

## Dr. Piers W. Lawrence

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**Research Interests** I am passionate about the development and application of novel mathematical and algorithmic solutions to real-world problems. My research projects in the past have explored diabetes care, measuring chaotic pendulum systems, evaluating special functions, finding periodic points in fractal sets, and designing stable algorithms for the solution of polynomial eigenvalue problems. Most recently, I have been working on a project based in Kikwit, DR Congo, on the development of networked embedded systems for the remote monitoring of fridges (for blood, vaccine, and medication storage) and water sources (wells, community taps, and purification activities) at health facilities. During the course of my PhD studies, I developed methods for the stable computation of the roots of polynomial equations expressed in Hermite and Lagrange bases and for barycentric rational interpolants, as well as exploring structured condition numbers and structured backward error for companion matrices. My postdoctoral research has also focused on developing linearizations of matrix polynomials, making a number of breakthroughs that significantly generalize and simplify the stability analysis. I am always eager to delve into interesting problems, especially those with a real-world impact.

**Citizenship** New Zealand and Australian; Belgian residence permit

**Education** **The University of Western Ontario** **2009 – 2013**  
PhD – Applied Mathematics  
Thesis title: *“Eigenvalue Methods for Interpolation Bases”*

**University of Canterbury** **2005 – 2008**  
BSc Hons – Mathematics (First class)  
Thesis title: *“Parameter estimation techniques for insulin-glucose models”*

**Research Experience** Postdoctoral Fellow/Project Coordinator Apr. 2016 – Mar. 2017  
Danny Hughes KU Leuven, DR Congo  
Development and application of long-range embedded sensor networks for remote monitoring of health and water services in Kikwit, DR Congo.

Postdoctoral Fellow Oct. 2015 – Mar. 2016  
Dirk Nuyens KU Leuven  
Application of high dimensional integration techniques and Bayesian inversion for the determination of insulin pump parameters for diabetic patients.

Postdoctoral Fellow Aug. 2013 – Sept. 2015  
Marc Van Barel and Paul Van Dooren KU Leuven and UC Louvain  
Investigating new methods for computing approximate greatest common divisors of polynomials expressed in interpolation bases; Stability analysis of linearizations of polynomial matrices expressed in the Lagrange and other interpolation bases.

Research Assistant Apr. 2009 – Jul. 2013  
Rob Corless (PhD supervisor) The University of Western Ontario  
Implementing algorithms for evaluation and rootfinding of Birkhoff and Hermite interpolants expressed by values; Robust event location for differential algebraic equations in the software package DAETS; Algorithms to deflate infinite eigenvalues from companion matrices

associated with barycentric Hermite interpolants; Algorithms to locate  $k$ -periodic points in the Mandelbrot set.

Research Assistant Nov. 2008 – Feb. 2009  
Raazesh Sainudiin University of Canterbury  
Designing and fabricating a measurable double pendulum apparatus for statistical experiments; Implementing logging software for capturing data from the device.

Research Assistant Mar. 2008 – Oct. 2008  
Chris Hann and Geoff Chase University of Canterbury  
Investigating novel methods for parameter estimation of differential equation models, applied to the estimation of insulin sensitivity from clinical data obtained in Intravenous Glucose Tolerance Testing in humans.

Research Assistant Nov. 2007 – Feb. 2008  
Stephen Roberts Australian National University  
Implementation of visualization tools for ANUGA shallow water wave equation modelling software, with particular application to a case study of water gauges in Lake Merimbula.

Research Assistant Mar. 2007 – Oct. 2007  
Jason Wong University of Canterbury  
Investigation of linear compartmental insulin-glucose model for Diabetic patients for the effective dosing of insulin; Development of fast algorithms for forward simulation and parameter reconstruction.

Research Assistant Oct. 2006 – Feb. 2007  
Chris Hann University of Canterbury  
Investigation of non linear insulin-glucose models; Development of fast algorithms for model based therapeutics.

## Teaching Experience

Invited Lecturer Nov. 2016  
African Institute for Mathematical Sciences Kigali, Rwanda  
Designed, prepared, and delivered a three-week intensive Master's course (30 hours of lectures, plus lab sessions) titled "*Numerical methods with barycentric Lagrange interpolants*"; supervision of Master's student Nov. 2016 – May 2017.

Instructor 2015 – 2016  
KU Leuven Leuven, Belgium  
First year Master's course on complex function theory and applications.

Teaching Assistant 2009 – 2013  
The University of Western Ontario London, Canada  
Courses taught: third year partial differential equations, second year numerical analysis, and masters/PhD-level numerical analysis; development of laboratory manual for numerical analysis course.

Tutor 2007 – 2008  
University of Canterbury Christchurch, New Zealand  
First and second year courses on computational mathematics and modelling; third year course on partial differential equations.

## Thesis Supervision

Oluwasegun Micheal Ibrahim, "*Spectral Collocation Methods for Solving Differential Equations and Epidemiological Modelling of Human African Trypanosomiasis*," African

Institute for Mathematical Sciences, Kigali, Rwanda (2016 – 2017).

## Other Scholarly Activities

Participant (expert North): “*UniversiTIC 3.0 formulation workshop.*” Joint ARES and VLIR-UOS academic mission and formulation workshop to define the strategic direction for the UniversiTIC 3.0 programme, Kinshasa, DR Congo, 15–20 May 2017.

Coordinator: “*MediFridge: ultra-low-power and long-range monitoring of development projects in DR Congo.*” Extensive fieldwork to prepare and implement a pilot project supporting local partners in the health sector in Kikwit, DR Congo, 3 field visits (5 months total) during April–Dec. 2016.

Referee: SIAM Journal on Matrix Analysis and Applications, IMA Journal of Numerical Analysis, Numerical Algorithms, and Dolomites Research Notes on Approximation.

Workshop participant: “*Chebfun and Beyond*”, Oxford, UK, 17–19 September 2012.

Visiting scholar: “*Rootfinding with linear barycentric rational interpolation,*” hosted by Prof. Jean-Paul Berrut and Georges Klein at the University of Fribourg, Switzerland, 6–15 February 2012.

Summer school: “*Approximation Theory, Spectral Methods and Chebfun,*” Dobbiaco, Italy, 12–17 June 2011.

Committee member of the Graduate Students Issues Committee, The University of Western Ontario (2011 – 2013).

Councillor for the Society of Graduate Students at The University of Western Ontario (2010 – 2013).

## Industrial Research

Mathematical consultant

2017 – Present

EigenPoly Consulting

Leuven, Belgium

Provision of expert mathematical advice and algorithmic solutions to diverse international clients.

## Research Grants

KU Leuven Internal Fund Category 3 (socio-economic applied research): “*Identification of patient-specific parameters for bolus calculators in type 1 diabetic patients,*” budget: 235000€, role: co-applicant (2016–2017).

## Awards

Best paper award: “*Developing IoT to support the health sector: A case study from Kikwit, DR Congo,*” awarded at the 1st EAI International Conference on Emerging Technologies for Developing Countries (AFRICATEK), Marrakesh, Morocco, 27–28 March 2017.

Second place in the LoRa Alliance Global IoT Challenge (out of 237 competitors), awarded at the GSMA Mobile World Congress, Barcelona, Spain, 27 Feb. – 2 Mar. 2017.

Western Graduate Research Scholarship: “*Eigenvalue Methods for Interpolation Bases*” (2009–2013)

University of Canterbury Summer Scholarship: “*Nonlinear timeseries with measurable double pendulum*” (2008–2009)

University of Canterbury Mathematics and Statistics Department Scholarship (2008)

Health Research Council scholarship, funded from Sir Charles Hercus Health Research Fellowship: “*Parameter estimation techniques for insulin-glucose models*” (2008)

Australian National University Summer Research Scholarship (2007–2008)

Health Research Council scholarship, funded from Sir Charles Hercus Health Research Fellowship: “*Geometric theory and application of integral based parameter identification*” (2007)

University of Canterbury Summer Scholarship: “Fast algorithms for glucose control protocol testing” (2006–2007)

## Publications

Froilán M. Dopico, **Piers W. Lawrence**, Paul Van Dooren, and Javier Pérez, “Block Kronecker linearizations of matrix polynomials and their backward errors.” *Numerische Mathematik*, in press (accepted, Feb. 2017).

**Piers W. Lawrence** and Javier Perez, “Constructing strong linearizations of matrix polynomials expressed in Chebyshev bases.” *SIAM Journal on Matrix Analysis and Applications*, **38**(3) (2017), pp. 683–709.

**Piers W. Lawrence**, Marc Van Barel, and Paul Van Dooren, “Backward error analysis of polynomial eigenvalue problems solved by linearization.” *SIAM Journal on Matrix Analysis and Applications*, **37**(1) (2016), pp. 123–144.

**Piers W. Lawrence** and Robert M. Corless, “Backward error of polynomial eigenvalue problems solved by linearization of Lagrange interpolants.” *SIAM Journal on Matrix Analysis and Applications*, **36**(4) (2015), pp. 1425–1442.

**Piers W. Lawrence** and Robert M. Corless, “Stability of rootfinding for barycentric Lagrange interpolants.” *Numerical algorithms*, **65**(3) (2014), pp. 447–446.

**Piers W. Lawrence**, “Fast reduction of generalized companion matrix pairs for barycentric Lagrange interpolants.” *SIAM Journal on Matrix Analysis and Applications*, **34**(3) (2013), pp. 1277–1300.

**Piers W. Lawrence**, Robert M. Corless, and David J. Jeffrey, “Complex double-precision evaluation of the Wright  $\omega$  function.” *ACM Transactions on Mathematical Software*, **38**(3) (2012), pp. 20:1–20:17.

**Piers W. Lawrence**, Michael Stuart, Richard Brown, Warwick Tucker and Raazesh Sainudiin, “A mechatronically measurable double pendulum for machine interval experiments.” *Indian Statistical Institute Technical Report* (2010), isibang/ms/2010/11.

Chris E. Hann, J. Geoffrey Chase, Michael F. Ypma, Jos Elfring, NoorHafiz Mohd Nor, **Piers W. Lawrence** and G.M. Shaw, “The impact of parameter identification methods on drug therapy control in an intensive care unit.” *The Open Medical Informatics Journal*, **2** (2008), pp. 92–104.

## Conference Proceedings (peer reviewed)

**Piers W. Lawrence**, Trisha Phippard, Gowri Sankar Ramachandran, and Danny Hughes, “Developing IoT to support the health sector: A case study from Kikwit, DR Congo.” *The 1st EAI International Conference on Emerging Technologies for Developing Countries (AFRICATEK)*. Springer, 2017.

Gowri Sankar Ramachandran, Fan Yang, **Piers W. Lawrence**, Sam Michiels, Wouter Joosen, and Danny Hughes, “ $\mu$ PnP-WAN: Wide area plug and play sensing and actuation with LoRa for the Internet-of-Things.” *9th International Conference on Communication Systems and Networks (COMSNETS)*. IEEE, 2017.

Robert M. Corless and **Piers W. Lawrence**, “The largest roots of the Mandelbrot polynomials.” In D. Bailey, H.H. Bauschke, P. Borwein, F. Garvan, M. Thera, J. Vanderwerff and H. Wolkowicz, editors, *Computational and Analytical Mathematics*, vol. 50 of Springer Proceedings in Mathematics & Statistics, Springer New York, 2013, pp. 305–324.

**Piers W. Lawrence** and Robert M. Corless, “Numerical stability of barycentric Hermite rootfinding.” In Marc Moreno Maza, editor, *Proceedings of the 2011 International Workshop on Symbolic-Numeric Computation*, ACM, 2011, pp. 147–148.

## Conference Presentations

*“LoRa Congo: low-power, long-range monitoring technology for development projects in DR Congo,”* presented at the imec SuperMinds 2016 conference, Brussels, 27 October 2016.

*“Block-anti-triangular linearizations of matrix polynomials expressed in interpolation bases,”* presented at the 20th Conference of the International Linear Algebra Society, Leuven, 11–15 July 2016.

*“Structured backward error analysis of eigenvalue problems solved by linearization,”* presented at the MatTriad 2015 conference on Matrix Analysis and its Applications, Coimbra, Portugal, 7–11 September 2015.

*“Backward error of polynomial eigenvalue problems solved by linearization,”* presented at the GAMM 86th Annual Meeting of the International Association of Applied Mathematics and Mechanics, Lecce, Italy, 23–27 March 2015.

*“On the stability of polynomial eigenvalue problems solved via linearization,”* presented at the 10th International Workshop on Accurate Solution of Eigenvalue Problems, Dubrovnik, Croatia, 2–5 June 2014.

*“Linearizations for interpolation bases,”* presented at the Manchester Workshop on Non-linear Eigenvalue Problems, Manchester, UK, 23–25 April 2014.

*“Rootfinding for polynomial and rational interpolants,”* presented at the 3rd Dolomites Workshop on Constructive Approximation and Applications, Alba di Canazei, Italy, 9–14 September 2012.

*“Eigenstructure of an arrowhead matrix pencil,”* presented at the 7th International Congress on Industrial and Applied Mathematics – ICIAM 2011, Vancouver, Canada, 18–22 July 2011.

*“Numerical stability of barycentric Hermite rootfinding,”* presented at Symbolic Numeric Computation 2011, San Jose, USA, 7–9 June 2011.

*“On the stability of barycentric Hermite rootfinding,”* presented at Southern Ontario Numerical Analysis Day 2011, McMaster University, Hamilton, Canada, 13 May 2011.

*“Event handling with barycentric Hermite interpolation,”* presented at CAIMS\*SCMAI 2010, St John's, Canada, 19–23 July 2010.

## Seminar Presentations

*“Fiedler-like linearizations for polynomial matrices,”* presented at the Department of Computer Science, KU Leuven, Leuven, Belgium, November 2015.

*“Semi-practical algorithms for computing the periodic points of the Mandelbrot set,”* presented at the Department of Mathematics, KU Leuven, Leuven, Belgium, April 2015.

*“Barycentric Lagrange interpolation and rootfinding,”* presented at the Department of Mathematical Engineering, UC Louvain, Louvain-la-Neuve, Belgium, October 2013.

## Posters

*“Linearizations for interpolation bases,”* presented at the IAP DYSCO Study Day: Dynamical systems, control and optimization, 2014, University of Namur, Namur, Belgium.

*“Mandelbrot polynomials and matrices,”* presented at the IAP DYSCO Study Day: Dynamical systems, control and optimization, 2013, Palais des Académies, Brussels, Belgium.

*“Mandelbrot polynomials and matrices,”* presented at the East Coast Computer Algebra Day (ECCAD) 2012, Oakland University, Rochester, Michigan, USA.

*“Computing roots of Mandelbrot polynomials,”* presented at the East Coast Computer Algebra Day (ECCAD) 2011, The University of Waterloo, Waterloo, Canada.

**Manuscripts in Preparation**

**Piers W. Lawrence** and Leonardo Robol, “*Linearization of Lagrange polynomials in a Fiedler-like way*”

**Piers W. Lawrence**, D. Steven Mackey, and Vasilije Perović, “*Development of an  $\mathbb{L}_1$ -like pencil Space for matrix polynomials in Lagrange bases.*”

**Piers W. Lawrence**, Froilán M. Dopico, Javier Pérez, and Paul Van Dooren, “*Polynomial roots from generalized eigenvalues.*”

**Piers W. Lawrence**, Robert M. Corless, and D.J. Jeffrey, “*Mandelbrot Polynomials and Matrices.*”

**Languages** English (native); French (intermediate); Dutch (basic)

**Computer Skills** Proficient in: MATLAB, L<sup>A</sup>T<sub>E</sub>X, Maple, Python, C/C++ (with skills in parallel programming with OpenMP and MPI), Fortran, bash, emacs lisp, HTML, Google cloud platform, MySQL.

**Referees**

Prof. Danny Hughes, Department of Computer Science KU Leuven +32 16 32 82 87 danny.hughes@cs.kuleuven.be	Prof. Rob Corless, Department of Applied Mathematics The University of Western Ontario +1 519 661 2111 x88785 rcorless@uwo.ca
Prof. Colin Denniston, Department of Applied Mathematics The University of Western Ontario +1 519 661 2111 x88791 cdennist@uwo.ca	Prof. Paul Van Dooren, Department of Mathematical Engineering Université catholique de Louvain +32 10 47 80 40 paul.vandooren@uclouvain.be