

# PHILIPPE H. TRINH

DARBY FELLOW IN APPLIED MATHEMATICS

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## RESEARCH INTERESTS

Fluid and solid mechanics, perturbation theory and asymptotic analysis, exponential asymptotics, free-surface flows, thin films and elastocapillary flows, wave-structure interactions, hydrodynamic instabilities

## RESEARCH SUMMARY

My research is motivated by a range of physical applications in fluid and solid mechanics, from classical hydrodynamics and wave-structure interactions, to thin film flow, elastocapillary systems, and biological models of tissue growth or pattern formation. My primary area of expertise concerns the study of problems that involve a breakdown of traditional techniques in perturbation theory. Many of these problems involve the study of nonlinear differential equations and require the development of specialized methodologies and techniques, such as *exponential asymptotics* or *asymptotics beyond-all-orders*.

## ACADEMIC POSITIONS

2012–2017 **Darby Fellow in Applied Mathematics**  
University of Oxford  
Oxford Centre for Industrial and Applied Mathematics  
Mathematical Institute & Lincoln College

2010–2012 **Lecturer & Research Associate**  
Princeton University  
Program in Applied and Computational Mathematics  
*Collaborators:* Profs. Weinan E & Howard A. Stone

## EDUCATION

2007–2010 **Doctor of Philosophy in Mathematics**  
University of Oxford  
Oxford Centre for Industrial and Applied Mathematics  
Mathematical Institute & Balliol College  
*Supervisor:* Prof. S. Jonathan Chapman  
*Thesis:* Exponential asymptotics and free-surface flows

2006–2007 **Master of Science in Applied Mathematics**  
Carleton University (Ottawa, Ontario)  
School of Mathematics and Statistics  
*Supervisor:* Prof. David E. Amundsen  
*Thesis:* Resonant solutions of Korteweg-de Vries equations

2004–2006 **Bachelor of Mathematics in Pure Mathematics**  
Carleton University (Ottawa, Ontario)  
School of Mathematics and Statistics

## RESEARCH VISITS

- May to Apr. 2014, 2015 Duke University  
Department of Mathematics  
*Working with:* Prof. Thomas P. Witelski  
*Research topics:* Formation of finite-time singularities in PDEs, rupture in thin film flows, vortex reconnection, self-similarity
- Jun. to Aug. 2013, 2014 University of British Columbia  
Mathematics Department  
*Working with:* Prof. Michael J. Ward  
*Research topics:* Reaction-diffusion equations on curved surfaces, localized spot patterns, differential-algebraic equations
- May 2014 Princeton University  
Department of Mathematics  
*Working with:* Prof. Howard A. Stone & the Complex Fluids Group  
*Research topics:* Thin film flows on curved surfaces, interfacial instabilities, bubble dynamics (Bretherton problem), contact line problems

## ACADEMIC ACHIEVEMENTS & AWARDS

- 2010 Oxford University Teaching Excellence Award (MPLS Division)
- 2010 Tuck Fellowship (IWWF/University of Adelaide)  
Inaugural recipient; award associated with the International Workshop on Water Waves and Floating Bodies, and administered by the University of Adelaide and Australian Mathematics Society.
- 2007-2010 Clarendon Scholarship (University of Oxford)
- 2007 Commonwealth Scholarship (CSFP)
- 2007-2010 NSERC Postgraduate Doctoral Scholarship (Canada)
- 2007 Gary S. Duck Award in Physics, Math, and Photonics
- 2007 University Senate Medal (Carleton)
- 2004, 2006 Canadian Governor General's Academic Medal
- 2006 NSERC Postgraduate Master's Scholarship (Canada)
- 2006 Graduate Studies and Research Scholarship (Carleton)
- 2006 Carleton Mathematics Departmental Scholarship (Carleton)
- 2005, 2006 USRA NSERC Undergrad. Research Award (Carleton)
- 2005 Helga H. Shirmer Mathematics Award (Carleton)

## SUBMITTED OR PRE-PRINT PUBLICATIONS\*

- 2016 Crew, S. C. & Trinh, P. H. 2016 New singularities for Stokes waves. *J. Fluid Mech.* (in review) [arxiv.org/abs/1510.04254](https://arxiv.org/abs/1510.04254)
- 2016 Trinh, P. H. 2016 A topological study of gravity waves generated by moving bodies using the method of steepest descents. *Proc. Roy. Soc. A* (in review) [arxiv.org/abs/1510.06014](https://arxiv.org/abs/1510.06014)
- 2016 Trinh, P. H. 2016 On reduced models for gravity waves generated by moving bodies. *J. Fluid Mech.* (in review) [arxiv.org/abs/1510.06647](https://arxiv.org/abs/1510.06647)
- 2016 Trinh, P. H., Wilson, S. K. & Stone, H. A. 2016 Elastic plates on thin viscous films. *J. Fluid Mech.* (To be submitted) [arxiv.org/abs/1410.8558](https://arxiv.org/abs/1410.8558)

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\* All preprints viewable on the arXiv or personal website.

- 2016 Hammoud, N., Trinh, P. H., Howell, P. D. & Stone, H. A. 2016 The influence of van der Waals forces on a bubble moving in a tube. *Phys. Rev. Fluids* (in review) [arxiv.org/abs/1601.00726](https://arxiv.org/abs/1601.00726)

## JOURNAL AND BOOK PUBLICATIONS\*\*

- 2016 Trinh, P. H. & Ward, M. J. 2016 The dynamics of localized spot patterns for reaction-diffusion systems on the sphere. *Nonlinearity* **29** (3), 766–806. doi:10.1088/0951-7715/29/3/766
- 2015 Ren, W., Trinh, P. H. & E, W. 2015 On the distinguished limits of the Navier slip model of the moving contact line problem. *J. Fluid Mech.* **772**, 107–126. doi:10.1017/jfm.2015.173
- 2015 Trinh, P. H. & Chapman, S. J. 2015 Exponential asymptotics and problems with coalescing singularities. *Nonlinearity* **28** (5), 1229–1256. doi:10.1088/0951-7715/28/5/1229
- 2014 Trinh, P. H., Wilson, S. K. & Stone, H. A. 2014 A pinned or free-floating rigid plate on a thin viscous film. *J. Fluid Mech.* **760**, 407–430. doi:10.1017/jfm.2014.526
- 2014 Trinh, P. H., Kim, H., Hammoud, N., Howell, P. D., Chapman, S. J. & Stone, H. A. 2014 Curvature suppresses the Rayleigh–Taylor instability. *Phys. Fluids* **26** (5), 051704. doi:10.1063/1.4876476
- 2014 Trinh, P. H. & Chapman, S. J. 2014 The wake of a two-dimensional ship in the low-speed limit: results for multi-cornered hulls. *J. Fluid Mech.* **741**, 492–513. doi:10.1017/jfm.2013.589
- 2013 Wexler, J. S., Trinh, P. H., Berthet, H., Quennouz, N., du Roure, Olivia, Huppert, H. E., Linder, A. & Stone, H. A. 2013 Bending of elastic fibres in viscous flows: the influence of confinement. *J. Fluid Mech.* **720**, 517–544. doi:10.1017/jfm.2013.49
- 2013 Chapman, S. J., Trinh, P. H. & Witelski, T. P. 2013 Exponential asymptotics for thin film rupture. *SIAM J. Appl. Math.* **73** (1), 232–253. doi:10.1137/120872012
- 2013 Trinh, P. H. & Chapman, S. J. 2013 New gravity-capillary waves at low speeds. Part 1: Linear theory. *J. Fluid Mech.* **724**, 367–391. doi:10.1017/jfm.2013.110
- 2013 Trinh, P. H. & Chapman, S. J. 2013 New gravity-capillary waves at low speeds. Part 2: Nonlinear theory. *J. Fluid Mech.* **724**, 392–424. doi:10.1017/jfm.2013.110
- 2011 Trinh, P. H., Chapman, S. J. & Vanden-Broeck, J.-M. 2011 Do waveless ships exist? Results for single-cornered hulls. *J. Fluid Mech.* **685**, 413–439. doi:10.1017/jfm.2011.325
- 2010 Trinh, P. H. 2010 *Asymptotic Methods in Fluid Mechanics: Survey and Recent Advances*, chap. Exponential Asymptotics and Stokes Line Smoothing for Generalized Solitary Waves, pp. 121–126. SpringerWienNewYork
- 2010 Trinh, P. & Amundsen, D. 2010 Unifying steady-state resonant solutions of a broad class of KdV-type equations. *J. Comput. Appl. Math.* **234** (6), 1788–1795. doi:10.1016/j.cam.2009.08.029

## IN PREPARATION

- Trinh, P. H. & Witelski, T. P. 20— Existence and non-existence of countable sequences of similarity solutions. (*In preparation*)
- Trinh, P. H. & Witelski, T. P. 20— Complex singularities and selection mechanisms in nonlinear differential equations. (*In preparation*)
- Macdonald, C. B., Mäerz, T. & Trinh, P. H. 20— Thin film equations with the Closest Point Method. (*In preparation*)
- Trinh, P. H. & Vella, D. 20— Near threshold buckling analysis of a floating elastic annulus. (*In preparation*)

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\*\*Only including refereed journal publications.

## GRADUATE RESEARCH SUPERVISION

- 2015–Present **Helen Fletcher**  
Doctor of Philosophy (Ph.D.) in Mathematics  
Industrially Focused Mathematical Modelling  
Mathematics, University of Oxford
- Thesis:* Active wave absorption for polychromatic waves  
*\* Co-advisor with Prof. S.J. Chapman (Oxford)*  
*\* Research in collaboration and with partial funding from Coastal and Hydraulics  
Laboratory, US Army ERDC and HR Wallingford, Ltd.*
- 2013–Present **Naima Hammoud**  
Doctor of Philosophy (Ph.D.) in Mathematics  
Mathematics, Princeton University
- Thesis:* Suppression of fluid instabilities in coating flows  
*\* Co-advisor with Prof. H.A. Stone (Princeton)*
- 2014–2015 **Amy Guyomard**  
Master of Science (M.Sc.) in Mathematics  
Mathematics, University of Oxford
- Thesis:* The multi-dimensional method of steepest descents

## UNDERGRADUATE RESEARCH SUPERVISION

- 2015–2016 **Sean Jamshidi**  
Master of Mathematics (MMath) dissertation  
Mathematics, University of Oxford
- Thesis:* Searching for new gravity-capillary waves
- 2015–2016 **Thomas Chandler**  
Mathematical Extended Essay (third year)  
Mathematics, University of Oxford
- Thesis:* Splash models for flows near the bow of a ship
- Summer 2015 **Samuel Crew**  
Undergraduate Research Programme  
Mathematics, University of Oxford
- Thesis:* On the singularity of the finite amplitude Stokes wave
- 2014–2015 **Alexander Gower**  
Master of Mathematics (MMath) dissertation  
Mathematics, University of Oxford
- Thesis:* Phase field models and the thin film limit
- 2014–2015 **Benjamin Whitlock**  
Master of Mathematics (MMath) dissertation  
Mathematics, University of Oxford
- Thesis:* Models for thin film flows on curved surfaces
- 2014–2015 **Jamie Cruickshank**  
Master of Mathematics (MMath) dissertation  
Mathematics, University of Oxford
- Thesis:* Tissue growth in a mono-layered epithelium

- 2013–2014 **Lucy Auton**  
 Master of Mathematics (MMath) dissertation  
 Mathematics, University of Oxford  
*Thesis:* Multiple scales for discrete difference equations
- 2013–2014 **Thomas Pettifor**  
 Master of Mathematics (MMath) dissertation  
 Mathematics, University of Oxford  
*Thesis:* Discrete and continuum models for in vitro tissue growth
- 2013–2014 **Melissa Varney**  
 Master of Mathematics (MMath) dissertation  
 Mathematics, University of Oxford  
*Thesis:* Mathematical models for the wrinkling of thin sheets
- 2013–2014 **Stephanie Yayoi Teramoto**  
 Certificate in Applied and Computational Mathematics  
 Department of Mathematics, Princeton University  
*Thesis:* Stability of patterns in reaction–diffusion equations  
 \* *Winning project in SIAM 2013 contest for Teaching Dynamical Systems*  
 \*\* *Winner of PACM Independent Project Prize*
- 2011–2012 **Rafaël Y. Grinberg**  
 Undergraduate Senior Thesis  
 Mathematics, Princeton University  
*Thesis:* Topics in Real Analysis  
 \* *Awarded a departmental distinction for thesis*
- 2011–2012 **Daniel Wu**  
 Undergraduate Research Project  
 Mathematics, Princeton University  
*Thesis:* Functional analysis and its applications to potential theory

## FUNDING & GRANTS

- 2016 **Oxford Mathematics Summer Research Bursary**  
 A grant for £2500 to Thomas Chandler (MMath) in order to undertake a summer research project on the study of splash models for breaking water waves. *Approved to begin Summer 2016*
- 2015 **EPSRC Centre for Doctoral Training in Industrially Focused Mathematical Modelling**  
 Joint principal investigator for a Ph.D. project to develop mathematical models to predict boundary and internal processes for a high resolution computational wave flume. Joint funding from the EPSRC Centre for Doctoral Training in Industrially Focused Mathematical Modelling (InFoMM) and the US Army Corps of Engineers (USACE). *Approved to begin 2016.*
- 2014 **Zilkha Fund (Lincoln College, Oxford)**  
 A grant for £2000 awarded by the Trustees of the Zilkha fund to cover a research trip to the University of British Columbia to study the formation of localized spots in reaction diffusion equations on surfaces with Prof. Michael Ward.

## TEACHING AWARDS

- 2010 **University of Oxford Teaching Excellence Award**  
Through student and faculty nominations, I was recognized by the Mathematical, Physical, and Life Sciences Division (MPLS) for my commitment to teaching and innovative approaches in the classroom.

## TEACHING EXPERIENCE

- 2011-2012 **Lecturer and Course Coordinator**  
*MAT350 Introduction to Differential Equations (3<sup>rd</sup> year, Mathematics)*  
Mathematics Department, Princeton University

*Responsibilities:* managing a teaching assistant, designing and delivering the course lectures, writing course notes and assignments, and creating midterm and final examinations.

- Various **Departmental & College Tutor**  
University of Oxford, Princeton University, Carleton University

I have taught all the classes below either as a departmental tutor (managing teaching assistants, directing and teaching classes of 15-30 students), or as a college tutor (in the Oxford tutorial system; a more supervisory role involving tutorial teaching). Many of these roles have given me the opportunity to develop further additional course material (for tutorials, examination preparation, etc.).

- Math Alive! • *Princeton (Mathematics, yr. 1)*
- Applied differential equations • *Princeton (Mathematics, yr. 3)*
- Geometry • *Oxford (Mathematics, yr. 1)*
- Multivariable calculus • *Oxford (Mathematics, yr. 1)*
- Fourier series and PDEs • *Oxford (Mathematics, yr. 1)*
- Applications to mathematical physics • *Oxford (Mathematics, yr. 1)*
- Differential equations I-II • *Oxford (Mathematics, yr. 2)*
- Integral equations • *Oxford (Mathematics, yr. 2)*
- Calculus of variations • *Oxford (Mathematics, yr. 2)*
- Classical mechanics • *Oxford (Mathematics, yr. 2)*
- Techniques in applied mathematics • *Oxford (Mathematics, yr. 3)*
- Viscous flows • *Oxford (Mathematics, yr. 3)*
- Waves and compressible flow • *Oxford (Mathematics, yr. 3)*
- Perturbation methods • *Oxford (Mathematics, yr. 4)*
- Applied complex variables • *Oxford (Mathematics, yr. 4)*
- Vector spaces and matrices • *Oxford (Physics, yr. 1)*
- Normal modes and waves • *Oxford (Physics, yr. 1)*
- Multiple integrals and vector calculus • *Oxford (Physics, yr. 1)*

## RESEARCH & ADMINISTRATIVE MANAGEMENT

- 2014 **OCIAM Industrial and Interdisciplinary Workshops**

In 2014, I was involved with coordinating and managing the industrial workshops. The role required collaborating with Oxford faculty in organizing speakers (chosen from industry or other departments), hosting visitors during the workshops, and serving as a bridge between the industrial and academic communities.

2012–Present **Member of Governing Body at Lincoln College**

I serve as an active member of Lincoln College’s Governing Body, which provides me with the opportunity to participate in many aspects of the college management. In particular, I have acted as an interviewer for several staff and lecturer positions, in addition to the typical responsibilities of interviewing undergraduate candidates within Oxford’s collegiate scheme.

2013–Present **Fellow for Schools Liaison at Lincoln College**

My role as the Fellow for Schools Liaison involves traveling to schools in Lincolnshire and the surrounding area for outreach efforts on behalf of the college. These events give me an opportunity to discuss Oxford applications, the interview process, academic and undergraduate life with younger school students. The role also involves acting as a host during open days or special events within Oxford.

2011–2012 **Princeton University ALTA faculty advisory board**

I was nominated to serve as a member of the faculty advisory board for the ALTA (Academic Life Total Assessment) project organized by the Princeton Undergraduate Student Government. The goal of the project is to provide a detailed assessment of undergraduate life and suggest ways of improving the student learning experience.

**A SELECTION OF TALKS**

*“Beyond all orders: the role of exponentially small effects in the physical sciences”*

*On:* The emergence of techniques in exponential asymptotics from the historical resolution of several long-standing problems; a survey of current research with focus on applications to thin film rupture and hydrodynamics.

- 2015 Applied and Computational Mathematics Seminar, Edinburgh University (UK)
- 2015 Center for Nonlinear and Complex Systems Seminar, Duke University (USA)
- 2015 Fluid Dynamics Seminar, Imperial College London (UK)

*“On Tulin’s paradox: an exact theory of gravity wave generation by moving bodies”*

*On:* The resolution of long-standing questions posed by M.P. Tulin in regards to developing an exact theory of wave–structure interactions; a proposal of a new steepest descent methodology.

- 2015 International Conference on Nonlinear Evolution Equations and Wave Phenomena (IMACS), University of Georgia (USA)
- 2015 International Applied and Computational Complex Analysis workshop, Imperial College London (UK)

*“Have you seen our water waves? Theoretical predictions of new gravity–capillary waves at low speeds”*

*On:* Exponential asymptotics has allowed for the theoretical prediction of new classes of gravity–capillary waves, induced by flows over nonlinear geometries.

- 2014 Applied Mathematics Seminar, University College London (UK)
- 2013 Applied Mathematics Seminar, University of Delaware (USA)
- 2011 Program in Applied and Computational Mathematics (PACM) Colloquium, Princeton University (USA)

*“Thin film flows on curved surfaces”*

*On:* On the importance and theory of thin film dynamics on general curved surfaces, and the suppression of the Rayleigh-Taylor instability through substrate curvature.

- 2013 Oxford-Princeton Collaborative Workshop, Princeton University (USA)
- 2012 Annual Meeting of the APS Division of Fluid Dynamics (San Diego, USA)

*“The contact lens problem and thin film flows with elastic structures”*

*On:* Studying the role of competing effects of surface tension, viscosity, and substrate rigidity on thin film free-surface interactions with a rigid or elastic plate.

- 2015 Fluids & Elasticity 2015, Biarritz (France)
- 2013 Applied Mathematics Seminar, University of Delaware (USA)

REFERENCES

**Prof. S. Jonathan Chapman**

Mathematical Institute  
University of Oxford (*Oxford, UK*)  
[chapman@maths.ox.ac.uk](mailto:chapman@maths.ox.ac.uk)

**Prof. Howard A. Stone**

Department of Mechanical & Aerospace Engineering  
Princeton University (*Princeton, USA*)  
[hastone@princeton.edu](mailto:hastone@princeton.edu)

**Dr. Dominic Vella**

Mathematical Institute  
University of Oxford (*Oxford, UK*)  
[vella@maths.ox.ac.uk](mailto:vella@maths.ox.ac.uk)

**Prof. Michael J. Ward**

Department of Mathematics  
University of British Columbia (*Vancouver, Canada*)  
[ward@math.ubc.ca](mailto:ward@math.ubc.ca)

**Prof. Stephen K. Wilson**

Department of Mathematics and Statistics  
University of Strathclyde (*Glasgow, UK*)  
[s.k.wilson@strath.ac.uk](mailto:s.k.wilson@strath.ac.uk)

**Prof. Thomas P. Witelski**

Department of Mathematics  
Duke University (*Durham, USA*)  
[witelski@math.duke.edu](mailto:witelski@math.duke.edu)