Utilisation des données ouvertes

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10 octobre 2019

LIGO-Virgo Open Public Alerts

GraceDB — Gravitational-Wave Candidate Event Database

HOME | PUBLIC ALERTS | SEARCH | LATEST | DOCUMENTATION

LIGO/Virgo O3 Public Alerts

Detection candidates: 33

- Public LIGO/Virgo alerts distributed using NASA's Gamma-ray Coordinates Network
  - GCN notices (machine-readable) and circulars (human-readable)
  - Preliminary GCN notice automatically sent within minutes of candidate detection
  - Initial notice and circular (or retraction) after human vetting
  - Update notice(s) when further analysis leads to improved estimates of sky localization, significance, or classification
- Alert contents
  - Significance
  - Sky localization
  - Inference: source classification and properties
    - Compact binary coalescence candidates only

➔ See Florian Aubin's talk

GWOSC

Gravitational Wave Open Science Center

Data ▾ Software ▾ Online Status ▾ About GWOSC ▾

The Gravitational Wave Open Science Center provides data from gravitational-wave observatories, along with access to tutorials and software tools.

O2 Data Release

O2 Time Range: November 30, 2016 through August 25, 2017
Detectors: H1, L1 and V1

4KHz Data | 16KHz Data | Documents | Timeline

O1 Data Release

O1 Time Range: September 12, 2015 through January 19, 2016
Detectors: H1 and L1

4KHz Data | 16KHz Data | Documents | Timeline

Data for Events

Events

Catalogs

GWTC-1

Gravitational-Wave Transient Catalog of Compact Binary Mergers (O1 & O2)

- **Documentation:** Notes
- **Strain Data:** Confident detections | Marginal Triggers
- **Auxillary Data:** PE Samples, Skymaps, and more

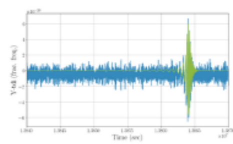
➔ See Agata Trovato's talk

LISA Data Challenge

- LISA Data Challenge 1: *Radler*
  - Tackle the main LISA sources separately, under an idealized instrument-noise model
  - Establish LDC process and standards
  - 6 subchallenges
  - Submit your results by December 31, 2019

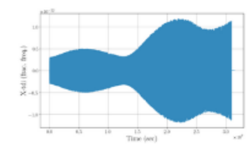
LDC1-1. A single GW signal from a merging massive-black-hole binary.

LIGO and Virgo have done it, so let's get LISA on the right path! MBHBs are represented with a frequency-domain inspiral–merger–ringdown phenomenological model (IMRPhenomD). The black holes are spinning, with spin vectors parallel to the orbital angular momentum. The release includes datasets for two methods (frequency- and time-domain) of applying the LISA response to the GWs.



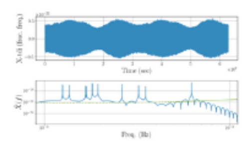
LDC1-2. A single GW signal from an extreme-mass-ratio inspiral.

EMRIs are modeled with the "classic" *Analytic Kludge* waveforms, which will be updated in future challenges, so make your code flexible! The signal is produced in the time domain and the response is applied using LISACode. The signal is of moderate strength, but the source parameters are drawn from relatively wide priors. This should make for a good challenge!



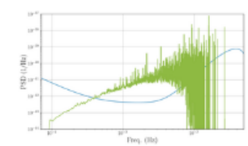
LDC1-3. Superimposed GW signals from several verification Galactic white-dwarf binaries.

We assume circular orbits and purely gravitational interactions. The phase of the signal includes frequency and first derivative. This one should be easy!



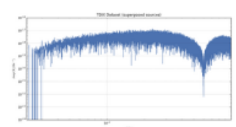
LDC1-4. A GW signal from a population of Galactic white-dwarf binaries.

Here's the classic cocktail-party problem: 26 million signals, produced with a "fast response" code. Parameters of all binaries are available in a large HDF5 file.



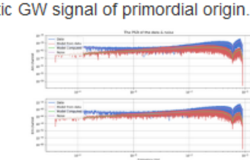
LDC1-5. A GW signal from a population of stellar-origin (stellar-mass) black-hole binaries.

LIGO and Virgo's gift to LISA. The population follows Salpeter's mass function, with an overall rate based on recent LIGO–VIRGO estimates. Waveform and LISA response are computed in the frequency domain.



LDC1-6. An isotropic stochastic GW signal of primordial origin.

Statistics are Gaussian, but the spectral shape is shrouded in mystery, with parameters chosen for us by the LISA Consortium Cosmology Working Group. The signal is generated using LISACode as a choir of elementary sources uniformly distributed across the sky. To make things easier for you, instrumental noise is Gaussian, uncorrelated, and of the same level in each LISA link.

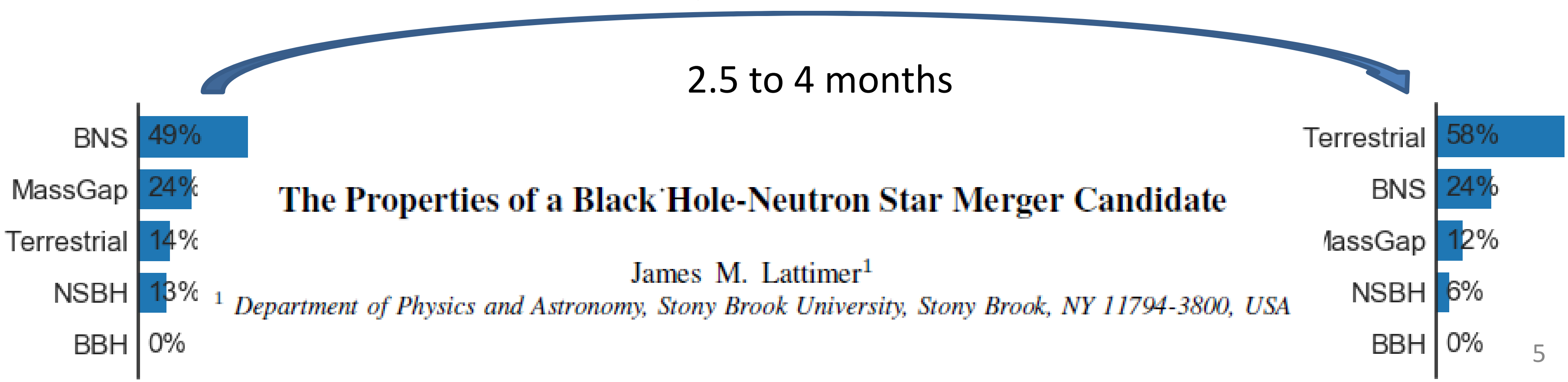


➔ See Stas Babak's talk

Use of Alerts

- Follow-up observations to search for counterparts
  - LIGO-Virgo candidates currently generate ~50% of GCN circular traffic
  - Vanilla BBH candidate typically generates 15-20 GCN circulars
  - S190425z (BNS) and S190814bv (NSBH) generated ~120 circulars
  - S190426c and S190510g (BNS then terrestrial) generated ~60-70 circulars
  - S190728q (MassGap then BBH) generated ~40 circulars

- Attempts to reverse-engineer source properties



Papers referring to GWOSC

- >80 papers listed on INSPIRE
  - ~50% from authors outside the LVC
    - Including ~20% from former LVC collaborators
  - ~35% from authors inside the LVC
  - ~15% with mixed authorship
    - Inside and outside LVC
  - Beyond the usual GW geography
    - Some papers from institutes in China, Iran, Mexico…
- Caveats on this list
  - Not exhaustive: almost certainly misses some other papers using data from GWOSC
  - Includes papers that do not really use data from GWOSC
  - Not all papers published in a journal

Parameter Estimation

- Impact of prior assumptions

Reanalysis of LIGO black-hole coalescences with alternative prior assumptions

Davide Gerosa[1] †, Salvatore Vitale[2], Carl-Johan Haster[3], Katerina Chatziioannou[3] and Aaron Zimmerman[3]

- Impact of noise estimation

Noise spectral estimation methods and their impact on gravitational wave measurement of compact binary mergers

Katerina Chatziioannou,[1] Carl-Johan Haster,[2,3] Tyson B. Littenberg,[4] Will M. Farr,[5,1]

- Impact of waveform model accuracy

Constraining the parameters of GW150914 & GW170104 with numerical relativity surrogates

Prayush Kumar,[1,*] Jonathan Blackman,[2] Scott E. Field,[3] Mark Scheel,[2] Chad R. Galley,[4,2] Michael

On the properties of the massive binary black hole merger GW170729

Katerina Chatziioannou,[1] Roberto Cotesta,[2] Sudarshan Ghonge,[3] Jacob Lange,[4] Ken K.-Y. Ng,[5] Juan Calderón

Parameter Estimation with a spinning multi-mode waveform model: IMRPhenomHM

Chinmay Kalaghatgi,[1] Mark Hannam,[1] and Vivien Raymond[1]

- Algorithmic issues

The Label Switching Problem in Bayesian Analysis for Gravitational Wave Astronomy

Riccardo Buscicchio,[*] Elinore Roebber, Janna M. Goldstein, and Christopher J. Moore

- Computing issues

Expediting Astrophysical Discovery with Gravitational-Wave Transients Through Massively Parallel Nested Sampling

Rory J. E. Smith[1,2,*] and Gregory Ashton[1,2,†]

Matter Effects

Tidal Deformabilities and Radii of Neutron Stars from the Observation of GW170817

Soumi De[1], Daniel Finstad[1], James M. Lattimer[2], Duncan A. Brown[1], Edo Berger[3], and Christopher M. Biwer[1,4]
[1] *Department of Physics, Syracuse University, Syracuse, NY 13244, USA*

Equation-of-state insensitive relations after GW170817

Zack Carson,[1] Katerina Chatziioannou,[2] Carl-Johan Haster,[3] Kent Yagi,[1] and Nicolás Yunes[4]
[1] *Department of Physics, University of Virginia, Charlottesville, Virginia 22904, USA*

Constraints on non-linear tides due to *p*-*g* mode coupling from the neutron-star merger GW170817

Steven Reyes[1] and Duncan A. Brown[1]

Gravitational-Wave Asteroseismology with Fundamental Modes from Compact Binary Inspirals

Geraint Pratten,[1,2,*] Patricia Schmidt,[1,†] and Tanja Hinderer[3,4,‡]
[1] *School of Physics and Astronomy and Institute for Gravitational Wave Astronomy, University of Birmingham, Edgbaston, Birmingham, B15 9TT, United Kingdom*

Astrophysics & Cosmology

Kicking gravitational wave detectors with recoiling black holes

Carlos O. Lousto and James Healy

from the other by advanced LIGO. We also come back to the first gravitational wave event GW150914, that we recently reanalyzed in Ref. [42], to evaluate the likelihood of recoils within a different simulation family, involving

Measuring the viewing angle of GW170817 with electromagnetic and gravitational waves

Daniel Finstad,[1] Soumi De,[1] Duncan A. Brown,[1] Edo Berger,[2] and Christopher M. Biwer[1,3]

The Impact of Peculiar Velocities on the Estimation of the Hubble Constant from Gravitational Wave Standard Sirens

Constantina Nicolaou,[1⋆] Ofer Lahav,[1] Pablo Lemos,[1] William Hartley[1,2] and Jonathan Braden[3]

wave standard sirens. We study the GW170817 event and the estimation of the peculiar velocity of its host galaxy, NGC 4993, when using Gaussian smoothing over nearby galaxies. NGC 4993 being a relatively nearby galaxy, at ~ 40 Mpc away, is subject to

Distinguishing Primordial Black Holes from Astrophysical Black Holes by Einstein Telescope and Cosmic Explorer

Zu-Cheng Chen[1,2,∗] and Qing-Guo Huang[1,2,3,4,†]

GW Polarizations

Constraining extra gravitational wave polarizations with Advanced LIGO, Advanced Virgo and KAGRA and upper bounds from GW170817

Yuki Hagihara[1], Naoya Era[1], Daisuke Iikawa[1], Atsushi Nishizawa[2,3], and Hideki Asada[1]

Detecting Beyond-Einstein Polarizations of Continuous Gravitational Waves

Maximiliano Isi,[1,*] Alan J. Weinstein,[1,†] Carver Mead,[1,‡] and Matthew Pitkin[2,§]

[1] *California Institute of Technology*

[2] *University of Glasgow*

(Dated: March 31, 2015)

Black Hole Ringdown

Modeling ringdown II: non-precessing binary black holes

L. T. London[1]

relativity. Here, the author presents the first ringdown model that captures the amplitude and relative phase of the dominant and subdominant quasi-normal modes for non-precessing binary black holes systems. For the first

Observational Black Hole Spectroscopy: A time-domain multimode analysis of GW150914

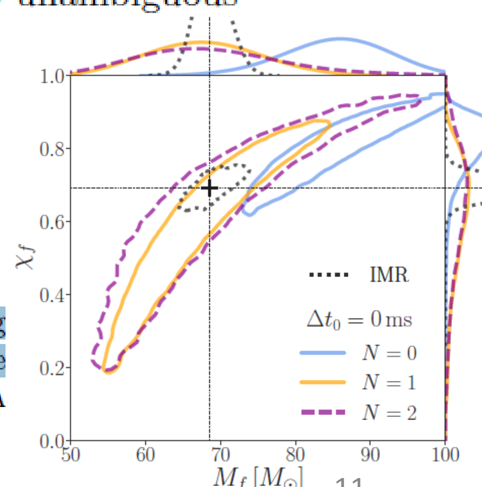
Gregorio Carullo,[1,2] Walter Del Pozzo,[1,2] and John Veitch[3]

analysis method which infers from the data the time of transition between the non-linear and quasi-linear regime of the post-merger emission in concert with all other parameters characterising the source. We find that the data provides no evidence for the presence of more than one quasi-normal mode. However, from the central frequency and damping time posteriors alone, no unambiguous

Testing the no-hair theorem with GW150914

Maximiliano Isi,[1,*] Matthew Giesler,[2] Will M. Farr,[3,4] Mark A. Scheel,[2] and Saul A. Teukolsky[2,5]
[1] *LIGO Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*

(GW150914) in search of the ringdown of the remnant black hole. Using observations beginning at the peak of the signal, we find evidence of the fundamental quasinormal mode and at least one overtone, both associated with the dominant angular mode ($\ell = m = 2$), with 3.6σ confidence. A



Search Methods

Leveraging waveform complexity for confident detection of gravitational waves

Jonah B. Kanner
LIGO Laboratory, California Institute of Technology, Pasadena, CA 91125, USA[*]

Characterization of non-Gaussianity in gravitational wave detector noise

Takahiro Yamamoto, Kazuhiro Hayama, Shuhei Mano, Yousuke Itoh, and Nobuyuki Kanda

Extraction of black hole coalescence waveforms from noisy data

Martin A. Green[a], J. W. Moffat[a,b]

Astrophysical signal consistency test adapted for gravitational-wave transient searches

V. Gayathri,[1] P. Bacon,[2] A. Pai,[1] E. Chassande-Mottin,[2] F. Salemi,[3] and G. Vedovato[4]

A time–frequency analysis of gravitational wave signals with non-harmonic analysis

Kenta Yanagisawa[1], Dongbao Jia[1,2], Shigeki Hirobayashi[1], Nami Uchikata[3], Tatsuya Narikawa[4], Koh Ueno[5], Hirotaka Takahashi[6], and Hideyuki Tagoshi[7,*]

Hierarchical search strategy for the efficient detection of gravitational waves from non-precessing coalescing compact binaries with aligned-spins

Bhooshan Uday Varsha Gadre,[1,*] Sanjit Mitra,[1,†] and Sanjeev Dhurandhar[1,‡]

Artificial Intelligence for GW Searches

Convolutional neural networks: A magic bullet for gravitational-wave detection?

Timothy D. Gebhard,[1,2,*] Niki Kilbertus,[1,3,*] Ian Harry,[4,5] and Bernhard Schölkopf[1]

[1] *Max Planck Institute for Intelligent Systems, Max-Planck-Ring 4, 72076 Tübingen, Germany*

In this section, we develop our main conceptual contributions, namely that (a) convolutional neural networks are not suited to claim statistically significant detections of gravitational waves, however, (b) they can still be useful tools for real-time trigger generation.

Gravitational wave signal recognition of O1 data by deep learning

He Wang,[1] Zhoujian Cao*,[2,†] Xiaolin Liu,[2] Shichao Wu,[2] and Jian-Yang Zhu[1]

[1] *Department of Physics, Beijing Normal University, Beijing 100875, China*

published in the literature. Based on our adjusted CNN, we can clearly recognize the eleven confirmed gravitational wave events included in O1 and O2. And more we find about 2000 gravitational wave triggers in O1 data.

The IAS-Princeton Case

- Small group outside LVC developed sophisticated BBH search
  - Builds on existing literature, but independently developed
  - Methods and results papers
- Aggressive search focused on parameter space of LVC detections
  - Claims new BBH detections, some of which are likely real

A Highly Spinning and Aligned Binary Black Hole Merger in the Advanced LIGO First Observing Run

Barak Zackay,[1,*] Tejaswi Venumadhav,[1] Liang Dai,[1] Javier Roulet,[2] and Matias Zaldarriaga[1]

A New Search Pipeline for Compact Binary Mergers: Results for Binary Black Holes in the First Observing Run of Advanced LIGO

New Binary Black Hole Mergers in the Second Observing Run of Advanced LIGO and Advanced Virgo

Template Bank for Compact Binary Coalescence Searches in Gravitational Wave Data: A General Geometric Placement Algorithm

Detecting Gravitational Waves in Data with Non-Gaussian Noise

Long-shot Searches

Gravitational waves from compact dark matter objects in the solar system

C. J. Horowitz*

Dark matter could be composed of compact dark objects (CDOs). We find that a close binary of CDOs orbiting *inside* solar system bodies can be a loud source of gravitational waves (GWs) for the LIGO and VIRGO detectors. An initial search of data from the first Advanced LIGO observing run (O1), sensitive to $h_0 \approx 10^{-24}$, rules out close binaries orbiting near the center of the Sun with GW frequencies (twice the orbital frequency) between 50 and 550 Hz and CDO masses above $\approx 10^{-9} M_\odot$.

Searching for Dark Photon Dark Matter in LIGO O1 Data

Huai-Ke Guo,[1] Keith Riles,[2] Feng-Wei Yang,[3,4] and Yue Zhao[4]

A gravitational wave detector can be used to search for dark photon dark matter. We use the publicly available data from LIGO's first observing run, O1, to perform the first such search. We find that, if a dark photon is the gauge boson of $U(1)_B$, LIGO-O1 data has already provided a sensitivity better in a mass band around $m_A \sim 4 \times 10^{-13}$ eV than achieved by prior experiments. Substantially improved search sensitivity is expected during the coming years of continued data taking by LIGO and other gravitational wave detectors in a growing global network.

Searching for ultralight bosons within spin measurements of a population of binary black hole mergers

Ken K. Y. Ng,[1,*] Otto A. Hannuksela,[2,†] Salvatore Vitale,[1] and Tjonnie G. F. Li[2]

Wishful Searching: Echoes

Echoes from the Abyss: Tentative evidence for Planck-scale structure at black hole horizons

Jahed Abedi,[1,2,3,*] Hannah Dykaar,[4,5] and Niayesh Afshordi[3,5,†]

Low significance of evidence for black hole echoes in gravitational wave data

Julian Westerweck,[1,2,*] Alex B. Nielsen,[1,2,†] Ofek Fischer-Birnholtz,[1,2,3,‡] Miriam Cabero,[1,2] Collin Capano,[1,2] Thomas Dent,[1,2] Badri Krishnan,[1,2] Grant Meadors,[1,4,5] and Alexander H. Nitz[1,2]

Gravitational wave echoes through new windows

Randy S. Conklin,[1,*] Bob Holdom,[1,†] and Jing Ren[1,2,‡]

Parameter estimation for black hole echo signals and their statistical significance

Alex B. Nielsen,[1,2,*] Collin D. Capano,[1,2,†] Ofek Birnholtz,[3,‡] and Julian Westerweck[1,2,§]

Template-based gravitational-wave echoes search using Bayesian model selection

Rico K. L. Lo,[1,2,a] Tjonnie G. F. Li,[1] and Alan J. Weinstein[3]

A wider look at the gravitational-wave transients from GWTC-1 using an unmodeled reconstruction method

F. Salemi,[1] E. Milotti,[2] G. A. Prodi,[3,4] G. Vedovato,[5]

Not quite black holes at LIGO

Bob Holdom*

There is a different concern worth mentioning. In their continuing efforts to reduce noise with respect to their merger-signal target, it is to be hoped that LIGO does not inadvertently remove poorly understood non-Gaussian noise that, as seen here, could harbour new physics.[7]

Lensing: Predictions

Precise LIGO Lensing Rate Predictions for Binary Black Holes

Ken K. Y. Ng,[*] Kaze W. K. Wong,[†] and Tjonnie G. F. Li
Department of Physics, The Chinese University of Hong Kong, Shatin N.T., Hong Kong

and chirp masses. Currently we estimate a detectable rate of lensed events $0.2^{+1.0}_{-0.1}\ \mathrm{yr}^{-1}$, that rises to $14.2^{+80.5}_{-10.7}\ \mathrm{yr}^{-1}$, at LIGO's design sensitivity limit, depending on the high redshift rate of black

What if LIGO's gravitational wave detections are strongly lensed by massive galaxy clusters?

Graham P. Smith,[1⋆] Mathilde Jauzac,[2,3,4,5] John Veitch,[1,6,7] Will M. Farr,[1,7] Richard Massey,[2] Johan Richard[8]

ulations of BBH GW sources and strong-lensing clusters, we estimate a conservative lower limit on the number of BBH mergers detected per detector year at LIGO/Virgo's current sensitivity that are multiply-imaged, of $R_{\mathrm{detect}} \simeq 10^{-5}\ \mathrm{yr}^{-1}$. This is equivalent

Reinterpreting Low Frequency LIGO/Virgo Events as Magnified Stellar-Mass Black Holes at Cosmological Distances.

Tom Broadhurst[1,2], Jose M. Diego[3], George Smoot III [4,5,6,7]

Lensing: Searches

SEARCH FOR GRAVITATIONAL LENSING SIGNATURES IN LIGO-VIRGO BINARY BLACK HOLE EVENTS

O.A. HANNUKSELA[1], K. HARIS[2], K.K.Y. NG[3,4], S. KUMAR[2,5,6], A.K. MEHTA[2], D. KEITEL[7], T.G.F. LI[1], P. AJITH[2,8]
[1] Department of Physics, Chinese University of Hong Kong, Sha Tin, Hong Kong

strong lensing by galaxies, 3) evidence of wave optics effects due to point-mass lenses. We find no compelling evidence of any of these signatures in the observed gravitational wave signals. However, as the sensitivities of

Targeted Sub-threshold Search for Strongly-lensed Gravitational-wave Events

Alvin K. Y. Li,[1,a] Rico K. L. Lo,[2,b] Surabhi Sachdev,[2,3,4] Tjonnie G. F. Li,[1] and Alan J. Weinstein[2]
[1]*Department of Physics, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong*

Twin LIGO/Virgo Detections of a Viable Gravitationally-Lensed Black Hole Merger

We identify a binary black hole (BBH) merger that appears to be multiply lensed by an intervening galaxy. The LIGO/Virgo events GW170809 and GW170814 [1] have indistinguishable

Continuous Wave Searches

❑ Methods

A NESTED SAMPLING CODE FOR TARGETED SEARCHES FOR CONTINUOUS GRAVITATIONAL WAVES FROM PULSARS

M. PITKIN,[1] M. ISI,[2] J. VEITCH,[1,3] AND G. WOAN[1]

Loosely coherent searches for medium scale coherence lengths

Vladimir Dergachev[1, 2, a]

Hierarchical Bayesian method for detecting continuous gravitational waves from an ensemble of pulsars

M. Pitkin[*] and C. Messenger[†]

An Analytic Approximation to the Bayesian Detection Statistic for Continuous Gravitational Waves

John J. Bero

❑ Actual searches

Sensitivity improvements in the search for periodic gravitational waves using O1 LIGO data

Vladimir Dergachev[1, 2, a] and Maria Alessandra Papa[1, 2, 3, b]

Loosely coherent search in LIGO O1 data for continuous gravitational waves from Terzan 5 and the galactic center

Vladimir Dergachev,[1, 2, a] Maria Alessandra Papa,[1, 2, 3, b] Benjamin Steltner,[1, 2, c] and Heinz-Bernd Eggenstein[1, 2, d]

Results from an extended Falcon all-sky survey for continuous gravitational waves

Vladimir Dergachev[1, 2, a] and Maria Alessandra Papa[1, 2, 3, b]

Results from an Einstein@Home search for continuous gravitational waves from Cassiopeia A, Vela Jr. and G347.3

J. Ming,[1, 2, a] M.A. Papa,[1, 3, 2, b] A. Singh,[1, 2, 4] H.-B. Eggenstein,[1, 2] S. J. Zhu,[1, 2] V. Dergachev,[1, 2]

GW & Supernovae

Observing gravitational waves from core-collapse supernovae in the advanced detector era

S. E. Gossan,[1,2] P. Sutton,[4] A. Stuver,[5,6] M. Zanolin,[3] K. Gill,[3] and C. D. Ott[2]

Inferring the core-collapse supernova explosion mechanism with gravitational waves

Jade Powell,[1] Sarah E. Gossan,[2] Joshua Logue,[1] and Ik Siong Heng[1]

Astrophysics with core-collapse supernova gravitational wave signals in the next generation of gravitational wave detectors

Vincent Roma,[1] Jade Powell,[2] Ik Siong Heng,[3] and Raymond Frey[1]

Conclusion

- Open data are used to
  - Address known current issues
    - Parameter estimation, post-merger signal, matter effects, polarization, GW sources contribution to dark matter…
  - Explore future issues, known or speculative
    - Supernovae and GW, strongly lensed GW sources…
  - Produce results of various quality
    - Less interesting stuff stems from bad faith, good faith but poor statistical treatment, precipitation…
- Personal view
  - Mixed authorship (inside + outside LVC) tends to be associated with higher added value
  - My favorite paper using open data

Testing the no-hair theorem with GW150914

Maximiliano Isi,[1,*] Matthew Giesler,[2] Will M. Farr,[3,4] Mark A. Scheel,[2] and Saul A. Teukolsky[2,5]

[1] *LIGO Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*