PROFESSOR BRENDAN GUILFOYLE
CURRICULUM VITAE

Current Position: Professor of Mathematics, Munster Technological University.
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Munster Technological University,
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Researchgate: www.researchgate.net/profile/Brendan_Guilfoyle
Google Scholar: https://scholar.google.com/citations?user=aLvWdFcAAAAJ

1. EDUCATION

1997 Ph.D. in Mathematics, University of Texas, Austin. Dissertation: *The Cauchy initial value problem for the gravitational Yang-Mills equations*, Supervisor: Prof. Karen K. Uhlenbeck

1991 Master of Science by Research in Mathematics, Trinity College, Dublin. Dissertation: *Weyl-type electrostatic fields: new exterior and interior solutions*, Supervisor: Prof. Petros Florides

1988 Bachelor of Arts in Mathematics, Trinity College, Dublin.

2. PROFESSIONAL POSITIONS

2021 − Professor in the Munster Technological University, Tralee, Ireland.
2019 − 2020 Professor in the Institute of Technology, Tralee, Ireland.
1996 − 2019 Lecturer in the Institute of Technology, Tralee, Ireland.
1993 − 1996 Assistant Instructor in the University of Texas, Austin, USA.
1991 − 1993 Teaching Assistant in the University of Texas, Austin, USA.

3. VISITING RESEARCH POSITIONS

2024 Research Fellowship, Mathematisches Forschungsinstitut Oberwolfach, Germany.
2024 Research Guest, Max Planck Institute for Mathematics, Bonn, Germany.
2023 Research Fellowship, Mathematisches Forschungsinstitut Oberwolfach, Germany.
September 2022 Invited guest, Institute for Advanced Studies, Princeton, USA.
Summer/Fall 2019 Distinguished Visitor, University College Dublin, Ireland.
Spring 2013 Research Member, Institut des Hautes Études Scientifiques, Paris, France.
Spring 2013 Research Guest, Max Planck Institute for Mathematics, Bonn, Germany.
Spring 2012 Research Member, Institut des Hautes Études Scientifiques, Paris, France.
Fall 2011 Research Guest, Max Planck Institute for Mathematics, Bonn, Germany.
2009/10 Research Associate, MSRI, Berkeley California.
2006/7/8 Research in Pairs Programme, Mathematisches Forschungsinstitut Oberwolfach, Germany.

2008 Research Visitor, Albert Einstein Institute, Golm, Germany.

2002/7/8 SFB Research Visitor, Humboldt University, Berlin, Germany.

2006 Invited participant on Pseudo-riemannian Geometry Programme, ESI, Vienna, Austria.

2002/4 Grey College Research Fellowship, University of Durham, England.

4. Awards and Honours

1995 Departmental Teaching Award at University of Texas, Austin.

1994 Departmental nomination for Sloan National Graduate Student Fellowship at University of Texas, Austin.

1987 Awarded (non-Foundation) Scholarship by Trinity College, Dublin.

5. Publications

(49) B. Guilfoyle and W. Klingenberg, *Proof of the Toponogov Conjecture on complete surfaces*, J. Gökova Geom. Topol. GGT **17** (2024) 1–50.

(48) B. Guilfoyle, *A note on umbilic points at infinity*, Beiträge Algebra Geom. (2024). DOI: https://doi.org/10.1007/s13366-024-00740-3

(47) B. Guilfoyle and A. Ortiz-Rodríguez, *Umbilic points on the finite and infinite parts of certain algebraic surfaces*, Math. Proc. R. Ir. Acad. **123A.2** (2023) 63–94. DOI: https://doi.org/10.1353/mpr.2023.a908326

(46) B. Guilfoyle and W. Klingenberg, *Roots of polynomials and umbilics of surfaces*, Results in Math. **78** (2023) 229. DOI: https://doi.org/10.1007/s00025-023-02003-4

(45) B. Guilfoyle, *From CT scans to 4-manifold topology via neutral geometry*, Irish Math. Soc. Bull. **91** Summer (2023) 9–32. DOI: https://doi.org/10.33232/BIMS.0091.9.32

(44) B. Guilfoyle, *A uniqueness theorem for incompressible fluid flows with straight streamlines*, J. Math. Fluid Mech. **24** (2022) 90. DOI: https://doi.org/10.1007/s00021-022-00725-z with Appendix at https://tinyurl.com/3k2ryhbx

(43) N. Georgiou and B. Guilfoyle, *Almost paracomplex structures on 4-manifolds*, Differential Geom. Appl. **82** (2022) 101890. DOI: https://doi.org/10.1016/j.difgeo.2022.101890

(42) N. Georgiou and B. Guilfoyle, *A new geometric structure on tangent bundles*, J. Geom. Phys. **172** (2022) 104415. DOI: https://doi.org/10.1016/j.geomphys.2021.104415

(41) B. Guilfoyle and W. Klingenberg, *Evolving to non-round Weingarten spheres: integer linear Hopf flows*, Partial Differ. Equ. Appl. **2** (2021) 72. DOI: https://doi.org/10.1007/s42985-021-00128-1

(40) G. Cobos and B. Guilfoyle, *An extension of Asgeirsson's mean value theorem for solutions of the ultra-hyperbolic equation in dimension four*, Differential Geom. Appl. **79** (2021) 101795. DOI: https://doi.org/10.1016/j.difgeo.2021.101795

(39) N. Georgiou and B. Guilfoyle, *The causal topology of neutral 4-manifolds with null boundary*, New York J. Math. **27** (2021) 477–507. http://nyjm.albany.edu/j/2021/27-20.html

(38) B. Guilfoyle, *On isolated umbilic points*, Comm. Anal. Geom. **28.8** (2020) 2005–2018. DOI: https://doi.org/10.4310/CAG.2020.v28.n8.a8

(37) B. Guilfoyle and W. Klingenberg, *Fredholm-regularity of holomorphic discs in plane bundles over compact surfaces*, Ann. Fac. Sci. Toulouse Math. Série 6, **29.3** (2020) 565–576. DOI: https://doi.org/10.5802/afst.1639

(36) B. Guilfoyle and W. Klingenberg, *Higher codimensional mean curvature flow of compact spacelike submanifolds*, Trans. Amer. Math. Soc. **372.9** (2019) 6263–6281. DOI: https://doi.org/10.1090/tran/7766

(35) B. Guilfoyle and W. Klingenberg, *A global version of a classical result of Joachimsthal*, Houston J. Math. **45.2** (2019) 455–467. ArXiv https://arxiv.org/abs/1404.5509

(34) B. Guilfoyle and W. Klingenberg, *Parabolic classical curvature flows*, J. Aust. Math. Soc. **104.3** (2018) 338–357. DOI: https://doi.org/10.1017/S1446788717000210

(33) N. Georgiou and B. Guilfoyle, *Hopf hypersurfaces in spaces of oriented geodesics*, J. Geom. **108.3** (2017) 1129–1135. DOI: https://doi.org/10.1007/s00022-017-0400-4

(32) B. Guilfoyle and W. Klingenberg, *A converging Lagrangian curvature flow in the space of oriented lines*, Kyushu J. **70.2** (2016) 343–351. DOI: https://doi.org/10.2206/kyushujm.70.343

(31) D.V. Alekseevsky, B. Guilfoyle and W. Klingenberg, *Erratum to: On the geometry of spaces of oriented geodesics*, Ann. Global Anal. Geom. **50.1** (2016) 97–99. DOI: https://doi.org/10.1007/s10455-016-9515-3

(30) N. Georgiou, B. Guilfoyle and W. Klingenberg, *Totally null surfaces in neutral Kähler 4-manifolds*, Balkan J. Geom. Appl. **21.1** (2016) 27–41. https://www.emis.de/journals/BJGA/v21n1/B21-1ge-a87.pdf

(29) S. Katina, A. Ayoub, B. Guilfoyle, B. Khambay, K. McNeil, P. Siebert, F. Sukno, J. Waddington, P. Whelan and A.W. Bowman, *The definition and validation of three-dimensional landmarks on the human face: an interdisciplinary view*, J. of Anatomy, **228.3** (2016) 355–365. DOI: https://doi.org/10.1111/joa.12407

(28) N. Georgiou and B. Guilfoyle, *Marginally trapped surfaces in spaces of oriented geodesics*, J. Geom. Phys. **82** (2014) 1–12. DOI: https://doi.org/10.1016/j.geomphys.2014.03.012

(27) D.V. Alekseevsky, B. Guilfoyle and W. Klingenberg, *On the geometry of spaces of oriented geodesics*, Ann. Global Anal. Geom. **40** (2011) 389–409. DOI: http://dx.doi.org/10.1007/s10455-011-9261-5

(26) H. Anciaux and B. Guilfoyle, *On the three-dimensional Blaschke-Lebesgue problem*, Proc. Amer. Math. Soc. **139.5** (2011) 1831–1839. DOI: https://doi.org/10.1090/S0002-9939-2010-10588-9

(25) H. Anciaux, B. Guilfoyle and P. Romon, *Minimal Lagrangian surfaces in the tangent bundle of a Riemannian surface*, J. Geom. Phys. **61.1** (2011) 237–247. DOI: https://doi.org/10.1016/j.geomphys.2010.09.017

(24) B. Guilfoyle and W. Klingenberg, *On Weingarten surfaces in Euclidean and Lorentzian 3-space*, Differential Geom. Appl. **28.4** (2010) 454–468. DOI: https://doi.org/10.1016/j.difgeo.2009.12.002

(23) B. Guilfoyle, M. Khalid and J. J. Ramón Marí, *Lagrangian curves on spectral curves of monopoles*, Math. Phys. Anal. Geom. **13.3** (2010) 255–273. DOI: https://doi.org/10.1007/s11040-010-9078-7

(22) N. Georgiou and B. Guilfoyle, *On the space of oriented geodesics of hyperbolic 3-space*, Rocky Mountain J. Math. **40.4** (2010) 1183–1219. DOI: https://www.jstor.org/stable/44239772

(21) N. Georgiou and B. Guilfoyle, *A characterization of Weingarten surfaces in hyperbolic 3-space*, Abh. Math. Sem. Univ. Hambg. **80.2** (2010) 233–253. DOI: https://doi.org/10.1007/s12188-010-0039-7

(20) B. Guilfoyle and W. Klingenberg, *On C^2-smooth surfaces of constant width*, Tbilisi Math. J. **2** (2009) 1–17. DOI: https://doi.org/10.32513/tbilisi/1528768838

(19) B. Guilfoyle and W. Klingenberg, *A neutral Kähler surface with applications in geometric optics*, in Recent developments in pseudo-Riemannian Geometry, European Mathematical Society Publishing House, Zurich (2008) 149–178.

(18) B. Guilfoyle and W. Klingenberg, *On area-stationary surfaces in certain neutral Kähler 4-manifolds*, Beiträge Algebra Geom. **49.2** (2008) 481–490. ArXiv: https://arxiv.org/pdf/math/0611707

(17) B. Guilfoyle and W. Klingenberg, *Geodesic flow on the normal congruence of a minimal surface*, Progr. Math. **265** (2007) 427–436. DOI: https://doi.org/10.1007/978-3-7643-8608-5_11

(16) B. Guilfoyle and W. Klingenberg, *Reflection of a wave off a surface*, J. Geom. **84.1** (2006) 55–72. DOI: https://doi.org/10.1007/s00022-005-0022-0

(15) B. Guilfoyle and W. Klingenberg, *On Hamilton's characteristic functions for reflection*, Irish Math. Soc. Bulletin **57** (2006) 29–40. https://www.maths.tcd.ie/pub/ims/bull57/R5701.pdf

(14) B. Guilfoyle and W. Klingenberg, *Reflection in a translation invariant surface*, Math. Phys. Anal. Geom. **9.3** (2006) 225–231. DOI: https://doi.org/10.1007/s11040-007-9013-8

(13) B. Guilfoyle and W. Klingenberg, *Geodesic flow on global holomorphic sections of TS^2*, Bull. Belg. Math. Soc. **14.2** (2007) 363–371. DOI: https://doi.org/10.36045/bbms/1179839229

(12) B. Guilfoyle and W. Klingenberg, *Isolated umbilical points on surfaces in $\mathbb{R}^3$*, Bull. Greek Math. Soc. **51** (2006) 23–30.

(11) B. Guilfoyle and W. Klingenberg, *An indefinite Kähler metric on the space of oriented lines*, J. London Math. Soc. **72.2** (2005) 497–509. DOI:https://doi.org/10.1112/S0024610705006605

(10) B. Guilfoyle, W. Klingenberg and S. Sen, *The Casimir effect between nonparallel plates by geometric optics*, Reviews in Math. Phys. **17.08** (2005) 859–880. DOI: https://doi.org/10.1142/S0129055X05002431

(9) B. Guilfoyle, *A structure theorem for stationary perfect fluids*, Class. Quantum Grav. **22.9** (2005) 1599–1606. DOI: https://doi.org/10.1088/0264-9381/22/9/008

(8) A. Diatta, P. Giblin, B. Guilfoyle and W. Klingenberg, *Level sets of functions and symmetry sets of surface sections*, in Mathematics of Surfaces. Lecture Notes in Computer Science **3604** (2005).

(7) B. Guilfoyle and W. Klingenberg, *On the space of oriented affine lines in* $\mathbb{R}^3$, Archiv der Math. **82.1** (2004) 81–84. DOI: https://doi.org/10.1007/s00013-003-4861-3

(6) B. Guilfoyle and W. Klingenberg, *Generalised surfaces in* $\mathbb{R}^3$, Math. Proc. R. Ir. Acad. **104A(2)** (2004) 199–209. DOI: https://arxiv.org/abs/math/0406185

(5) B. Guilfoyle, *The local moduli of Sasakian 3-manifolds*, Int. J. Math. Sci. **32.2** (2002) 117–127. DOI: https://doi.org/10.1155/S0161171202006774

(4) B. Guilfoyle, *Weyl-type fields with geodesic lines of force*, J. Math. Phys. **40.4** (2000) 2032–2045. DOI: https://doi.org/10.1063/1.532849

(3) C.M. Delahunty and B. Guilfoyle, *Volatile compound release during consumption: a proposed aroma stimulus index*, in Flavour Release, ACS Symposium Series 763, American Chemical Society, Washington, DC (2000) 405–412. DOI: https://doi.org/10.1021/bk-2000-0763.ch033

(2) B. Guilfoyle, *Interior Weyl-type solutions to the Einstein-Maxwell field equations*, Gen. Rel. and Grav. **31.11** (1999) 1645–1674. DOI: https://doi.org/10.1023/A:1026706031676

(1) B. Guilfoyle and B. Nolan, *Yang's gravitational theory*, Gen. Rel. and Grav. **30.3** (1998) 473–495. DOI: https://doi.org/10.1023/A:1018815027071

6. Preprints

(7) B. Guilfoyle and W. Klingenberg, *Parabolic evolution with boundary to the Bishop family of holomorphic discs*, (2023) ArXiv: https://arxiv.org/abs/2304.05702.

(6) B. Guilfoyle and M. Robson, *Properties and transformations of Weingarten surfaces*, (2022) ArXiv: https://arxiv.org/abs/2210.10035

(5) G. Cobos and B. Guilfoyle, *A conformal mean value theorem for solutions of the ultrahyperbolic equation*, (2022) ArXiv: https://arxiv.org/abs/2210.08155

(4) B. Guilfoyle and M. Robson, *On the convergence of non-integer linear Hopf flow*, (2022) ArXiv: https://arxiv.org/abs/2205.15978

(3) B. Guilfoyle and W. Klingenberg, *An index bound for umbilic points on smooth convex surfaces* (2012) https://arxiv.org/abs/1207.5994

(2) B. Guilfoyle and W. Klingenberg, *Proof of the Carathéodory conjecture* (2011) ArXiv https://arxiv.org/abs/0808.0851

(1) B. Guilfoyle, *Einstein metrics adapted to contact structures on 3-manifolds* (2000) ArXiv https://arxiv.org/abs/math/0012027

7. Expository Video

(1) *From CT Scans to 4-manifold Topology* (2023) https://www.youtube.com/watch?v=Dm-KEGGjD3o

(2) *On isolated umbilic points* (2021) https://www.youtube.com/watch?v=Wjja4PcMtxc

(3) *University College Dublin Distinguished Visitor Lectures* (2019)
  (a) Lecture 1: The Carathéodory conjecture and beyond https://www.youtube.com/watch?v=jnaZdsbUNZ8

(b) Lecture 2: Curvature flows https://www.youtube.com/watch?v=20zgPGoWoUs
(c) Lecture 3: Living in a land with two times https://www.youtube.com/watch?v=nWPRW4nUak0
(d) Lecture 4: Why is the 4-dimensional smooth Poincaré Conjecture still open? https://www.youtube.com/watch?v=VZs1UG2Wtn8

(4) *The causal topology of neutral 4-manifolds with null boundary (in 3 parts)* (2016)
(a) Part 1: Conformal compactifications https://www.youtube.com/watch?v=VUlPMPwT-hA
(b) Part 2: Tangent hypersurfaces https://www.youtube.com/watch?v=7u3jaRMtDj8
(c) Part 3: Intersection tori https://www.youtube.com/watch?v=2D2ujxfYGeU

(5) *Parabolic classical curvature flows*: http://youtu.be/Sx1T6legtgQ

(6) *From global to local (in 5 parts)* (2012)
(a) Introduction: http://youtu.be/ybop3dETUjc
(b) Background: http://youtu.be/Plwz-QC40wo
(c) Reformulation: http://youtu.be/9PO w5ToJouM
(d) Totally Real Blow-up: http://youtu.be/UMPHniXAV3M
(e) Global Aspects: http://youtu.be/D-T1_rP4H5I

8. Social Media

- Website: www.brendanguilfoyle.ie
- Researchgate: https://www.researchgate.net/profile/Brendan_Guilfoyle
- Scholar: https://scholar.google.com/citations?user=aLvWdFcAAAAJ
- Mathoverflow: https://stackexchange.com/users/2954765/brendan-guilfoyle

9. Educational Issues

(5) B. Guilfoyle, *New Metrics for Detecting Changes in Educational Standards*, (2011)

(4) B. Guilfoyle, *Grade Inflation in Irish Second and Third Level Education*, Teachers Union of Ireland News, Nov/Dec 2008.

(3) B. Guilfoyle, *Grade Inflation in Second and Third Level Education*, Public Affairs Ireland Journal **49** July 2008, 16–17.

(2) M. O'Grady and B. Guilfoyle, *Grade Inflation in Irish Universities 1994 - 2004*, (2007)

(1) M. O'Grady and B. Guilfoyle, *Evidence of Grade Inflation 1994 - 2004 in the Institute of Technology Sector in Ireland*, (2007).

10. In the National Media

- *Grades soar yet 'some students with 2:1 degrees are functionally illiterate'* The Sunday Times (Irish Edition), September 18, 2022
- *Grade inflation: lowering standards in higher education* Irish Times, November 4, 2021, https://tinyurl.com/8p4rstkz
- *Student literacy levels: It is almost as if they are word blind*, Irish Times, February 25, 2019, http://tinyurl.com/y225sfa3

- *Irish universities' grade inflation sparks claims of 'dumbing down'*, Irish Times, December 31, 2018, http://tinyurl.com/y5xtg8jk
- *Revealed: the universities most likely to award higher grades*, Irish Times, December 31, 2018, http://tinyurl.com/yyvyfo3m
- *Surge in first-class honours at institutes of technology*, Irish Times, June 14, 2016, http://tinyurl.com/y2vuw3vx
- *The researchers who exposed grade inflation*, Irish Times, March 6, 2010, http://tinyurl.com/y3959jz2

11. Selected Invited Talks

2024
- *The ultrahyperbolic equation and neutral geometry in dimension 4*, Geometry Seminar, University of Durham, England.
- *From Euclidean 3-space to pseudo-Riemannian spaces without relativity*, Mathematics Colloquium, Trinity College Dublin, Ireland.

2023
- *From CT scans to 4-manifold topology*, Geometry Seminar, SISSA, Trieste, Italy.

2022
- *The failure of geometry in dimension 4*, joint Irish Geometry and Groups in Galway Conferences, NUI Galway, Ireland.

2021
- *The Toponogov Conjecture for complete surfaces*, Irish Geometry Seminar, NUI Galway, Ireland.
- *From CAT scans to 4-manifold topology*, Irish Mathematical Society September Meeting, University College Cork/Munster Technological University, Cork, Ireland.

2020
- *Why is the smooth 4-dimensional Poincaré conjecture still open?*, Geometry Seminar, University of Durham, England.

2019
- *Curvature Flows*, Analysis Seminar, University College Dublin, Ireland.
- *The Carathéodory Conjecture and Beyond*, Mathematics Colloquium, University College Dublin, Ireland.
- *The life and mathematics of Karen Uhlenbeck*, Women and EDI in STEM, University College Dublin, Ireland.

2017
- *Neutral metrics and mathematical physics*, Colloquium, Dublin City University.

2016
- *Flowing to non-round Weingarten spheres*, Geometry Seminar, University of Durham, England.

2015
- *The shape of worn stones*, Mathematics Research Day, NUI Galway.

2013
- *Proof of the Carathéodory conjecture*, 4 lectures in the Perspectives in Geometry Series, University of Texas at Austin, USA.

- *From global to local*, Differential Geometry and Geometric Analysis Seminar, Princeton University, USA.
- *Classical surface theory revisited*, New York Polytechnic, USA.

2012

- *Carathéodory's conjecture on umbilic points and a codimension 2 capillary problem*, Geometry Seminar, Universite Paul Sabatier, Toulouse, France.
- *A new geometric application of PDE*, Geometry seminar, Pierre et Marie Curie University, Paris, France.

2011

- *Carathéodory's conjecture on the umbilics of a convex surface*, Max Planck Institute for Mathematics, Bonn, Germany.
- *Proof of the Carathéodory conjecture I and II*, CIRM, Marseille, France.

2010

- *Mean curvature flow, holomorphic discs and umbilic points on surfaces*, 6th William Rowan Hamilton Geometry and Topology Workshop, Hamilton Mathematics Institute, Trinity College Dublin.
- *From Codazzi-Mainardi to Cauchy-Riemann*, Geometry Seminar, Stanford University, California.
- *Wild symplectic structures, mean curvature flow and holomorphic discs*, Research Seminar, MSRI, Berkeley, California.
- *Neutral Kaehler geometry, mean curvature flow and holomorphic curves*, Geometry and Topology Seminar, Imperial College, London.

2009

- *Proof of the Carathéodory Conjecture by mean curvature flow*, Pure Mathematics Department Colloquium, Cambridge University, England.
- *Mean curvature flow in indefinite spaces*, Differential Geometry Seminar, University of Köln, Germany.
- *Proof of the Carathéodory Conjecture by mean curvature flow*, Differential Geometry Seminar, University of Münster, Germany.
- *Proof of the Carathéodory Conjecture I and II*, SFB Seminar, Humboldt University, Berlin, Germany.

2008

- *A neutral Kähler surface with applications in geometric optics*, Mathematical Physics Seminar, Cambridge University, England.

2005

- *An indefinite metric on the space of oriented lines*, Erwin Schrödinger Institute, Vienna, Austria.

12. ERASMUS Partners

- Durham University, England.
- University of Cyprus, Nicosia, Cyprus.
- Humboldt University, Berlin, Germany.

13. Postgraduate Student Supervision

2023   Morgan Robson, awarded PhD for thesis: *Weingarten Surfaces: Curvature Flows and Stationary Properties*

2022 Guillermo Cobos, awarded PhD for thesis: *The ultrahyperbolic equation*,
2009 Nikos Georgiou awarded PhD for thesis: *The geometry of the space of oriented geodesics of hyperbolic 3-space.*

14. Postdoctoral Researcher Supervision

2017 – 2018   Dr. Adriana Ortiz-Rodríguez, funded by UNAM, Mexico.
2010 – 2011   Dr. Nikos Georgiou, funded by SFI Research Frontiers Programme.
2007 – 2010   Dr. Henri Anciaux, funded by SFI Research Frontiers Programme.
2006 – 2008   Dr. Madeeha Khalid, funded by IRCSET Embark Initiative.

15. External Examinership

2024 Tristan Hasson (Durham University, UK) PhD thesis: *The Geometry of Hyperbolic Polynomials and Applications*,
2023 Samuel Gonzales Castillo (Maynooth University, Ireland) MSc by Research thesis: *The Dirichlet Energies of Functions Between Spheres*,
2022 El Hayes (Maynooth University, Ireland) MSc by Research thesis: *Smooth Structures on Spheres*,
2022 Matthew Cherrie (Portsmouth University, UK) PhD thesis: *Focal Sets of Geodesics in Convex Manifolds*,
2019 Daniel Ballesteros-Chávez (Durham University, UK) PhD thesis: *Curvature Estimates of Spacelike Surfaces in deSitter Space*,
2012 Benjamin Lambert (Durham University, UK) PhD thesis: *Mean Curvature Flow with a Neumann Boundary Condition in Flat Spaces.*