

Jamie Michael Foster

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- Date and place of birth: 8th August 1986, Salisbury, Wiltshire. UK.
- Nationality: British.

RESEARCH INTERESTS

My work focusses on developing and analysing mathematical models of physical process arising in practical problems and interpreting the results into their original context. The majority of my work takes place on the interface between mathematics and other sciences, namely; physics, chemistry, engineering and biology. Areas of application that I have worked on/am working in, include; (i) lithium-ion batteries; (ii) organic and hybrid (particularly perovskite) solar cells; (iii) signal propagation in axons, and; (iv) fluid flow in glass manufacture. Working in these areas I have naturally developed keen interests in the following arenas of mathematics: (a) differential (and integro-differential) equations; (b) asymptotic/perturbation methods; (c) numerical methods/scientific computation; (d) continuum mechanics (both solid and fluid); (e) free boundary problems; (f) homogenisation and upscaling in multiscale systems, and; (g) Monte Carlo simulation.

EDUCATION

- University of Southampton, Oct 2007 - Sept 2010
Ph.D. Applied Mathematics: Modelling the spreading and draining of viscous films
Supervisors: Prof C. P. Please & Prof A. D. Fitt
- University of Southampton, Oct 2004 - Sept 2007
B.Sc. Mathematics with Physics, First Class Honours

ACADEMIC CAREER

- **University of Portsmouth, Jun 2016 - present**
Lecturer — Department of Mathematics
- **McMaster University, Jan 2017 - present**
Adjunct Assistant Professor — Department of Mathematics and Statistics
- Fields Institute for Research in Mathematical Sciences, Jan 2016 - Jun 2016
Research fellow — Multiscale Scientific Computing: from Quantum Physics and Chemistry to Material Science and Fluid Mechanics
- McMaster University, Apr 2014 - Jan 2016
Post-doctoral research assistant — Lithium-ion batteries

- University of Southampton/University of Oxford, Oct 2011 - Apr 2014
Post-doctoral research assistant — Organic and perovskite hybrid solar cells
- University of Southampton, Oct 2010 - Oct 2011
Mathematics research fellowship

RESEARCH VISITS

- Helmholtz Zentrum Berlin, Jul 2017
Collaboration with Dr A. Abate
- McMaster University, Dec 2016
Collaboration with Prof B. Protas and Prof G. Goward
- Isaac Newton Institute for Mathematical Sciences at the University of Cambridge, Sept 2015
Collaboration with Prof J. R. King
- University of Bath, Aug 2014 - Sept 2014 & Sept 2015
Collaboration with Prof A. B. Walker, Dr P. J. Cameron & Dr. S. E. J. O’Kane
- University of Nottingham, Sept 2014
Collaboration with Prof J. R. King
- University of Oxford, Oct 2011 - Apr 2014
Collaboration with Dr H. J. Snaith, Mr T. Leijtens, Mr G. Eperon, Prof S. J. Chapman & Prof A. Goriely
- Queensland University of Technology, Apr 2008 - Sept 2008
Collaboration with Dr S. McCue & Prof G. Pettet

PUBLICATIONS

1. **J. M. Foster**, S. J. Chapman, G. Richardson & B. Protas, ‘A mathematical model for mechanically-induced deterioration of the binder in lithium-ion electrodes’, *SIAM Journal on Applied Mathematics*, **77(6)**:2172–2198 (2017).
2. K. J. Harris, **J. M. Foster**, M. Z. Tessaro, M. Jiang, X. Yang, Y. Wu, B. Protas & G. R. Goward, ‘Structure solution of metal-oxide Li battery cathodes from simulated annealing and lithium NMR spectroscopy’, *Chemistry of Materials*, **29(13)**:5550–5557 (2017).
3. **J. M. Foster**, X. Huang, M. Jiang, S. J. Chapman, B. Protas & G. Richardson, ‘Causes of binder damage in porous battery electrodes and strategies to prevent it’, *Journal of Power Sources*, **350**:140–151 (2017).
4. K. Domanski, B. Roose, M. Taisuke, M. Saliba, J. Correa-Baena, G. Richardson, **J. M. Foster**, F. De Angelis, A. Petrozza, N. Mine, W. Tress, U. Steiner, A. Hagfeldt & A. Abate, ‘Migration of cations induces reversible performance losses over day/night cycling in perovskite solar cells’, *Energy & Environmental Science*, **10**:604–613 (2017).
5. S. E. J. O’Kane, G. Richardson, A. Pockett, R. G. Niemann, J. M. Cave, N. Sakai, G. E. Eperon, H. J. Snaith, **J. M. Foster**, P. J. Cameron & A. B. Walker, ‘Measurement and modelling of dark current decay transients

- in perovskite solar cells’, *Journal of Materials Chemistry C*, **5**:452–462 (2017).
6. **J. M. Foster** & D. E. Pelinovsky, ‘Self-similar solutions for reversing interfaces in the nonlinear diffusion equation with constant absorption’, *SIAM Journal on Applied Dynamical Systems*, **15**(4):2017–2050 (2016).
 7. G. Richardson, S. E. J. O’Kane, R. G. Niemann, T. A. Peltola, **J. M. Foster**, P. J. Cameron & A. B. Walker, ‘Can slow-moving ions explain hysteresis in the current-voltage curves of perovskite solar cells?’, *Energy & Environmental Science*, **9**:1476–1485 (2016).
 8. H. Liu, **J. M. Foster**, A. Gully, S. Krachkovskiy, M. Jiang, Y. Wu, X. Yang, B. Protas, G. R. Goward & G. A. Botton, ‘Three-dimensional investigation of cycling-induced microstructural changes in lithium-ion battery cathodes using focused ion beam/scanning electron microscopy’, *Journal of Power Sources*, **306**:300–308 (2016).
 9. A. Abate, R. P. Tejada, K. Wojciechowski, **J. M. Foster**, A. Sadhanala, U. Steiner H. J. Snaith, S. Franco & J. Orduna, ‘Phosphonic anchoring groups in organic dyes for solid-state solar cells’, *Physical Chemistry Chemical Physics*, **17**:18780–18789 (2015).
 10. **J. M. Foster**, A. Gully, H. Liu, S. Krachkovskiy, Y. Wu, S. Schougaard, M. Jiang, G. Goward, G. A. Botton & B. Protas, ‘A homogenization study of the effects of cycling on the electronic conductivity of commercial lithium-ion battery cathodes’, *Journal of Physical Chemistry C*, **119**(22):12199–12208, (2015).
 11. S. Guarnera, A. Abate, W. Zhang, **J. M. Foster**, G. Richardson, A. Petrozza & H. J. Snaith, ‘Improving the long-term stability of perovskite solar cells with a porous Al₂O₃ buffer-layer’, *Journal of Physical Chemistry Letters*, **6**(3):432–437 (2015).
 12. S. George, **J. M. Foster** & G. Richardson, ‘Modelling in vivo action potential propagation along a giant axon’, *Journal of Mathematical Biology*, **70**:237–263 (2015).
 13. **J. M. Foster**, T. Leijtens, H. J. Snaith & G. Richardson, ‘A model for perovskite based hybrid solar cells: analysis and comparison with experiment’, *SIAM Journal on Applied Mathematics*, **74**(6):1935–1966 (2014).
 14. **J. M. Foster** & A. D. Fitt, ‘The halting of contact lines in slender viscous films driven by gravity and surface tension gradients’, *Physics of Fluids*, **26**:073601 (2014).
 15. **J. M. Foster**, J. Kirkpatrick & G. Richardson, ‘Asymptotic and numerical prediction of current-voltage curves for an bilayer organic solar cell under varying illumination and comparison to the Shockley equivalent circuit’, *Journal of Applied Physics*, **114**(10):104501 (2013).
 16. G. Richardson, C. P. Please, **J. M. Foster** & J. Kirkpatrick, ‘Asymptotic solution of a model for bilayer organic diodes and solar cells’, *SIAM Journal on Applied Mathematics*, **72**(6):1792–1817 (2012).

17. **J. M. Foster**, C. P. Please & A. D. Fitt, ‘The slow spreading of several viscous films over a deep viscous pool’, *Physics of Fluids*, **24(6)**:063601 (2012).
18. **J. M. Foster**, C. P. Please, A. D. Fitt & G. Richardson, ‘The reversing of interfaces in slow diffusion processes with strong absorption’, *SIAM Journal on Applied Mathematics*, **72(1)**:144–162 (2012).
19. **J. M. Foster**, C. P. Please & A. D. Fitt, ‘The slow spreading of a viscous fluid film over a deep viscous pool’, *Journal of Engineering Mathematics*, **71**:393–408 (2011).

In review:

20. **J. M. Foster**, P. Gysbers, J. R. King & D. E. Pelinovsky, ‘Bifurcations of self-similar solutions for reversing interfaces in the slow diffusion equation with absorption’, submitted for publication.
21. N. E. Courtier, **J. M. Foster**, S. E. J. O’Kane, A. B. Walker & G. Richardson, ‘Systematic derivation of a surface polarization model for planar perovskite solar cells’, submitted for publication.
22. N. E. Courtier, G. Richardson & **J. M. Foster**, ‘A fast and robust numerical scheme for solving models of charge carrier transport and ion vacancy motion in perovskite solar cells’, submitted for publication.
23. F. Font, B. Protas, G. Richardson & **J. M. Foster**, ‘Binder migration during drying of lithium-ion battery electrodes: modelling and comparison to experiment’, submitted for publication.
24. S. A. Krachkovskiy, **J. M. Foster**, J. David Bazak, Bruce J. Balcom, Nicole D. Ellison, I. C. Halalay & G. R. Goward, ‘Spatially resolved phase transformation and in-operando mapping of the Li concentration in graphite electrodes by in-situ MRI and NMR’, submitted for publication.
25. N. E. Courtier, J. M. Cave, **J. M. Foster**, A. B. Walker & G. Richardson, ‘How transport layer properties affect perovskite solar cell performance: insights from a coupled charge transport/ion migration model’, submitted for publication.

**TEACHING
EXPERIENCE**

Lecturing experience: Portsmouth University

- M305: Unit coordinator for Projects in Mathematics (Perturbation theory), Sept 2017 – May 2018
- M221: Applied Mathematics part II, Jan 2017 – May 2017, Jan 2018 – May 2018
- M121: Mathematical Models part I, Sept 2016 – Dec 2016, Sept 2017 – Dec 2017

Lecturing experience: EPSRC Centre for Doctoral Training, New and Sustainable Photovoltaics

- Numerical methods, Feb 2017, Feb 2018

Lecturing experience: McMaster University

- CSE702: Advanced computational methods and models, Jan 2016 – March 2016 (with positive feedback from students - detailed feedback available on request)
- MATH3Q03: Numerical explorations, Sept 2015 – Dec 2015 (4 lectures only)
- MATH2ZZ3: Engineering Mathematics IV, Jan 2015 – March 2015 (5 lectures only)

Lecturing experience: University of Southampton

- MATH1004: Introductory mathematics for chemists and oceanographers, Oct 2013 - Jan 2014 (with very positive feedback from students - 4.7/5 student satisfaction rating)
- MATH1004: Introductory mathematics for chemists and oceanographers, Oct 2012 - Jan 2013 (with very positive feedback from students - 4.6/5 student satisfaction rating)

Demonstrating experience: University of Southampton

- Partial differential equation, Feb 2012 - Jun 2012
- Mathematical methods for physicists, Oct 2011 - Jan 2012
- Differential equations, Oct 2011 - Jan 2012
- Mathematical methods for physicists & engineering workshops, Feb 2011 - Jun 2011
- MAPLE demonstrating & engineering workshops, Oct 2010 - Jan 2011
- Engineering workshops, Feb 2010 - Jun 2010
- Self paced course for engineers & engineering workshops, Oct 2009 - Jan 2010
- Introduction to applied mathematics & engineering workshops, Feb 2009 - Jun 2009
- Applications of vector calculus & engineering workshops, Oct 2008 - Jan 2009
- Complex variable theory & Calculus I, Feb 2008 - Jun 2008
- MAPLE demonstrating & linear algebra II, Oct 2007 - Jan 2008
- Home school tutoring, part time employee teaching mathematics and physics to AS and A level students, Oct 2004 - Sept 2007

PhD supervision

- M. Castle, Sept 2017 - present

Informal PhD supervision

- S. George (with G. Richardson).
- R. Ranom (with G. Richardson).
- A. Sethurajan (with B. Protas).

Undergraduate Student Supervision

- V. Nenh undergraduate project, 3rd year Mathematics at Portsmouth University.
- T. Wildsmith undergraduate project, 3rd year Mathematics at Portsmouth University.
- M. Castle undergraduate project, 3rd year Mathematics at Portsmouth University.
- R. Costa undergraduate project, 3rd year Mathematics at Portsmouth University.
- T. Ting undergraduate project, 3rd year Mathematics at Portsmouth University.
- J. Wilkinson summer project (co-supervised with W. Lee), 2nd year BSc Mathematics at Cambridge University.
- P. Gysbers undergraduate project (co-supervised with D. Pelinovsky), 4th year BSc Physics at McMaster University.
- M. Burton undergraduate project (co-supervised with J. Owen), 4th year MSc Chemistry at Southampton University.
- J. Witham undergraduate project (co-supervised with G. Richardson), 3rd year MSc Mathematics at Southampton University.

SELECTED CONFERENCE AND SEMINARS

- *University of Southampton, *Applied seminar series*, ‘Mechanical degradation in lithium-ion batteries’, Nov 2016.
- University of Portsmouth, *Applied Mathematics seminar series*, ‘Mechanical degradation in lithium-ion batteries’, Nov 2016.
- *University of Warwick, *Multiscale phenomena in electrochemical and porous systems*, ‘Binder delamination in lithium-ion cells’, Jun 2016.
- École Polytechnique Fédérale de Lausanne (in association with Fraunhofer Institute for Solar Energy Systems), *ModVal13: 13th Symposium for Fuel Cell and Battery Modeling and Experimental Validation*, ‘Explaining the mechanisms for binder delamination in lithium-ion cells’, Mar 2016.
- *The Fields Institute for Research in Mathematical Sciences, *Fields Institute Applied Mathematics Seminar*, ‘Continuum mechanics models for investigating the morphological ageing of lithium-ion battery electrodes: formulation, homogenization, numerical and asymptotic solutions and comparison to experiment’, Jan 2016.
- McMaster Automotive Research Centre, *Automotive Partnership Canada: Annual meeting*, ‘Monte-Carlo modelling of the annealing process in NMC battery active materials’, Dec 2015.
- *University of Ontario Institute of Technology, *Modelling and Computational Science seminar series*, ‘Degradation in lithium-ion batteries’, Oct 2015.

- *Wilfrid Laurier University, *CAIMS-AMMCS Congress*, ‘The effects of cycling on the ‘connectedness’ of the binder in lithium-ion cathodes’, Jun 2015.
- *Wilfrid Laurier University, *CAIMS-AMMCS Congress*, ‘Self-similar reversing interfaces (contact lines) for the porous medium equation with absorption: the dynamical system framework’, Jun 2015.
- Freiburg (in association with Fraunhofer Institute for Solar Energy Systems), *ModVal12: 12th Symposium for Fuel Cell and Battery Modeling and Experimental Validation*, ‘The effects of cycling on the ‘connectedness’ of the binder matrix in lithium-ion cathodes’, Mar 2015.
- McMaster Automotive Research Centre, *Automotive Partnership Canada: Annual meeting*, ‘Towards modelling the ageing of the binder in Li-ion cell cathodes during cycling’, Nov 2014.
- *University of Oxford, *Snaith group meeting*, ‘Drift-diffusion modelling of perovskite solar cells’, Sept 2013.
- OCCAM University of Oxford, *Challenges in Applied Mathematics*, ‘A model for perovskite based solar cells’, Jun 2013.
- OCCAM University of Oxford, *Solar cell focus group*, ‘Current-voltage curves in organic bilayer solar cells’, Aug 2012.
- Munich (in association with University of Regensburg), *Free boundary problems*, ‘Reversing interfaces in solutions to the porous medium equation’, Jun 2012.
- *St. Catherine’s College University of Oxford, *KTN annual meeting*, ‘Diffusion processes in glass manufacture’, Nov 2011.
- *University of Southampton, *Applied seminar series*, ‘Revering interfaces in diffusion processes’, Nov 2011.
- University of Edinburgh, *BAMC/BMC*, ‘Slow diffusion processes with strong absorption’, Mar 2010.
- *St. Catherine’s College University of Oxford, *KTN annual meeting*, ‘The slow spreading of a viscous film over a deep viscous pool’, Nov 2009.
- University of Nottingham, *BAMC*, ‘A model for the spreading of a foam under gravity’, Mar 2009.
- QUT Brisbane, *Applied mathematics seminar series*, ‘Modelling the flow in a float glass furnace’, Jun 2008.
- University of Manchester, *BAMC*, ‘The mathematics of a glass furnace’, Mar 2008.

Starred entries indicate invited presentations.

FUNDING
(>£1000/\$1000)

- Industrial funding *Meltz LLC./BeVrada Systems* (2017).
£4,400 (GBP) as PI & £4,400 (GBP) as Co-I.
- Named collaborator on Collaborative Research & Development (CRD) Program with General Motors Global R&D as industrial partner. Natural Sciences and Engineering Research Council of Canada, Structural evolution of electrode materials and mitigation of degradation by Mn-trapping in Li-Ion Batteries via complementary characterization methods and mathematical modeling (2016).
\$826,000 (CAD) from NSERC and \$416,000 (CAD) from General Motors Global R&D.
- Postdoctoral fellowship at *The Fields Institute for Research in Mathematical Sciences* (2016).
\$45,000 (CAD).
- Postdoctoral fellowship at the *University of Southampton* (2011).
£16,000 (GBP).

SERVICE

Refereeing duties:

I act as a referee for the following journals: (i) the SIAM Journal of Applied Mathematics; (ii) the Journal of the Electrochemical Society; (iii) the Journal of Applied Physics; (iv) the Journal of Engineering Mathematics; (v) the Journal of Physical Chemistry, and; (vi) the European Physical Journal Plus. In addition I am also a reviewer for Mathematical Reviews (AMS).

Organisational duties:

I organised and acted as chair in a session in the 2014 CMS winter meeting. I am the founder and acted as the principal organiser for the mathematics PG applied seminar series. This is an ongoing series of weekly seminars (typically attended by 15-25 PG students at the University of Southampton) given by and aimed at PG students in the applied mathematics discipline.

COMPUTING SKILLS

I am proficient in the following languages/environments: Unix, Linux, LaTeX, MATLAB (including Chebfun), COMSOL, MAPLE, Mathematica, Python and FreeFEM++.