Stephen Taylor | Curriculum Vitae

TAPIR Group, MC 350-17, California Institute of Technology
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Objectives

- My goal is to probe **compact objects** (neutron stars and black holes), their **environments**, and their **demographic properties** across the **full gravitational-wave spectrum**.
- I use the most sensitive **pulsar-timing** datasets to probe the dynamics and astrophysical environments of **supermassive black-hole binaries** in the nanohertz gravitational-wave band.
- My future goals include performing full model-independent recoveries of the **demographics of LIGO-detected systems** to investigate their progenitor properties and evolutionary paths.

Research Interests

Primary interests: gravitational-wave astronomy • theoretical astrophysics • massive black-hole binaries • stellar-mass compact objects • pulsar timing • statistical inference

Secondary interests: galaxy formation and evolution • cosmology • pulsar physics and demographics • ionised interstellar medium

Specific interests: pulsar-timing data-analysis for nanohertz gravitational-wave searches • pulsar-timing noise characterisation and mitigation • waveform modelling for supermassive black-hole binary searches • modelling final-parsec dynamics of supermassive black-hole binaries • stochastic signal analysis strategies • compact-binary demographics and population inference • Bayesian hierarchical modelling

Education

Institute of Astronomy, University of Cambridge **Cambridge, UK**
PhD (Astronomy) *2010–2014*
Advisor: Dr. Jonathan R. Gair; **Thesis Title:** *Exploring The Cosmos With Gravitational Waves*
Description: A new Bayesian hierarchical modelling scheme is introduced to use compact-binary gravitational-wave standard sirens to infer the mass-distribution of the binary population, the progenitor star-formation rate, and cosmological parameters. Advanced pulsar-timing array techniques are developed to map the nanohertz gravitational-wave sky through a parametrised overlap-reduction function, and large accelerations to the Bayesian searches for single supermassive black-hole binaries are proposed.

University of Oxford **Oxford, UK**
MPhys (1^{st} Class), [ranked 1^{st} in Jesus College, 4^{th} across University] *2006–2010*
Advisor: Prof. Steven Rawlings; **Thesis Title:** *The Cosmic Evolution Of Black-hole Accretion*

Professional Experience

California Institute of Technology **Pasadena, USA**
Caltech Postdoctoral Scholar (TAPIR group) *2016–Present*
Visiting scholar (TAPIR group) *2014–2016*

NASA Jet Propulsion Laboratory **Pasadena, USA**
NASA Postdoctoral Fellow *2014–2016*

Institute of Astronomy, University of Cambridge **Cambridge, UK**
PhD candidate *2010–2014*

Grants & Funding

Jun 2016: **"New Directions and New Opportunities for NANOGrav Astrophysics"**

Awarded $11k by the NANOGrav Physics Frontier Center for a proposal on behalf of the collaboration's Astrophysics Working Group. Funding will ensure undergraduate/graduate students and outside experts can attend a sprint week in April 2017 to advance several key areas of interest, and to achieve rapid progress on collaboration projects.

Honours & Awards

2015: International Pulsar Timing Array (IPTA) Steering Committee Prize — "Honourable Mention"

2015: Gravitational Wave International Committee (GWIC) Thesis Prize — "Honourable Mention"

2014: NASA Postdoctoral Fellowship (JPL)

2014: Royal Astronomical Society Travel Award — £750

2013: Royal Astronomical Society Travel Award — £700

2012–2014: Christ's College (Cambridge) Travel Grants [various; total exceeds £1k]

2010: Science and Technology Facilities Council (STFC) — full PhD studentship award

2008: Examiner's Prize, Oxford Physics Speaking Competition

2007: Oxford Physics department prize for laboratory work

2007–2010: Undergraduate Scholar of Jesus College, Oxford

2006–2010: Regularly awarded Oxford undergraduate departmental and college examination prizes

Teaching Experience

Jun–Aug 2016: Co-supervisor of Caltech summer undergraduate student (Maya Fuller)

May 2016: Guest Lecturer for Caltech Ph237 class "Gravitational Waves"

Mar 2016: Co-organiser of student workshop at NANOGrav Spring meeting

Sep 2015: Lecturer for NANOGrav detection-group workshop at Caltech

Jun 2015: Lecturer at "CSI PTA" Aspen summer workshop

2011–2013: Supervisor for Cambridge Part II undergraduate students in Relativity

2011: Prepared computing coursework for Cambridge Part II undergraduate students

Professional Service

Reviewer for international journals

Monthly Notices of the Royal Astronomical Society (MNRAS), Physical Review D (PRD)

Conference organisation

Oct 2016: Chair of SOC for NANOGrav Fall meeting at University of Illinois Urbana-Champaign

Mar 2016: SOC and LOC member for NANOGrav Spring meeting at Caltech

Mar 2016: Co-organiser of NANOGrav student workshop at Caltech

Mar 2014: SOC and LOC member for British Gravity meeting (BritGrav) at Cambridge, UK

Seminar organisation

2015–2016: Caltech TAPIR and LIGO postdoctoral lunch seminar series

Professional affiliations

- North American Nanohertz Observatory for Gravitational-waves (NANOGrav), *Full member*
- European Pulsar Timing Array (EPTA), *Member*
- International Pulsar Timing Array (IPTA), *Member*
- American Physical Society (DGRAV), *Member*

- American Astronomical Society, *Member*
- Royal Astronomical Society, *Fellow*

Outreach & Media Engagement

Outreach

2016: Featured gravitational-wave expert at NASA's "Ticket to Explore JPL" event

2013: Interactive presentation at Cambridge's Institute of Astronomy Open Day

2012–2014: Presentation to prospective students (Institute of Astronomy graduate interviews)

2012: Outreach talk at Institute of Astronomy public-observing evening: "The Space Race"

2011: Interactive presentation at Cambridge's Institute of Astronomy Open Day

Press releases

Feb 2016: First-author research: "*Pulsar Web Could Detect Low-Frequency Gravitational Waves*" (JPL press release)

Apr 2016: Collaboration research: "*Gravitational Wave Search Provides Insights into Galaxy Evolution and Mergers*" (NRAO press release)

Media coverage

- Interviewed and quoted by *Science* magazine: "In Search of Spacetime Megawaves" by Daniel Clery, Science 11 Mar 2016: Vol. 351, Issue 6278, pp. 1124-1125
- Quoted, with research featured in *Gizmodo*, *Engadget*, *Phys.org*, *Astronomy magazine*, *Universe Today*
- Collaboration research featured in *Science Daily*, *Astronomy Now* (online)

Publications

• 22 **peer-reviewed publications (of which** 8 **are first-author) with** 317 **citations, h-index** 10.
• Up-to-date metrics available at https://scholar.google.com/citations?user=iN2djBMAAAAJ&hl=en.
• 5 key publications are indicated below with preceding asterisks.

Submitted & In Preparation

S. R. Taylor, L. Lentati, S. Babak, P. Brem, J. R. Gair, A. Sesana, A. Vecchio. "*All correlations must die: Assessing the significance of a stochastic gravitational-wave background in pulsar-timing arrays*". Submitted to Physical Review D. arXiv:1606.09180.

S. R. Taylor, R. van Haasteren. "*Optimized anisotropic modelling of the nanohertz gravitational-wave sky with pulsar-timing arrays*". (In Prep.)

S. R. Taylor, J. Simon, L. Sampson. "*Bayesian model emulation for astrophysical inference of supermassive black-hole binaries with pulsar-timing arrays*". (In Prep.)

Publications In Peer-reviewed International Journals

May 2016: G. Desvignes, R. N. Caballero, L. Lentati, [and 40 others, including ***S. R. Taylor***]. "*High-precision timing of 42 millisecond pulsars with the European Pulsar Timing Array*". MNRAS, 458:3341–3380.

May 2016: L. Lentati, R. M. Shannon, W. A. Coles, [and 80 others, including ***S. R. Taylor***]. "*From spin noise to systematics: stochastic processes in the first International Pulsar Timing Array data release*". MNRAS, 458:2161–2187.

May 2016 : J. P. W. Verbiest, L. Lentati, G. Hobbs, [and 89 others, including ***S. R. Taylor***]. "*The International Pulsar Timing Array: First data release*". MNRAS, 458:1267–1288.

Apr 2016 : Z. Arzoumanian, A. Brazier, S. Burke-Spolaor, [and 48 others, including ***S. R. Taylor***]. "*The NANOGrav Nine-year Data Set: Limits on the Isotropic Stochastic Gravitational Wave Background*". Astrophys. J., 821:13.

Apr 2016 : R. N. Caballero, K. J. Lee, L. Lentati, [and 36 others, including ***S. R. Taylor***]. "*The noise properties of 42 millisecond pulsars from the European Pulsar Timing Array and their impact on gravitational-wave*

searches". MNRAS, 457:4421–4440.

*__Mar 2016__ : ***S. R. Taylor***, M. Vallisneri, J. A. Ellis, C. M. F. Mingarelli, T. J. W. Lazio, and R. van Haasteren. "*Are We There Yet? Time to Detection of Nanohertz Gravitational Waves Based on Pulsar-timing Array Limits*". Astrophys. J. Lett, 819:L6.

Jan 2016 : ***S. R. Taylor***, E. A. Huerta, J. R. Gair, and S. T. McWilliams. "*Detecting Eccentric Supermassive Black Hole Binaries with Pulsar Timing Arrays: Resolvable Source Strategies*". Astrophys. J., 817:70.

Jan 2016 : S. Babak, A. Petiteau, A. Sesana, P. Brem, P. A. Rosado, ***S. R. Taylor***, [and 30 others]. "*European Pulsar Timing Array limits on continuous gravitational waves from individual supermassive black hole binaries*". MNRAS, 455:1665–1679.

Nov 2015 : J. R. Gair, J. D. Romano, and ***S. R. Taylor***. "*Mapping gravitational-wave backgrounds of arbitrary polarisation using pulsar timing arrays*". Phys. Rev. D, 92(10):102003.

*__Nov 2015__ : L. Lentati, ***S. R. Taylor***, C. M. F. Mingarelli, [and 33 others]. "*European Pulsar Timing Array limits on an isotropic stochastic gravitational-wave background*". MNRAS, 453:2576–2598.

Sep 2015 : E. A. Huerta, S. T. McWilliams, J. R. Gair, and ***S. R. Taylor***. "*Detection of eccentric supermassive black hole binaries with pulsar timing arrays: Signal-to-noise ratio calculations*". Phys. Rev. D, 92(6):063010.

Aug 2015 : J. D. Romano, ***S. R. Taylor***, N. J. Cornish, J. Gair, C. M. F. Mingarelli, and R. van Haasteren. "*Phase-coherent mapping of gravitational-wave backgrounds using ground-based laser interferometers*", Phys. Rev. D, 92(4):042003.

*__Jul 2015__: ***S. R. Taylor***, C. M. F. Mingarelli, J. R. Gair, [and 32 others]. "*Limits on Anisotropy in the Nanohertz Stochastic Gravitational Wave Background*". Phys.Rev. Lett, 115(4):041101.

Mar 2015: C. J. Moore, ***S. R. Taylor***, and J. R. Gair. "*Estimating the sensitivity of pulsar timing arrays*", Classical and Quantum Gravity, 32(5):055004.

Nov 2014: ***S. R. Taylor***, J. Ellis, and J. Gair. "*Accelerated Bayesian model-selection and parameter-estimation in continuous gravitational-wave searches with pulsar-timing arrays*". Phys. Rev. D, 90(10):104028.

Oct 2014: J. Gair, J. D. Romano, ***S. R. Taylor***, and C. M. F. Mingarelli. "*Mapping gravitational-wave backgrounds using methods from CMB analysis: Application to pulsar timing arrays*". Phys. Rev. D, 90(8):082001.

Aug 2014: R. M. Shannon, S. Chamberlin, N. J. Cornish, J. A. Ellis, C. M. F. Mingarelli, D. Perrodin, P. Rosado, A. Sesana, ***S. R. Taylor***, [and 14 others]. "*Summary of Session C1: pulsar timing arrays*". General Relativity and Gravitation, 46:1765.

*__Oct 2013__: ***S. R. Taylor*** and J. R. Gair. "*Searching for anisotropic gravitational-wave backgrounds using pulsar timing arrays*". Phys. Rev. D, 88(8):084001.

May 2013: L. Lentati, P. Alexander, M. P. Hobson, ***S. R. Taylor***, J. Gair, S. T. Balan, and R. van Haasteren. "*Hyper-efficient model-independent Bayesian method for the analysis of pulsar timing data*". Phys. Rev. D, 87(10):104021.

Feb 2013 : ***S. R. Taylor***, J. R. Gair, and L. Lentati. "*Weighing the evidence for a gravitational-wave background in the first International Pulsar Timing Array data challenge*". Phys. Rev. D, 87(4):044035.

Jul 2012: ***S. R. Taylor*** and J. R. Gair. "*Cosmology with the lights off: Standard sirens in the Einstein Telescope era*". Phys. Rev. D, 86(2):023502.

*__Jan 2012__: ***S. R. Taylor***, J. R. Gair, and I. Mandel. "*Cosmology using advanced gravitational-wave detectors alone*". Phys. Rev. D, 85(2):023535.

Presentations

- 33 **oral presentations (of which** 13 **were invited), with** 4 **conference leadership roles.**
- Recent presentations are available to view at https://speakerdeck.com/stevertaylor.

Invited Talks

Oct 2016: *Astrophysical inference of supermassive black-hole binaries with pulsar-timing arrays*, Leonard E. Parker Center seminar, University of Wisconsin–Milwaukee, Milwaukee WI, USA

Oct 2016: *Astrophysical inference of supermassive black-hole binaries with pulsar-timing arrays*, CIERA seminar, Northwestern University, Evanston IL, USA

Oct 2016: *New data-analysis approaches for gravitational-wave searches with pulsar-timing arrays*, Montana State University seminar, Bozeman MT, USA

Jul 2016: *New horizons in gravitational-wave astronomy with pulsar-timing arrays*, Armagh Observatory seminar, Armagh, UK

Jul 2016: *Probing the final-parsec problem with pulsar-timing arrays*, Anton Pannekoek Institutt seminar, University of Amsterdam, Amsterdam, Netherlands

Jul 2016: *Probing the final-parsec problem with pulsar-timing arrays*, Radboud University astrophysics seminar, Radboud, Netherlands

Jun 2016: *Gravitational-wave data-analysis techniques for pulsar-timing arrays*, IPTA conference, Stellenbosch, South Africa

Mar 2016: *Sources of nanohertz gravitational-waves for pulsar-timing array searches*, NANOGrav student workshop, Caltech, Pasadena CA, USA

Dec 2015: *Prospects for near future detection and astrophysical inference with PTAs*, Gravitational-wave group seminar, University of Birmingham, UK

Dec 2015: *Prospects for near future detection and astrophysical inference with PTAs*, Statistics group seminar (School of Mathematics), University of Edinburgh, UK

Dec 2015: *Prospects for near future detection and astrophysical inference with PTAs*, CaJAGWR seminar, California Institute of Technology

May 2013: *Searching For Anisotropic Gravitational-wave Backgrounds Using Pulsar Timing Arrays*, Albert Einstein Institute (AEI) GW seminar, Hanover

Dec 2012: *Weighing the evidence for a gravitational-wave background*, Gravitational-wave group seminar, University of Birmingham, UK

Contributed Presentations

Oct 2016: *Optimized gravitational-wave sky mapping with pulsar-timing arrays*, NANOGrav Fall Meeting 2016, NCSA, Urbana-Champaign IL, USA

May 2016: *Carrying the physics of supermassive black-hole binary evolution into pulsar-timing array searches*, EPTA meeting, Bielefeld, Germany

Apr 2016: *Are we there yet? Time to detection of nanohertz gravitational waves*, American Physical Society meeting, Salt Lake City UT, USA

Mar 2016: *Carrying the physics of supermassive black-hole binary evolution into pulsar-timing array searches*, NANOGrav meeting, Caltech, Pasadena CA, USA

Oct 2015: *Are we there yet? Time to detection of nanohertz gravitational waves*, NANOGrav meeting, McGill University, Montreal, Canada

Jun 2015: *Eccentric supermassive black-hole binary signals in pulsar-timing data*, European Pulsar Timing Array meeting, Bonn, Germany

Apr 2015: *Eccentric supermassive black-hole binary signals in pulsar-timing data*, American Physical Society meeting, Baltimore MD, USA

Feb 2015: *Eccentric supermassive black-hole binary signals in pulsar-timing data*, NANOGrav meeting, Arecibo, Puerto Rico

Jan 2015: *Exploring the cosmos with gravitational waves*, American Astronomical Society meeting, Seattle WA, USA

Nov 2014: *EPTA constraints on gravitational-wave anisotropy*, European Pulsar Timing Array meeting, Cambridge, UK

Jun 2014: *EPTA and IPTA searches for gravitational-wave background anisotropy*, International Pulsar Timing Array meeting, Banff, Canada

May 2014: *EPTA limits on gravitational-wave anisotropy*, European Pulsar Timing Array meeting, Astron, Netherlands

Oct 2013: *The pulsar-term in PTA continuous-wave searches: a blessing and a curse*, European Pulsar Timing Array meeting, Pula, Sardinia

Jul 2013: *Probing anisotropy of the GW background with pulsar timing arrays*, 20th International Conference on General Relativity and Gravitation and 10th Amaldi Conference on Gravitational Waves, Warsaw

Jun 2013: *The first PTA search pipeline for anisotropy in the GW background*, International Pulsar Timing Array meeting, Krabi, Thailand

Apr 2013: *Searching For Anisotropic Gravitational-wave Backgrounds Using Pulsar Timing Arrays*, European Pulsar Timing Array meeting, l'Observatoire de Paris, Paris

Feb 2013: *Weighing the evidence for a gravitational-wave background*, Institute of Astronomy seminar, University of Cambridge

Nov 2012: *Weighing the evidence for a gravitational-wave background*, European Pulsar Timing Array meeting, Albert Einstein Institute (AEI), Potsdam, Germany

Jun 2012: *Milestones in Spacetime: Double Neutron-Star Binaries as Gravitational-Wave Standard Sirens*, Institute of Astronomy seminar, University of Cambridge, UK

Feb 2012: *Hubble without the Hubble: Cosmology using advanced gravitational-wave detectors alone*, Gravitational-Wave Meeting, Institut de Ciències de l'Espai, Barcelona, Spain

Posters

Aug 2015: *Galactic environment effects on gravitational wave signals in pulsar timing arrays*, Postdoc Research Day, NASA Jet Propulsion Laboratory

Aug 2012: *Cosmology without EM counterparts: Standard sirens in the advanced era and beyond*, Rattle and Shine, KITP Santa Barbara

Dec 2011: *Cosmology using advanced gravitational-wave detectors alone*, Graduate Student Conference 2011, Cavendish Laboratory, University of Cambridge

Computing Skills

- **OS:** Linux/UNIX, Windows
- **Programming:** C/C++, Python, UNIX shell scripting, HTML, GPU programming (CUDA C, PyCUDA)
- **Typography:** LaTeX, Bibtex, Microsoft Office, Pages, OpenOffice
- **Scientific:** Mathematica, Matlab, Python

References

Dr Jonathan R. Gair [*PhD advisor*]
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