, McGill University. September 30, 2019.
7. *Spatio-temporal Pattern Formation in 2-D Coupled Bulk-Surface Reaction-Diffusion Systems*.
 - PIMS - Germany Workshop on Modeling and Analysis of PDEs for Biological Applications, Heidelberg, Germany, June 25, 2019.
 - SIAM Conference on Applications of Dynamical Systems, session on Recent Advances in Diffusive and Reaction-Diffusion Systems, Snowbirds, Utah. May 20, 2019.
6. *The Dynamics of Diffusively Coupled Oscillators*. Mathematical Biology Seminar, UBC. January 23, 2019.
5. *Pattern Formation and Oscillatory Dynamics in a 2-D Coupled Bulk-Surface Reaction-Diffusion System*.
 - Applied Maths Seminar, University of Notre-Dame, Indiana. August 28, 2018.
 - Advanced Summer School on Continuation Methods for Nonlinear Problems, University of Illinois at Urbana-Champaign. August 13, 2018.
 - Annual CAIMS meeting, Ryerson University. June 6, 2018.

4. *Interactions of 1-D Bulk Diffusion with Localized Reactions*. Annual CAIMS meeting, Dalhousie University. July 20, 2017.
3. *Bifurcations dans les Systèmes Couplés EDOs-EDPs*. Applied Maths Seminar, Université Laval. December 16, 2016.
2. *Complex Dynamics and Patterns in a 2-D Coupled Model of Bulk Diffusion and Surface Reaction*. Annual CAIMS meeting, University of Alberta. June 29, 2016.
1. *Mathematical Modeling of Erythropoiesis*. Mathematical Biology Seminar, UBC. April 7, 2015.

Selected Workshops

- PIMS - Germany Workshop on Modeling and Analysis of PDEs for Biological Applications, Heidelberg, Germany, June 24-26, 2019.
- Advanced Summer School on Continuation Methods for Nonlinear Problems, University of Illinois at Urbana-Champaign, August 13-24, 2018.
- Workshop on Numerical Methods for PDEs on Surfaces, Vancouver, June 11-15, 2017.
- Graduate Summit in Mathematical Biology and Applied PDE, Jasper, May 25-28, 2017.
- Séminaire de Mathématiques Supérieures on Dynamics of Biological Systems, University of Alberta, May 29 to June 11, 2016.
- 2015 CAMBAM-MBI-NIMBioS Summer School on Nonlinear Dynamics of Biological Systems, McGill University, June 1-12, 2015.
- AARMS Summer School on Dynamical Systems and Mathematical Biology, Memorial University of Newfoundland, July 15 to August 9, 2013.

Grants and Awards

- NSERC Postdoctoral fellowship, Jan 2024 - Dec 2025.
- Postdoctoral fellowship from the Fondation ARC pour la Recherche sur le Cancer, Jan 2021 - Dec 2023.
- Graduate Research Award, Department of Mathematics, UBC, 2020.
- AARMS Postdoctoral Fellowship, Dalhousie University, 2020 (**declined**).
- Stanley M Grant Scholarship, Department of Mathematics, UBC, 2018.
- NSERC Doctoral Award, UBC, 2015-2017.
- Four Year Doctoral Fellowship, UBC, 2015-2018.
- Admission Fellowship, Institute of Applied Mathematics, UBC, 2015.
- FRQNT Doctoral Award, UdeM, 2014 (**declined**).
- FRQNT Master Research Scholarship, UdeM, 2013-2014.

Teaching

The University of British Columbia:

- Teaching for Integral Calculus with Applications to Physical Sciences and Engineering (MATH 101), Winter 2019 Term 2.
- Grading for a number of upper-level courses, including Engineering Analysis (MATH 358), Vector Calculus for Electrical Engineering (MATH 264), Complex Analysis (MATH 301 and 305) and Variational and Approximate Methods in Applied Mathematics (MATH 406).
- Problem-solving sessions for Multivariable Calculus (MATH 253), 2016.

Université de Montréal:

- Computer labs supervision for Introduction to Numerical Analysis (MAT 2412), 2012-2013.

Other Professional Experiences

- Mathematician at Side City Studios Inc., Montréal, 2012.
- Research assistant in physical oceanography at Maurice-Lamontagne Institute, Fisheries and Oceans Canada, Sainte-Flavie, 2011.

Relevant Skills

- French: native level. English: advanced level. Spanish: basic level.
- Advanced programming skills with MATLAB, Maple and Mathematica.
- Commercial PDE softwares: COMSOL and FlexPDE.
- Expert user of numerical bifurcation softwares and path-following packages such as AUTO, COCO and *pde2path*.
- Knowledge of Java, python, C/C++ and R.