Hunter Gabbard

CONTACT INFORMATION

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EDUCATION

University of Glasgow, Glasgow, UK

Ph.D. Physics and Astronomy, *in progress*

- Thesis: *Machine Learning for Gravitational Wave Astronomy*

University of Mississippi, Oxford, MS

B.S. Physics, May 2016

- Honors Thesis: *A Study on the Characterization and Implementation of Tools for Advanced LIGO*

RESEARCH EXPERIENCE

Institute for Gravitational Research, University of Glasgow

Ph.D. Candidate, Researcher — 09/2017 - present

- I am working on the direct application of cutting edge machine learning techniques for the purpose of identifying and characterising gravitational wave signals in data generated by the LIGO-Virgo Collaboration.
- I lead a study showing for the first time that deep convolutional neural networks could be used to detect gravitational waves 10^4 times faster than existing techniques. This study has now been published in Physical Review Letters.
- I showed for the first time that a form of machine learning could produce posteriors describing the physical parameters of a gravitational wave 6 times faster than existing techniques. This work is currently with referees at Nature Physics.

Craft Prospect

Industry Research Placement — 09/2019 - 03/2020

- I looked at the opportunities of utilising emerging machine learning techniques in the practical delivery of space-based quantum key delivery systems.
- Outcome of my work was partially used to win a £100,000+ joint industry-government grant for further research into machine learning techniques for quantum key assurance.

Max Planck Institute for Gravitational Physics (Hannover, Germany)

Fulbright Scholar — 09/2016 - 07/2017

- Utilising several machine learning techniques (restricted boltzmann machines, deep fully connected neural networks, etc) I developed an automatic flagging system to identify noise artefacts hindering gravitational wave search pipelines.
- Using deep learning classification methods, I developed a new complementary detection statistic to be integrated into the primary worldwide gravitational wave search tool (PyCBC).

University of Mississippi

Undergraduate Research Assistant — 01/2013 - 05/2016

- I performed glitch investigations of gravitational wave observation run data.

- I authored the "Terramon" monitor used in the LIGO mission control rooms to help predict the effects of imminent earthquakes to the site using machine learning techniques.

University of Texas Rio Grande Valley
Undergraduate NSF Summer Research Fellow 05/2015 - 08/2015
- I developed a fast glitch classification algorithm for gravitational wave data analysis using unsupervised machine learning methods.

University of Florida and Laboratoire de l'Accelerateur Lineaire
Undergraduate NSF Summer Research Fellow 05/2014 - 08/2014
- I characterized and enhanced the primary glitch analysis tool used for gravitational wave data analysis (Omicron) using various statistical techniques.

Awards

Scottish Universities Physics Alliance
SUPA Higgs Prize Fellowship. 2017-2021

U.S. Department of State
Fulbright Scholar. 2016-2017

University of Mississippi
Portz Fellowship Nominee. Spring 2016

Fundamental Physics Breakthrough Prize
LIGO Scientific Collaboration Authors, Breakthrough Prize in Physics Spring 2016

University of Mississippi
Goldwater Scholarship Nominee. 2015

The Boy Scouts of America
Eagle Scout Award 2010

Selected Publications

Gabbard, H. et al. (2018) "Matching matched filtering with deep networks in gravitational-wave astronomy". In: Phys.Rev.Lett. doi:10.1103/PhysRevLett.120.141103.

Cuoco, E. , ... , **Gabbard, H.** et al. (2020) "Enhancing Gravitational-Wave Science with Machine Learning". In: Machine Learning: Science and Technology. doi:10.1088/2632-2153/abb93a..

Biscans, S. , ... , **Gabbard, H.** et al. (2018) "Control strategy to limit duty cycle impact of earthquakes on the LIGO gravitational-wave detectors". In: Class. Quant. Grav. doi:10.1088/1361-6382/aaa4aa.

Coughlin, M. , ... , **Gabbard, H.** et al. (2017) "Limiting the effects of earthquakes on gravitational-wave interferometers". In: Class. Quant. Grav. doi:10.1088/1361-6382/aa5a60.

Gabbard, H. (2016) "A Study on the Characterization and Implementation of Tools for Advanced LIGO". Honors thesis, Mississippi U. In: SMBHC Thesis Repository.

Gabbard, H. et al. (2019) "Bayesian parameter estimation using conditional variational autoencoders for gravitational-wave astronomy". arXiv:1909.06296.

Programming Skills	Python, TensorFlow, Keras, Bash, LaTeX

Presentations

Invited talk, *Bayesian Parameter Estimation using Conditional Variational Autoencoders for Gravitational Wave Astronomy*, Gravitational Wave Data Centre Machine Learning Webinar Series, Australia. (June, 2020)

Bayesian Parameter Estimation using Conditional Variational Autoencoders for Gravitational Wave Astronomy, Bayesian Deep Learning for Cosmology and Gravitational waves, PCCP, APC laboratory, Universite de Paris, France. (March, 2020)

Invited talk, *Hyper-fast gravitational wave parameter estimation*, PyData Edinburgh Meeting, Edinburgh, UK. (January, 2020)

Invited talk, *Machine Learning and its application towards the search for Gravitational waves*, The International Congress on Industrial and Applied Mathematics (ICIAM), Valencia, Spain. (July, 2019)

Invited talk, *Matching Matched Filtering Using Deep Learning*, SUPA Annual Gathering, Glasgow, UK. (July, 2019)

CNNs and GANs applied towards the search for gravitational waves, Annual ScotDist Meeting, Glasgow, UK. (December, 2018)

Invited talk, *Gravitational wave data analysis with machine learning*, Edinburgh MOST Meeting, Edinburgh, UK. (November, 2018)

Invited talk, *Gravitational wave data analysis with machine learning*, Gravitational-wave Excellence through Alliance Training Kick-off Meeting, Beijing Normal University, Beijing, China. (August 2018)

Invited talk, *An overview of LIGO-Virgo machine learning applications for gravitational wave astronomy*, Machine Learning in Science and Engineering conference, Carnegie Mellon, Pittsburgh, PA. (June 2018)

Matching Matched Filtering with Deep Networks in Gravitational-wave Astronomy, LIGO-Virgo Meeting, Sonoma, CA. (March 2018)

Machine Learning and Gravitational-wave Astronomy, 7 Minutes of Science, Glasgow, UK. (February 2018)

Limiting the effects of earthquakes on gravitational-wave interferometers, LSC-Virgo Meeting, Pasadena, CA. (March 2017)

LIGO Detector Characterization with Genetic Programming, April APS Meeting, Washington, DC. (January 2017)

Genetic Programming Applied to Glitch Classification at LIGO, Computing in High Energy AstroParticle Research Conference, Columbus, OH. (August 2016)

A low-latency Glitch Classification Algorithm Based in Waveform Morphology for Advanced LIGO, April APS Meeting, Salt Lake City, UT. (April 2016)

Additional Experience

Leadership and Professional Service

- Treasurer, Society of Physics Students. (Fall 2015)
- Vice President, Society of Physics Students. (2013-2014)
- Reviewer
  - IEEE Transactions on Systems, Man, and Cybernetics: Systems
  - The Astronomical Journal
  - Machine Learning: Science and Technology
  - Frontiers of Physics

Outreach

- Science podcast series co-host, MarketScale. (2017 - 2018)
- GW170104 reddit AMA organizer/participant, Max Planck Institute for Gravitational Physics, (Spring 2017)

Teaching

- Astronomy 1 Teaching Assistant, University of Glasgow. (Spring 2018)
- Phys 108 Lab Teaching Assistant, University of Mississippi. (Spring 2016)
- LIBA 150 interdisciplinary science course Teaching Assistant, University of Mississippi. (Fall 2015)

Activities and Associations

- LIGO Scientific Collaboration member. (2013 - present)
- Sigma Pi Sigma (Physics Honor Society).
- Phi Mu Epsilon (Mathematics Honor Society).
- Omicron Delta Kappa (National Leadership Honor Society)
- APS (American Physical Society). (2014-2016)

References

Dr. Chris Messenger, Lecturer, University of Glasgow, +44 01413303536,
`Christopher.Messenger@glasgow.ac.uk`

Prof. Marco Cavaglia, Professor, Missouri University of Science and Technology, +1 (573) 341-4781,
`cavaglia@olemiss.edu`

Prof. Martin Hendry, Professor, University of Glasgow, +44 01413305685,
`martin.hendry@glasgow.ac.uk`

LIGO Publications

The standard practice in the LIGO Scientific collaboration is to list all active members as authors, strictly alphabetically in most cases, to represent the contributions that all of us have made to the assembly, testing, infrastructure, operation, data analysis and internal review for the experiments and results.

Abbott, B. P. et al. (2020) "GW190425: Observation of a Compact Binary Coalescence with Total Mass 3.4 M ", Astrophysical Journal Letters, 892(1). doi: 10.3847/2041-8213/ab75f5.

Abbott, B. P. et al. (2020) "Model comparison from LIGO-Virgo data on GW170817's binary components and consequences for the merger remnant", Classical and Quantum Gravity, 37(4). doi: 10.1088/1361-6382/ab5f7c.

Abbott, B. P. et al. (2020) "Optically targeted search for gravitational waves emitted by core-collapse supernovae during the first and second observing runs of advanced LIGO and advanced Virgo", Physical Review D, 101(8). doi: 10.1103/PhysRevD.101.084002.

Gamma-Ray Burst Monitor, F. et al. (2020) "A joint fermi-gbm and ligo/virgo analysis of compact binary mergers from the first and second gravitational-wave observing runs", Astrophysical Journal, 893(2). doi: 10.3847/1538-4357/ab7d3e.Ligo Scientific Collaboration And The Virgo Collaboration,

T. et al. (2020) "A guide to LIGO-Virgo detector noise and extraction of transient gravitational-wave signals", Classical and Quantum Gravity, 37(5). doi: 10.1088/1361-6382/ab685e.

Abbott, B. P. et al. (2019) "Search for intermediate mass black hole binaries in the first and second observing runs of the Advanced LIGO and Virgo network", Physical Review D, 100(6). doi: 10.1103/PhysRevD.100.064064.

Abbott, B. P. et al. (2019) "Search for Gravitational-wave Signals Associated with Gamma-Ray Bursts during the Second Observing Run of Advanced LIGO and Advanced Virgo", Astrophysical Journal, 886(1). doi: 10.3847/1538-4357/ab4b48.

Abbott, B. P. et al. (2019) "Search for Subsolar Mass Ultracompact Binaries in Advanced LIGO's Second Observing Run", Physical Review Letters, 123(16). doi: 10.1103/PhysRevLett.123.161102.

Abbott, B. P. et al. (2019) "Search for Eccentric Binary Black Hole Mergers with Advanced LIGO and Advanced Virgo during Their First and Second Observing Runs", Astrophysical Journal, 883(2). doi: 10.3847/1538-4357/ab3c2d.

Abbott, B. P. et al. (2019) "All-sky search for long-duration gravitational-wave transients in the second Advanced LIGO observing run", Physical Review D, 99(10). doi: 10.1103/PhysRevD.99.104033.

Abbott, B. P. et al. (2019) "All-sky search for short gravitational-wave bursts in the second Advanced LIGO and Advanced Virgo run", Physical Review D, 100(2). doi: 10.1103/PhysRevD.100.024017.

Abbott, B. P. et al. (2019) "GWTC-1: A Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs", Physical Review X, 9(3). doi: 10.1103/PhysRevX.9.031040.

Abbott, B. P. et al. (2019) "Tests of general relativity with the binary black hole signals from the LIGO-Virgo catalog GWTC-1", Physical Review D, 100(10). doi: 10.1103/PhysRevD.100.104036.

Abbott, B. P. et al. (2019) "Searches for Continuous Gravitational Waves from 15

Supernova Remnants and Fomalhaut b with Advanced LIGO", Astrophysical Journal, 875(2). doi: 10.3847/1538-4357/ab113b.

Abbott, B. P. et al. (2019) "All-sky search for continuous gravitational waves from isolated neutron stars using Advanced LIGO O2 data", Physical Review D, 100(2). doi: 10.1103/PhysRevD.100.024004.

Abbott, B. P. et al. (2019) "Searches for Gravitational Waves from Known Pulsars at Two Harmonics in 2015-2017 LIGO Data", Astrophysical Journal, 879(1). doi: 10.3847/1538-4357/ab20cb.

Abbott, B. P. et al. (2019) "Erratum: Searches for gravitational waves from known pulsars at two harmonics in 2015-2017 LIGO data (Astrophysical Journal (2019) 879 (10) DOI: 10.3847/1538-4357/ab20cb)", Astrophysical Journal, 882(1). doi: 10.3847/1538-4357/ab3231.

Abbott, B. P. et al. (2019) "Directional limits on persistent gravitational waves using data from Advanced LIGO's first two observing runs", Physical Review D, 100(6). doi: 10.1103/PhysRevD.100.062001.

Abbott, B. P. et al. (2019) "Narrow-band search for gravitational waves from known pulsars using the second LIGO observing run", Physical Review D, 99(12). doi: 10.1103/PhysRevD.99.122002.

Abbott, B. P. et al. (2019) "Low-latency Gravitational-wave Alerts for Multimessenger Astronomy during the Second Advanced LIGO and Virgo Observing Run", Astrophysical Journal, 875(2). doi: 10.3847/1538-4357/ab0e8f.

Abbott, B. P. et al. (2019) "Search for Transient Gravitational-wave Signals Associated with Magnetar Bursts during Advanced LIGO's Second Observing Run", Astrophysical Journal, 874(2). doi: 10.3847/1538-4357/ab0e15.

Abbott, B. P. et al. (2019) "Search for gravitational waves from Scorpius X-1 in the second Advanced LIGO observing run with an improved hidden Markov model", Physical Review D, 100(12). doi: 10.1103/PhysRevD.100.122002.

Abbott, B. P. et al. (2019) "Search for the isotropic stochastic background using data from Advanced LIGO's second observing run", Physical Review D, 100(6). doi: 10.1103/PhysRevD.100.061101.

Abbott, B. P. et al. (2019) "Properties of the Binary Neutron Star Merger GW170817", Physical Review X, 9(1). doi: 10.1103/PhysRevX.9.011001.

Abbott, B. P. et al. (2019) "Tests of General Relativity with GW170817", Physical Review Letters, 123(1). doi: 10.1103/PhysRevLett.123.011102.

Abbott, B. P. et al. (2019) "Constraining the p-Mode-g-Mode Tidal Instability with GW170817", Physical Review Letters, 122(6). doi: 10.1103/PhysRevLett.122.061104.

Abbott, B. P. et al. (2019) "Search for Gravitational Waves from a Long-lived Remnant of the Binary Neutron Star Merger GW170817", Astrophysical Journal, 875(2). doi: 10.3847/1538-4357/ab0f3d.

Albert, A. et al. (2019) "Search for Multimessenger Sources of Gravitational Waves

and High-energy Neutrinos with Advanced LIGO during Its First Observing Run, ANTARES, and IceCube", Astrophysical Journal, 870(2). doi: 10.3847/1538-4357/aaf21d.

Burns, E. et al. (2019) "A Fermi Gamma-Ray Burst Monitor Search for Electromagnetic Signals Coincident with Gravitational-wave Candidates in Advanced LIGO's First Observing Run", Astrophysical Journal, 871(1). doi: 10.3847/1538-4357/aaf726.

Ligo Scientific Collaboration And The Virgo Collaboration, T. et al. (2019) "Binary Black Hole Population Properties Inferred from the First and Second Observing Runs of Advanced LIGO and Advanced Virgo", Astrophysical Journal Letters, 882(2). doi: 10.3847/2041-8213/ab3800.

Soares-Santos, M. et al. (2019) "First Measurement of the Hubble Constant from a Dark Standard Siren using the Dark Energy Survey Galaxies and the LIGO/Virgo Binary-Black-hole Merger GW170814", Astrophysical Journal Letters, 876(1). doi: 10.3847/2041-8213/ab14f1.

Abbott, B. P. et al. (2018) "Prospects for observing and localizing gravitational-wave transients with Advanced LIGO, Advanced Virgo and KAGRA", Living Reviews in Relativity, 21(1). doi: 10.1007/s41114-018-0012-9.

Abbott, B. P. et al. (2018) "All-sky search for long-duration gravitational wave transients in the first Advanced LIGO observing run", Classical and Quantum Gravity, 35(6). doi: 10.1088/1361-6382/aaab76.

Abbott, B. P. et al. (2018) "Effects of data quality vetoes on a search for compact binary coalescences in Advanced LIGO's first observing run", Classical and Quantum Gravity, 35(6). doi: 10.1088/1361-6382/aaaafa.

Abbott, B. P. et al. (2018) "GW170817: Implications for the Stochastic Gravitational-Wave Background from Compact Binary Coalescences", Physical Review Letters, 120(9). doi: 10.1103/PhysRevLett.120.091101.

Abbott, B. P. et al. (2018) "Search for Tensor, Vector, and Scalar Polarizations in the Stochastic Gravitational-Wave Background", Physical Review Letters, 120(20). doi: 10.1103/PhysRevLett.120.201102.

Abbott, B. P. et al. (2018) "Constraints on cosmic strings using data from the first Advanced LIGO observing run", Physical Review D, 97(10). doi: 10.1103/PhysRevD.97.102002.

Abbott, B. P. et al. (2018) "First Search for Nontensorial Gravitational Waves from Known Pulsars", Physical Review Letters, 120(3). doi: 10.1103/PhysRevLett.120.031104.

Abbott, B. P. et al. (2018) "Full band all-sky search for periodic gravitational waves in the O1 LIGO data", Physical Review D, 97(10). doi: 10.1103/PhysRevD.97.102003.

Abbott, B. P. et al. (2018) "GW170817: Measurements of Neutron Star Radii and Equation of State", Physical Review Letters, 121(16). doi: 10.1103/PhysRevLett.121.161101.

Abbott, B. P. et al. (2018) "Search for Subsolar-Mass Ultracompact Binaries in Advanced LIGO's First Observing Run", Physical Review Letters, 121(23). doi: 10.1103/PhysRevLett.121.231103.

Abbott, B. P. et al. (2017) "Search for Gravitational Waves Associated with Gamma-Ray Bursts during the First Advanced LIGO Observing Run and Implications for the Origin of GRB 150906B", Astrophysical Journal, 841(2). doi: 10.3847/1538-4357/aa6c47.

Abbott, B. P. et al. (2017) "Directional Limits on Persistent Gravitational Waves from Advanced LIGO's First Observing Runâ, Physical Review Letters, 118(12). doi: 10.1103/PhysRevLett.118.121102.

Abbott, B. P. et al. (2017) "Upper Limits on the Stochastic Gravitational-Wave Background from Advanced LIGO's First Observing Runâ, Physical Review Letters, 118(12). doi: 10.1103/PhysRevLett.118.121101.

Abbott, B. P. et al. (2017) "First Search for Gravitational Waves from Known Pulsars with Advanced LIGO", Astrophysical Journal, 839(1). doi: 10.3847/1538-4357/aa677f.

Abbott, B. P. et al. (2017) "Effects of waveform model systematics on the interpretation of GW150914", Classical and Quantum Gravity, 34(10). doi: 10.1088/1361-6382/aa6854.

Abbott, B. P. et al. (2017) Observation of gravitational waves from a binary black hole merger, Centennial of General Relativity: A Celebration. doi: $10.1142/9789814699662_0011$.

Abbott, B. P. et al. (2017) "The basic physics of the binary black hole merger GW150914", Annalen der Physik, 529(1â2). doi: 10.1002/andp.201600209.

Abbott, B. P. et al. (2017) "All-sky search for short gravitational-wave bursts in the first Advanced LIGO run", Physical Review D, 95(4). doi: 10.1103/PhysRevD.95.042003.

Abbott, B. P. et al. (2017) "Search for continuous gravitational waves from neutron stars in globular cluster NGC 6544", Physical Review D, 95(8). doi: 10.1103/PhysRevD.95.082005.

Abbott, B. P. et al. (2017) "Calibration of the Advanced LIGO detectors for the discovery of the binary black-hole merger GW150914", Physical Review D, 95(6). doi: 10.1103/PhysRevD.95.062003.

Abbott, B. P. et al. (2017) "Exploring the sensitivity of next generation gravitational wave detectors", Classical and Quantum Gravity, 34(4). doi: 10.1088/1361-6382/aa51f4.

Abbott, B. P. et al. (2017) "Gravitational Waves and Gamma-Rays from a Binary Neutron Star Merger: GW170817 and GRB 170817A", Astrophysical Journal Letters, 848(2). doi: 10.3847/2041-8213/aa920c.

Abbott, B. P. et al. (2017) "GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral", Physical Review Letters, 119(16). doi: 10.1103/PhysRevLett.119.161101.

Abbott, B. P. et al. (2017) "Multi-messenger observations of a binary neutron star merger", Astrophysical Journal Letters, 848(2). doi: 10.3847/2041-8213/aa91c9.

Abbott, B. P. et al. (2017) "GW170814: A Three-Detector Observation of Gravitational Waves from a Binary Black Hole Coalescence", Physical Review Letters, 119(14).

doi: 10.1103/PhysRevLett.119.141101.

Abbott, B. P. et al. (2017) "Search for Post-merger Gravitational Waves from the Remnant of the Binary Neutron Star Merger GW170817", Astrophysical Journal Letters, 851(1). doi: 10.3847/2041-8213/aa9a35.

Abbott, B. P. et al. (2017) "GW170608: Observation of a 19 Solar-mass Binary Black Hole Coalescence", Astrophysical Journal Letters, 851(2). doi: 10.3847/2041-8213/aa9f0c.

Abbott, B. P. et al. (2017) "A gravitational-wave standard siren measurement of the Hubble constant", Nature, 551(7678). doi: 10.1038/nature24471.

Abbott, B. P. et al. (2017) "On the Progenitor of Binary Neutron Star Merger GW170817", Astrophysical Journal Letters, 850(2). doi: 10.3847/2041-8213/aa93fc.

Abbott, B. P. et al. (2017) "Estimating the Contribution of Dynamical Ejecta in the Kilonova Associated with GW170817", Astrophysical Journal Letters, 850(2). doi: 10.3847/2041-8213/aa9478.

Abbott, B. P. et al. (2017) "Upper Limits on Gravitational Waves from Scorpius X-1 from a Model-based Cross-correlation Search in Advanced LIGO Data", Astrophysical Journal, 847(1). doi: 10.3847/1538-4357/aa86f0.

Abbott, B. P. et al. (2017) "GW170104: Observation of a 50-Solar-Mass Binary Black Hole Coalescence at Redshift 0.2", Physical Review Letters, 118(22). doi: 10.1103/PhysRevLett.118.221101.

Abbott, B. P. et al. (2017) "First narrow-band search for continuous gravitational waves from known pulsars in advanced detector data", Physical Review D, 96(12). doi: 10.1103/PhysRevD.96.122006.

Abbott, B. P. et al. (2017) "Search for gravitational waves from Scorpius X-1 in the first Advanced LIGO observing run with a hidden Markov model", Physical Review D, 95(12). doi: 10.1103/PhysRevD.95.122003.

Abbott, B. P. et al. (2017) "All-sky search for periodic gravitational waves in the O1 LIGO data", Physical Review D, 96(6). doi: 10.1103/PhysRevD.96.062002.

Abbott, B. P. et al. (2017) "Search for intermediate mass black hole binaries in the first observing run of Advanced LIGO", Physical Review D, 96(2). doi: 10.1103/PhysRevD.96.022001.

Abbott, B. P. et al. (2017) "First low-frequency Einstein@Home all-sky search for continuous gravitational waves in Advanced LIGO data", Physical Review D, 96(12). doi: 10.1103/PhysRevD.96.122004.

Albert, A. et al. (2017) "Search for high-energy neutrinos from gravitational wave event GW151226 and candidate LVT151012 with ANTARES and IceCube", Physical Review D, 96(2). doi: 10.1103/PhysRevD.96.022005.

Albert, A. et al. (2017) "Search for High-energy Neutrinos from Binary Neutron Star Merger GW170817 with ANTARES, IceCube, and the Pierre Auger Observatory", Astrophysical Journal Letters, 850(2). doi: 10.3847/2041-8213/aa9aed.

Aasi, J. et al. (2016) "Search of the Orion spur for continuous gravitational waves using a loosely coherent algorithm on data from LIGO interferometers", Physical Review D, 93(4). doi: 10.1103/PhysRevD.93.042006.

Aasi, J. et al. (2016) "First low frequency all-sky search for continuous gravitational wave signals", Physical Review D, 93(4). doi: 10.1103/PhysRevD.93.042007.

Abbott, B. P. et al. (2016) "Characterization of transient noise in Advanced LIGO relevant to gravitational wave signal GW150914", Classical and Quantum Gravity, 33(13). doi: 10.1088/0264-9381/33/13/134001.

Abbott, B. P. et al. (2016) "Observation of gravitational waves from a binary black hole merger", Physical Review Letters, 116(6). doi: 10.1103/PhysRevLett.116.061102.

Abbott, B. P. et al. (2016) "SUPPLEMENT: "LOCALIZATION and BROADBAND FOLLOW-UP of the GRAVITATIONAL-WAVE TRANSIENT GW150914" (2016, ApJL, 826, L13)", Astrophysical Journal, Supplement Series, 225(1). doi: 10.3847/0067-0049/225/1/8.

Abbott, B. P. et al. (2016) "Localization and broadband follow-up of the gravitational-wave transient GW150914", Astrophysical Journal Letters, 826(1). doi: 10.3847/2041-8205/826/1/L13.

Abbott, B. P. et al. (2016) "ASTROPHYSICAL IMPLICATIONS of the BINARY BLACK HOLE MERGER GW150914", Astrophysical Journal Letters, 818(2). doi: 10.3847/2041-8205/818/2/L22.

Abbott, B. P. et al. (2016) "Properties of the Binary Black Hole Merger GW150914", Physical Review Letters, 116(24). doi: 10.1103/PhysRevLett.116.241102.

Abbott, B. P. et al. (2016) "Tests of General Relativity with GW150914", Physical Review Letters, 116(22). doi: 10.1103/PhysRevLett.116.221101.

Abbott, B. P. et al. (2016) "Observing gravitational-wave transient GW150914 with minimal assumptions", Physical Review D, 93(12). doi: 10.1103/PhysRevD.93.122004.

Abbott, B. P. et al. (2016) "GW150914: First results from the search for binary black hole coalescence with Advanced LIGO", Physical Review D, 93(12). doi: 10.1103/PhysRevD.93.122003.

Abbott, B. P. et al. (2016) "Supplement: The Rate Of Binary Black Hole Mergers Inferred From Advanced Ligo Observations Surrounding Gw150914", Astrophysical Journal, Supplement Series, 227(2). doi: 10.3847/0067-0049/227/2/14.

Abbott, B. P. et al. (2016) "First targeted search for gravitational-wave bursts from core-collapse supernovae in data of first-generation laser interferometer detectors", Physical Review D, 94(10). doi: 10.1103/PhysRevD.94.102001.

Abbott, B. P. et al. (2016) "The rate of binary black hole mergers inferred from advanced LIGO observations surrounding GW150914", Astrophysical Journal Letters, 833(1). doi: 10.3847/2041-8205/833/1/L1.

Abbott, B. P. et al. (2016) "GW150914: The advanced LIGO detectors in the era of first discoveries", Physical Review Letters, 116(13). doi: 10.1103/PhysRevLett.116.131103.

Abbott, B. P. et al. (2016) "Search for transient gravitational waves in coincidence with short-duration radio transients during 2007-2013", Physical Review D, 93(12). doi: 10.1103/PhysRevD.93.122008.

Abbott, B. P. et al. (2016) "GW150914: Implications for the stochastic gravitational-wave background from binary black holes", Physical Review Letters, 116(13). doi: 10.1103/PhysRevLett.116.131102.

Abbott, B. P. et al. (2016) "Binary Black Hole Mergers in the First Advanced LIGO Observing Run", Physical Review X, 6(4). doi: 10.1103/PhysRevX.6.041015.

Abbott, B. P. et al. (2016) "Improved analysis of GW150914 using a fully spin-precessing waveform model", Physical Review X, 6(4). doi: 10.1103/PhysRevX.6.041014.

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