

Kevin Church

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Education

- 2015–2019 **Ph.D Applied Mathematics**, *University of Waterloo*.
Thesis: *Invariant manifold theory for impulsive functional differential equations with applications*.
Advisors: Xinzhi Liu and Jun Liu.
Completed "Fundamentals of University Teaching" certificate program.
- 2012–2014 **M.Sc Mathematics**, *University of Ottawa*.
Thesis: *Applications of impulsive differential equations to the control of malaria outbreaks and introduction to impulse extension equations: a general framework to study the validity of ordinary differential equation models with discontinuities in state*.
Advisor: Stacey Smith?
- 2008–2012 **B.Sc, Honours, Major in Mathematics, Minor in Life Sciences**, *University of Ottawa*.

Employment

- 2022– **Senior Consultant, Quantitative Risk Modelling**, *Canadian Imperial Bank of Commerce*, Enterprise Risk Management, Model Quantification.
- 2021–2022 **Postdoctoral Fellow**, *Université de Montréal*, Centre de Recherches Mathématiques.
Advisor: Jean-Philippe Lessard,
- 2019–2021 **Postdoctoral Fellow**, *McGill University*.
Advisor: Jean-Philippe Lessard
- 2019–2022 **Lecturer**, *McGill University*.
○ Math 262 (Intermediate Calculus): May 2022 [condensed 1-month term].
○ Math 262 (Intermediate Calculus): September 2021 – December 2021.
○ Math 262 (Intermediate Calculus): September 2020 – December 2020.
○ Math 263 (Ordinary Differential Equations): September 2019 – December 2019.
- 2015–2019 **Lecturer, Teaching Assistant**, *University of Waterloo*.
○ Lecturer for Math 127 (Calculus for the Sciences): September 2017 – December 2017.
○ Teaching Assistant: various academic terms from 2015 – 2019 for courses including
- AMATH 851 (Stability Theory and Applications): January 2019 – April 2019
- AMATH 451 (Introduction to Dynamical Systems): January 2018 – April 2018
- AMATH 331 (Applied Real Analysis): January 2018 – April 2018
- CS 240 (Data Structures and Data Management): May 2016 – August 2016
- MATH 237 (Calculus III for Honours Mathematics): May 2016 – August 2016

2012–2015 **Teaching Assistant, Tutor**, *University of Ottawa*.

- o Teaching Assistant: various academic terms from September 2012 – December 2014.
- o Math Help Center: September 2014 – April 2015.
 - Tutored students in first-year mathematics courses.
 - Bilingual (English, French) position.

Works submitted for publication

- [1] I. Hewage, K.E.M. Church and E.J. Schwartz. Investigating the dynamics of COVID-19 infection with vaccination and differential morbidity: A mathematical and numerical analysis. *Submitted April, 2023*.
- [2] K.E.M. Church. Computer-assisted proofs with deep neural networks. *Submitted February, 2023*.

Papers in journals and refereed conference proceedings

- [1] J. Cyranka, K.E.M. Church and J. Lessard. Worrysome Properties of Neural Network Controllers and Their Symbolic Representations. *26th European Conference on Artificial Intelligence (ECAI 2023)*, Kraków, Poland. (Accepted)
- [2] K.E.M. Church and E. Queirolo. Computer-assisted proofs of Hopf bubbles and degenerate Hopf bifurcations. *Journal of Dynamics and Differential Equations*, 2023.
- [3] K. Church, O. Hénot, P. Lappicy, J. Lessard and H. Sprinke. Periodic orbits in Hořava-Lifshitz cosmologies. *General Relativity and Gravitation*, 55:2, 2023.
- [4] K.E.M. Church. Uniqueness of solutions and linearized stability for impulsive differential equations with state-dependent delay. *Journal of Differential Equations*, 338(25), 415–440, 2022.
- [5] K.E.M. Church. Validated integration of differential equations with state-dependent delay. *Communications in Nonlinear Science and Numerical Simulation*, 115, 106762, 2022.
- [6] K.E.M. Church and J. Lessard. Rigorous verification of Hopf bifurcations in functional differential equations of mixed type. *Physica D: Nonlinear Phenomena*, 429, 133072, 2022.
- [7] K.E.M. Church and G.W. Duchesne. Rigorous continuation of periodic solutions for impulsive delay differential equations. *Applied Mathematics and Computation*, 415(15):126733, 2022.
- [8] K.E.M. Church and C. Fortin. Computer-assisted methods for analyzing periodic orbits in vibrating gravitational billiards. *International Journal of Bifurcation and Chaos*, 31(08):2130021, 2021.
- [9] K.E.M. Church. Analysis of pandemic closing-reopening cycles using rigorous homotopy continuation: a case study with Montreal COVID-19 data. *SIAM Journal on Applied Dynamical Systems*, 20(2), 745–783, 2021.
- [10] K.E.M. Church and X. Liu. Invariant manifold-guided impulsive stabilization of delay equations. *IEEE Transactions on Automatic Control*, 66(12), 5997–6002, 2021.

- [11] K.E.M. Church. Eigenvalues and delay differential equations: periodic coefficients, impulses and rigorous numerics. *Journal of Dynamics and Differential Equations*, 33, 2173—2252, 2021.
- [12] K.E.M. Church and Xinzhi Liu. Cost-Effective Robust Stabilization and Bifurcation Suppression. *SIAM Journal on Control and Optimization*, 57(3):2240–2268, 2019.
- [13] K.E.M. Church and Xinzhi Liu. Analysis of a SIR model with pulse vaccination and temporary immunity: Stability, bifurcation and a cylindrical attractor. *Nonlinear Analysis: Real World Applications*, 50:240–266, 2019.
- [14] K.E.M. Church and Xinzhi Liu. Computation of centre manifolds and some codimension-one bifurcations for impulsive delay differential equations. *Journal of Differential Equations*, 267(6):3852–3921, 2019.
- [15] K.E.M. Church and Xinzhi Liu. Smooth centre manifolds for impulsive delay differential equations. *Journal of Differential Equations*, 265(4):1696–1759, 2018.
- [16] K.E.M. Church and R.J. Smith. Continuous approximation of linear impulsive systems and a new form of robust stability. *Journal of Mathematical Analysis and Applications*, 457(1):614–644, 2018.
- [17] K.E.M. Church and Xinzhi Liu. Bifurcation Analysis and Application for Impulsive Systems with Delayed Impulses. *International Journal of Bifurcation and Chaos*, 27(12):1750186, 2017.
- [18] K.E.M. Church and Xinzhi Liu. Bifurcation of Bounded Solutions of Impulsive Differential Equations. *International Journal of Bifurcation and Chaos*, 26(14):1650242, 2016.
- [19] K.E.M. Church and R.J. Smith. Comparing malaria surveillance with periodic spraying in the presence of insecticide-resistant mosquitoes: Should we spray regularly or based on human infections? *Mathematical Biosciences*, 276, 2016.
- [20] K.E.M. Church and R.J. Smith. Existence and uniqueness of solutions of general impulse extension equations with specification to linear equations. *Dynamics of Continuous, Discrete and Impulsive Systems Series B: Applications and Algorithms*, 22(3), 2015.
- [21] K.E.M. Church and Robert J Smith. Analysis of piecewise-continuous extensions of periodic linear impulsive differential equations with fixed, strictly inhomogeneous impulses. *Dynamics of Continuous, Discrete and Impulsive Systems Series B: Applications & Algorithms*, 21:101–119, 2014.

Research monographs

- [1] K.E.M. Church and X. Liu. Bifurcation theory of impulsive dynamical systems. *IFSR International Series in Systems Science and Systems Engineering, Vol. 34. Springer Nature*, 2021.

Theses and non-refereed conference proceedings

- [1] K. Church. Invariant manifold theory for impulsive functional differential equations with applications. Ph.D Thesis, University of Waterloo, 2019.
- [2] K.E.M. Church. Linearization and local topological conjugacies for impulsive systems. *In: Kilgour, D.M., Kunze, H., Makarov, R., Melnik, R., Wang, X. (Eds.) Recent Advances in Mathematical and Statistics Methods: IV AMMCS International Conference, Waterloo, Canada, August 20-25, 2017.*
- [3] K.E.M. Church. A new measure of robust stability for linear ordinary impulsive differential equations. *In: Belair, J., Frigaard I., Kunze H., Makarov R., Melnik R., Spiteri R. (Eds.) Mathematical and Computational Approaches in Advancing Modern Science and Engineering, 2016.*
- [4] K. Church. Applications of impulsive differential equations to the control of malaria outbreaks and introduction to impulse extension equations: a general framework to study the validity of ordinary differential equation models with discontinuities in state. M.Sc Thesis, University of Ottawa, 2014.

Selected honours, grants and fellowships

- 2021 **CRM-Simons Postdoctoral Fellowship**, Simons Foundation, administered by Centre de Recherches Mathématiques, one year fellowship.
- 2020 **Applied Mathematics Doctoral Award**, University of Waterloo.
- 2019 **NSERC Postdoctoral Fellowship**, Natural Sciences and Engineering Research Council of Canada, two-year fellowship.
- 2019 **Joseph Wai-Hung Liu Graduate Scholarship**, University of Waterloo.
- 2019 **Travel Grant**, Waterloo Institute for Complexity and Innovation.
- 2018 **Graduate Fellowship**, Waterloo Institute for Complexity and Innovation.
- 2018 **Winner, Three Minute Thesis Competition, Mathematics Faculty Heat**, University of Waterloo.
- 2017 **Alexander Graham Bell Canada Graduate Scholarship**, Natural Sciences and Engineering Research Council of Canada, held 2017-2019.
- 2015 **President's Graduate Scholarship**, University of Waterloo, held 2015–2019.
- 2015 **Ontario Graduate Scholarship**, Government of Ontario, through University of Waterloo, held 2015–2017.
- 2016 **Best Student Paper Prize: Mathematics and Statistics**, University of Ottawa.
- 2014 **Honorable Mention, Excellence Award for Teaching Assistants**, University of Ottawa.

Invited talks and organized sessions

- 2023 **Time lag monotonicity-breaking in time-delay systems with impulses**, *10th International Congress on Industrial and Applied Mathematics*, Waseda University, Tokyo, Japan, August 20-25.

- 2021 **Validated integration and implicit method of steps for differential equations with state-dependent delay**, *50 years of Functional Differential Equations at ICMC*, University of São Paulo, São Carlos, August 2-6.
- 2021 **Computer-assisted proof of Hopf bifurcation in functional differential equations of mixed type**, *Recent advances in theory and applications of functional differential equations*, 2021 CMS 75th +1 Anniversary Summer Meeting, June 7-11.
- 2021 **Rigorous homotopy continuation for periodic orbits in a non-smooth epidemic model**, *Minisymposium: Computer-assisted Mathematical Proofs in Nonlinear Dynamics*, SIAM Conference on Applications of Dynamical Systems, May 23-27.
- 2021 **Computer-assisted proof of Hopf bifurcation in functional differential equations**, *Special Session on Functional Differential Equations, Theory and Applications*, 2021 AMS Spring Southeastern Sectional Meeting (formerly at Georgia Institute of Technology), March 13-14.
- 2020 **Session organizer**, *Applications and Recent Developments in Discontinuous Dynamical Systems*, 2020 CMS Winter Meeting, December 3-8.
- 2017 **Control of malaria in the presence of insecticide-resistant mosquitoes**, *The 10th Annual Ottawa Mathematics Conference*, uOttawa Distinguished Student Paper Lecture, June 16-19.
- 2016 **Bifurcations in impulsive differential equations**, *The 9th Annual Ottawa Mathematics Conference*, June 17-19.
- 2013 **A comparison of two malaria vector control strategies with impulsive differential equations**, *2013 CMS Winter Meeting*, session "Infectious Disease Modelling", December 6-9.

Contributed talks

- 2021 **Validated two-parameter continuation of periodic orbits in delay equations**, *Workshop on Controlling Error and Efficiency of Numerical Models: Methods, benchmarks, and case studies*, Fields Institute, December 1-3.
- 2020 **Spectral theory for impulsive delay differential equations**, *2020 CMS Winter Meeting*, session "Applications and Recent Developments in Discontinuous Dynamical Systems", December 3-8.
- 2019 **Centre manifolds for impulsive delay differential equations: theory and applications**, *SIAM Conference on Applications of Dynamical Systems*, May 19-23.
- 2017 **Linearization and topological conjugacies for impulsive systems**, *The IV AMMCS International Conference*, August 20-25.
- 2015 **A new measure of robust stability for impulsive differential equations**, *The 2015 AMMCS-CAIMS Congress*, June 7-12.
- 2011 **Modelling biological phenomena with impulsive differential equations**, *2011 Canadian Undergraduate Mathematics Conference*, June 15-19.

Seminars

- 2022 **The unreasonable effectiveness of computer-assisted proofs in nonlinear dynamics**, *NCTS Webinar on Nonlinear Evolutionary Dynamics*, National Center for Theoretical Sciences, October 27.
- 2021 **Validated integration for state-dependent delay equations**, *Applied and Computational Math Seminar*, George Mason University, November 19.
- 2020 **Floquet theory, invariant manifolds and control with impulsive delay differential equations**, *ISS Informal Systems Seminar*, GERAD Group for Research in Decision Analysis, November 27.
- 2020 **Rigorous computation of periodic solutions and Floquet multipliers in delay differential equations with time-forced discontinuities**, *CRM-CAMP in Nonlinear Analysis Seminar Series*, Centre de Recherches Mathématiques, October 13.
- 2020 **Ill-posed functional differential equations and applications to traveling waves in nonlocal reaction-diffusion equations**, *Applied Mathematics Working Seminar*, McGill University, September 22.
- 2020 **Centre manifolds for impulsive delay differential equations: approximation and applications**, *CRM Applied Mathematics Seminars*, Centre de Recherches Mathématiques, February 24.
- 2019 **The hidden geometry of complex dynamics and how to exploit it**, *WICI Graduate Fellowship Awardee Research Symposium*, University of Waterloo, February 12.

Workshops attended

- 2021 **Workshop on Controlling Error and Efficiency of Numerical Models: Methods, benchmarks, and case studies**, *December 1-3*, Ottawa, Canada.
- 2020 **Connections in Infinite Dimensional Dynamics**, *May 18-22*, Banff, Canada.
- 2019 **Rigorous Computational Dynamics in Infinite Dimensions**, *April 3-6*, Montreal, Canada.

Supervision and mentorship

- 2020, 2022 **Undergraduate Summer Research Students.**
 - 2022: Supervised Kevin Constantineau, a fourth-year undergraduate student in mathematics on a NSERC studentship. He worked on a project I proposed on traveling waves in integrodifference equations.
 - 2020: Supervised Clément Fortin, a second-year undergraduate student in mathematical physics. He worked on a project that I proposed on gravitational billiards. Findings were written up as a paper and published at International Journal of Bifurcation and Chaos.
- 2022 **Undergraduate Honours Project Supervision.**
 - Supervised Heyang Song, a fourth-year undergraduate student at McGill. He learned the basics of computer-assisted proofs and gained experience with MATLAB.
- 2020 **CÉGEP Supervision Program.**
 - Supervised three CÉGEP (pre-university) students on a winter term research project.
 - Students worked on a project in infectious disease modelling and vaccination, completing independent readings, writing up a report and giving a presentation to their peers.

Service

- 2021, 2022 **PhD comprehensive exam standing committee member**, McGill University.
o Served on the committees of Miguel Ayala, Gabriel William Duchesne & Olivier Hénot.
o Acted as an additional examiner for their Part B comprehensive exams.
- 2021 **Panelist, Graduate Orientation NSERC Session**, McGill University.
- 2021, 2022 **NSERC CGS-M Selection Committee**, McGill University.
- 2021 **Poster Session / Red Socks Award Judge**, *SIAM Conference on Applications of Dynamical Systems 2021*.
- 2018–2019 **Chair**, *Applied Mathematics Graduate Student Colloquium*, University of Waterloo.

Refereeing and editorial activities

Refereeing for journals, (*in alphabetical order*).

Bulletin des Sciences Mathématiques. Chaos, Solitons and Fractals. Communications in Nonlinear Science and Numerical Simulation. Differential and Integral Equations. Evolution Equations and Control Theory. Foundations of Computational Mathematics. IEEE Transactions on Automatic Control. International Journal of Bifurcation and Chaos. Journal of Applied Mathematics. Journal of Differential Equations. Journal of Dynamics and Differential Equations. Journal of Mathematical Analysis and Applications. Nonlinear Analysis. Nonlinear Analysis: Hybrid Systems. Nonlinear Analysis: Real-World Applications. SIAM Journal on Control and Optimization. Systems and Control Letters.

Reviewer, *MathSciNet Reviews*.

Languages

English Native
French Proficient