# Leo Tsukada

*Email:* leo.tsukada@ligo.org
*Website:* leotsukada.github.io
*LinkedIn:* leo-tsukada

## Employment

**Pennsylvania State University** — University Park, PA
Assistant Research Professor — 2022–present

**Pennsylvania State University** — University Park, PA
Postdoctoral Scholar — 2021–2022

## Education

**The University of Tokyo** — Tokyo, Japan
Ph.D. in Physics, Advisor: Prof.Kipp Cannon — 2018–2021

- Thesis title : Modeling and Searching for Stochastic Gravitational-waves Backgrounds from Ultralight Boson Particles

**The University of Tokyo** — Tokyo, Japan
M.S. in Physics, Advisor: Prof.Kipp Cannon — 2016–2018

- Thesis title : Towards a Search for Stochastic Gravitational-Wave Backgrounds from Ultra-light Bosons

**The University of Tokyo** — Tokyo, Japan
B.S. in Applied Physics, Advisor: Prof.Norikatsu Mio — 2011–2016

- Thesis title : Performance evaluation of the frequency reference cavity for KAGRA gravitational-wave detector

## Research Experience

**Pennsylvania State University** — University Park, PA
2021–present

- Development of a low-latency gravitational wave (GW) search pipeline, GstLAL
- Bayesian parameter estimation for targeted anisotropic GW background

**Research Center for the Early Universe, The University of Tokyo** — Tokyo, Japan
*M.S./Ph.D. Research, supervised by Prof.Kipp Cannon* — 2016–2021

- Fast evaluation of trigger consistency between multiple detectors using GstLAL
- Searches for ultra-light bosons using stochastic GW background

**LIGO Lab, California Institute of Technology** — Pasadena, CA
*LIGO visitor program, hosted by Prof.Alan Weinstein* — Summer 2019

- Development and event follow-up for online analysis of a GW detection pipeline, GstLAL
- Joint study on GW search for the ultra-light boson particle through superradiant instability

**Laboratoire d'Annecyde Physiquedes Particules** — Annecy, France
*Visiting research, supervised by Dr.Tania Regimbau* — Fall 2018

- Mock data study for the detection of stochastic GW background from anisotopically distributed compact binary coalescence.

**University of Minnesota** — Minneapolis, MN
*Visiting research, supervised by Prof.Vuk Mandic* — Spring 2018

- Development of a search pipeline for GW background from ultra-light scalar fields.

**The University of Tokyo** Tokyo, Japan
*B.S. Research, supervised by Prof.Norikatsu Mio* 2015–2016

– Evaluating optical properties and frequency stability of the reference cavity KAGRA.

**LIGO Livingston Observatory, California Institute of Technology** Livingston, LA
*LIGO SURF program, supervised by Dr.Valery Frolov* Summer 2014

– Constructing the theoretical model of the optical loss inside the arm cavities of the Advanced LIGO.

## Scholarships and Awards

- **Best Poster Award**, Gravitational Wave Orchestra 2022
- **Best Presentation Award**, The 7th KAGRA International Workshop 2020
- **Japan Society for the Promotion of Science DC1 fellowship** 2018–2021
- **LIGO Visitor Program**, California Institute of Technology 2019
- **Overseas Challenge Program for Young Researchers**, JSPS 2019
- **GRASP Scholarship**, The University of Tokyo 2018
- **SURF Program**, California Institute of Technology 2014
- **Best Project Award**, Cosmic/Particle Spring school 2014

## Research Talks

### Invited talks, seminars, panel, symposium

*The improvement of GstLAL's ranking statistics toward the fourth observing run* 2023
Utrecht & UMass Dartmouth joint seminar USA (online)

*Panel for gravitational waves and multi-messenger astronomy* 2023
New Evolution of Multi-Messenger Astrophysics, Penn State State College, USA

*Observation of neutron stars during LIGO-Virgo-KAGRA's observing runs* 2022
APS April meeting New York, USA

*Modeling and searching for a stochastic GW background from ultralight bosons* 2021
GW Physics and Astronomy: Genesis, The Fourth Annual Area Symposium Japan (online)

*Low-latency detection of the GWs from compact binary coalescences* 2022
ISAS seminar, ISM astronomy seminar, JGW seminar Japan

*Low-latency detection of the GWs from compact binary coalescences* 2022
ISM astronomy seminar Japan (online)

*Low-latency detection of the GWs from compact binary coalescences* 2022
JGW seminar Japan (online)

*Gravitational waves from neutron star-black hole coalescences* 2021
LIGO-Virgo-KAGRA Collaboration webinar

*First observations of black hole and neutron star mergers* 2021
Fundamental Theory Seminar, Penn State Pennsylvania, USA

*First search for stochastic GW backgrounds from ultra-light bosons* 2018
The CGCA seminar, University of Wisconsin Milwaukee Wisconsin, USA

*Application of a low-latency whitening filter to CBC GW searches* 2016
RESCEU joint seminar, The University of Tokyo Tokyo, Japan

## Selected contributed talks

*The improvement of GstLAL's ranking statistics toward the fourth observing run* — 2023
APS April meeting — Minnesota, USA

*First observations of black hole and neutron star mergers* — 2021
The 8th KAGRA International Workshop — Korea (online)

*Modeling and searching for a stochastic GW background from ultralight bosons* — 2021
Amaldi 14 — Australia (online)

*Stochastic GW backgrounds from ultra-light vectors* — 2019
The 29th Workshop on General Relativity and Gravitation in Japan — Kobe, Japan

*Anisotropic GW background Mock data study* — 2019
Gravitational Wave Physics and Astronomy Workshop — Tokyo, Japan

*A first search for stochastic GW backgrounds from ultra-light scalars* — 2018
Gravitational Wave Physics and Astronomy Workshop — Maryland, USA

*Application of a low-latency whitening filter to CBC GW searches* — 2017
The Third KAGRA International Workshop — Taipei, Taiwan

## Teaching Experience

- **Substitute Lecturer** at Pennsylvania State University — Fall 2022
  *Electromagnetism*
- **Teaching Assistant** at The University of Tokyo — Fall 2016
  *Analytical mechanics*

## Mentoring Experience

- **Soichiro Kuwahara** Ph.D student at The University of Tokyo
  *GPU-accelerated parameter estimation for anisotropic gravitational-wave backgrounds*
- **Santiago Jaraba** Ph.D student at Universidad Aut'onoma de Madrid
  *Parameter estimation for anisotropic gravitational-wave backgrounds [9]*
- **Deepali Agarwal** Ph.D student at Inter-University Centre for Astronomy and Astrophysics (IUCAA)
  *Parameter estimation for anisotropic gravitational-wave backgrounds [9]*
- **Erik Floden** Ph.D student at University of Minnesota
  *Parameter estimation and spherical-harmonics searches of anisotropic gravitational-wave backgrounds [9], [13], [26]*
- **Anarya Ray** Ph.D student at University of Wisconsin-Milwaukee
  *Improving background sampling procedure for GstLAL*
- **Richard George** Ph.D student at The University of Texas at Austin
  *Improving* SNR $-\xi^2$ *signal model of GstLAL [2]*
- **Andre Guimaraes** Ph.D student at Louisiana State University
  *Improving* SNR $-\xi^2$ *signal model of GstLAL [2]*
- **Shio Sakon** Ph.D student at Pennsylvania State University
  *Optimization of GstLAL's template bank [11]*
- **Shomik Adhicary** Ph.D student at Pennsylvania State University
  *Improving ranking statistics for gravitational-wave detection pipeline, GstLAL [2]*
- **Prathamesh Joshi** Ph.D student at Pennsylvania State University
  *Implementation of contamination removal and bank-$\xi^2$ statistics in GstLAL [2], [7]*
- **Takuya Tsutsui** Ph.D student at The University of Tokyo
  *Rapid localization of gravitational wave sources [17]*

## Professional Service

- **Thesis committee**, Pennsylvania State University 2023–2023
- **Co-leader of anisotropic stochastic-background working group**, LVK Collaboration 2022–present
- **Referee**, Physical Review D 2022–present
- **Advanced LIGO science summaries**, Writer and japanese translator 2021–present
- **Vice director**, Cosmic/Astrophysics Student Summer School in Japan 2019
- **Workshop Assistant**, Gravitational Wave Physics and Astronomy Workshop 2019

## Outreach

- **KAGRA outreach group** 2020–2021
- **SCJSF&JABA forum talk** 2020
- **Japanese translation of GW190425's science summary** 2019
- **GW education at a public school in Pasadena** 2019
- **RESCEU Open Lab** 2017, 2018
- **International Space Education Board Student Program** 2015, 2016

# Publication List

## Short Author List Publications and Preprints


[1] **L. Tsukada**, *Extension of the bayesian searches for anisotropic stochastic gravitational-wave background with non-tensorial polarizations*, Aug. 2023. arXiv: 2308.09020 [astro-ph.IM].

[2] **L. Tsukada**, P. Joshi, *et al.*, "Improved ranking statistics of the gstlal inspiral search for compact binary coalescences", *Physical Review D*, vol. 108, no. 4, Aug. 2023.

[3] Arianna Renzini, *et al.* including **L. Tsukada**, "Pygwb: A python-based library for gravitational-wave background searches", *The Astrophysical Journal*, vol. 952, no. 1, p. 25, Jul. 2023.

[4] S. Morisaki, R. Smith, **L. Tsukada**, S. Sachdev, S. Stevenson, C. Talbot, and A. Zimmerman, *Rapid localization and inference on compact binary coalescences with the advanced ligo-virgo-kagra gravitational-wave detector network*, Jul. 2023. arXiv: 2307.13380.

[5] Anarya Ray, *et al.* including **L. Tsukada**, *When to point your telescopes: Gravitational wave trigger classification for real-time multi-messenger followup observations*, Jun. 2023. arXiv: 2306.07190 [gr-qc].

[6] B. Ewing, R. Huxford, D. Singh, **L. Tsukada**, *et al.*, *Performance of the low-latency gstlal inspiral search towards ligo, virgo, and kagra's fourth observing run*, May 2023. arXiv: 2305.05625 [gr-qc].

[7] P. Joshi, **L. Tsukada**, and C. Hanna, *Background filter: A method for removing signal contamination during significance estimation of a gstlal anaysis*, May 2023. arXiv: 2305.18233 [gr-qc].

[8] S. Banagiri, C. P. L. Berry, G. S. C. Davies, **L. Tsukada**, and Z. Doctor, *A unified $p_{\mathrm{astro}}$ for gravitational waves: Consistently combining information from multiple search pipelines*, Apr. 2023. arXiv: 2305.00071 [astro-ph.IM].

[9] **L. Tsukada**, S. Jaraba, D. Agarwal, and E. Floden, "Bayesian parameter estimation for targeted anisotropic gravitational-wave background", *Physical Review D*, vol. 107, no. 2, Jan. 2023.

[10] Chad Hanna, *et al.* including **L. Tsukada**, "Binary tree approach to template placement for searches for gravitational waves from compact binary mergers", *Physical Review D*, vol. 108, no. 4, 2023.

[11] S. Sakon, **L. Tsukada**, *et al.*, *Template bank for compact binary mergers in the fourth observing run of advanced ligo, advanced virgo, and kagra*, Nov. 2022. arXiv: 2211.16674 [gr-qc].

[12] Chad Hanna, *et al.* including **L. Tsukada**, "Metric assisted stochastic sampling search for gravitational waves from binary black hole mergers", *Physical Review D*, vol. 106, no. 8, Oct. 2022.

[13] E. Floden, V. Mandic, A. Matas, and **L. Tsukada**, "Angular resolution of the search for anisotropic stochastic gravitational-wave background with terrestrial gravitational-wave detectors", *Physical Review D*, vol. 106, no. 2, Jul. 2022.

[14] Kipp Cannon, *et al.* including **L. Tsukada**, "Gstlal: A software framework for gravitational wave discovery", *SoftwareX*, vol. 14, p. 100 680, Jun. 2021, ISSN: 2352-7110.

[15] Debnandini Mukherjee, *et al.* including **L. Tsukada**, "Template bank for spinning compact binary mergers in the second observation run of advanced ligo and the first observation run of advanced virgo", *Physical Review D*, vol. 103, no. 8, Apr. 2021.

[16] **L. Tsukada**, R. Brito, W. E. East, and N. Siemonsen, "Modeling and searching for a stochastic gravitational-wave background from ultralight vector bosons", *Phys. Rev. D*, vol. 103, p. 083 005, 8 Apr. 2021.

[17] T. Tsutsui, K. Cannon, and **L. Tsukada**, "High speed source localization in searches for gravitational waves from compact object collisions", *Phys. Rev. D*, vol. 103, p. 043 011, 4 Feb. 2021.

[18] Surabhi Sachdev, *et al.* including **L. Tsukada**, "An early-warning system for electromagnetic follow-up of gravitational-wave events", *The Astrophysical Journal*, vol. 905, no. 2, p. L25, Dec. 2020.

[19] Cody Messick, *et al.* including **L. Tsukada**, *Automating the inclusion of subthreshold signal-to-noise ratios for rapid gravitational-wave localization*, Nov. 2020. arXiv: 2011.02457 [astro-ph.IM].

[20] Patrick Godwin, *et al.* including **L. Tsukada**, *Incorporation of statistical data quality information into the gstlal search analysis*, Oct. 2020. arXiv: 2010.15282 [gr-qc].

[21] Chiwai Chan, *et al.* including **L. Tsukada**, "Improving the background estimation technique in the gstlal inspiral pipeline with the time-reversed template bank", Sep. 2020. eprint: 2009.03025.

[22] C. Hanna, S. Caudill, C. Messick, A. Reza, S. Sachdev, **L. Tsukada**, *et al.*, "Fast evaluation of multidetector consistency for real-time gravitational wave searches", *Physical Review D*, vol. 101, no. 2, Jan. 2020.

[23] **L. Tsukada**, T. Callister, A. Matas, and P. Meyers, "First search for a stochastic gravitational-wave background from ultralight bosons", *Physical Review D*, vol. 99, no. 10, May 2019.

[24] Surabhi Sachdev, *et al.* including **L. Tsukada**, *The gstlal search analysis methods for compact binary mergers in advanced ligo's second and advanced virgo's first observing runs*, Jan. 2019. arXiv: 1901.08580 [gr-qc].

[25] **L. Tsukada**, K. Cannon, C. Hanna, D. Keppel, D. Meacher, and C. Messick, "Application of a zero-latency whitening filter to compact binary coalescence gravitational-wave searches", *Physical Review D*, vol. 97, no. 10, May 2018.

## Collaboration Publications (major contribution)

[26] B. P. Abbott *et al.*, "Search for anisotropic gravitational-wave backgrounds using data from advanced ligo and advanced virgo's first three observing runs", *Phys. Rev. D*, vol. 104, p. 022 005, 2 Jul. 2021.

[27] B. P. Abbott *et al.*, "Gwtc-2: Compact binary coalescences observed by ligo and virgo during the first half of the third observing run", *Physical Review X*, vol. 11, no. 2, Jun. 2021.

[28] B. P. Abbott *et al.*, "Observation of gravitational waves from two neutron star–black hole coalescences", *The Astrophysical Journal Letters*, vol. 915, no. 1, p. L5, Jun. 2021.