Leo Tsukada

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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

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

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

Research Experience

Pennsylvania State University — University Park, PA
2021–present
- Develoment 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 (CBC).

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, colloquia

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

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

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

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

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

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

Seminar *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
Search for anisotropic GW backgrounds from LIGO and Virgo's O3	2021
Japan Physics Society Meeting	Japan (online)
Towards a search for stochastic GW backgrounds from ultra-light bosons	2018
Gravitational Wave Physics and Astronomy: Genesis	Chiba, Japan
Application of a low-latency whitening filter to CBC GW searches	2017
Japan Physics Society Meeting	Tochigi, Japan

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 [7]
- **Deepali Agarwal** Ph.D student at Inter-University Centre for Astronomy and Astrophysics (IUCAA)
  Parameter estimation for anisotropic gravitational-wave backgrounds [7]
- **Erik Floden** Ph.D student at University of Minnesota
  Parameter estimation and spherical-harmonics searches of anisotropic gravitational-wave backgrounds [7], [9], [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 $\text{SNR} - \xi^2$ signal model of GstLAL [8]
- **Andre Guimaraes** Ph.D student at Louisiana State University
  Improving $\text{SNR} - \xi^2$ signal model of GstLAL [8]
- **Shio Sakon** Ph.D student at Pennsylvania State University
  Optimization of GstLAL's template bank [6]
- **Shomik Adhicary** Ph.D student at Pennsylvania State University
  Improving ranking statistics for gravitational-wave detection pipeline, GstLAL [8]
- **Prathamesh Joshi** Ph.D student at Pennsylvania State University
  Implementation of contamination removal and bank-ξ^2 statistics in GstLAL [3], [8]
- **Takuya Tsutsui** Ph.D student at The University of Tokyo
  Rapid localization of gravitational wave sources [15]

PROFESSIONAL SERVICE

- **Co-leader**, Working group of anisotropic stochastic background in LVK Collaboration · 2022–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

SHORT AUTHOR LIST PUBLICATIONS AND PREPRINTS

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

[2] B. Ewing, R. Huxford, D. Singh, **L. Tsukada**, C. Hanna, Y.-J. Huang, P. Joshi, A. K. Y. Li, R. Magee, C. Messick, A. Pace, A. Ray, S. Sachdev, S. Sakon, R. Tapia, S. Adhicary, P. Baral, A. Baylor, K. Cannon, S. Caudill, S. S. Chaudhary, M. W. Coughlin, B. Cousins, J. D. E. Creighton, R. Essick, H. Fong, R. N. George, P. Godwin, R. Harada, J. Kennington, S. Kuwahara, D. Meacher, S. Morisaki, D. Mukherjee, W. Niu, C. Posnansky, A. Toivonen, T. Tsutsui, K. Ueno, A. Viets, L. Wade, M. Wade, and G. Waratkar, *Performance of the low-latency gstlal inspiral search towards ligo, virgo, and kagra's fourth observing run*, 2023. arXiv: 2305.05625 `[gr-qc]`.

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

[4] A. Ray, W. Niu, S. Sakon, B. Ewing, J. D. E. Creighton, C. Hanna, S. Adhicary, P. Baral, A. Baylor, K. Cannon, S. Caudill, B. Cousins, H. Fong, R. N. George, P. Godwin, R. Harada, Y.-J. Huang, R. Huxford, P. Joshi, S. Kapadia, J. Kennington, S. Kuwahara, A. K. Y. Li, R. Magee, D. Meacher, C. Messick, S. Morisaki, D. Mukherjee, A. Pace, C. Posnansky, S. Sachdev, D. Singh, R. Tapia, **L. Tsukada**, T. Tsutsui, K. Ueno, A. Viets, L. Wade, and M. Wade, *When to point your telescopes: Gravitational wave trigger classification for real-time multi-messenger followup observations*, 2023. arXiv: 2306.07190 `[gr-qc]`.

[5] A. I. Renzini, A. Romero-Rodrguez, C. Talbot, M. Lalleman, S. Kandhasamy, K. Turbang, S. Biscoveanu, K. Martinovic, P. Meyers, **L. Tsukada**, K. Janssens, D. Davis, A. Matas, P. Charlton, G.-C. Liu, I. Dvorkin, S. Banagiri, S. Bose, T. Callister, F. D. Lillo, L. D'Onofrio, F. Garufi, G. Harry, J. Lawrence, V. Mandic, A. Macquet, I. Michaloliakos, S. Mitra, K. Pham, R. Poggiani, T. Regimbau, J. D. Romano, N. van Remortel, and H. Zhong, *Pygwb: Python-based library for gravitational-wave background searches*, 2023. arXiv: 2303.15696 `[gr-qc]`.

[6] S. Sakon, **L. Tsukada**, H. Fong, C. Hanna, J. K. W. Niu, S. Adhicary, P. Baral, A. Baylor, K. Cannon, S. Caudill, B. Cousins, J. D. E. Creighton, B. Ewing, P. Godwin, R. Harada, Y.-J. Huang, R. Huxford, P. Joshi, S. Kuwahara, A. K. Y. Li, R. Magee, D. Meacher, C. Messick, S. Morisaki, D. Mukherjee, A. Pace, C. Posnansky, S. Sachdev, D. Singh, R. Tapia, T. Tsutsui, K. Ueno, A. Viets, L. Wade, M. Wade, and J. Wang, *Template bank for compact binary mergers in the fourth observing run of advanced ligo, advanced virgo, and kagra*, 2023. arXiv: 2211.16674 `[gr-qc]`.

[7] **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, 2023.

[8] **L. Tsukada**, P. Joshi, S. Adhicary, R. George, A. Guimaraes, C. Hanna, R. Magee, A. Zimmerman, P. Baral, A. Baylor, K. Cannon, S. Caudill, B. Cousins, J. D. E. Creighton, B. Ewing, H. Fong, P. Godwin, R. Harada, Y.-J. Huang, R. Huxford, J. Kennington, S. Kuwahara, A. K. Y. Li, D. Meacher, C. Messick, S. Morisaki, D. Mukherjee, W. Niu, A. Pace, C. Posnansky, A. Ray, S. Sachdev, S. Sakon, D. Singh, R. Tapia, T. Tsutsui, K. Ueno, A. Viets, L. Wade, and M. Wade, *Improved ranking statistics of the gstlal inspiral search for compact binary coalescences*, 2023. arXiv: 2305.06286 `[astro-ph.IM]`.

[9] 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.

[10] C. Hanna, P. Joshi, R. Huxford, K. Cannon, S. Caudill, C. Chan, B. Cousins, J. D. E. Creighton, B. Ewing, M. Fernandez, H. Fong, P. Godwin, R. Magee, D. Meacher, C. Messick, S. Morisaki, D. Mukherjee, H. Ohta, A. Pace, S. Privitera, S. Sachdev, S. Sakon, D. Singh, R. Tapia, **L. Tsukada**, D. Tsuna, T. Tsutsui, K. Ueno, A. Viets, L. Wade, M. Wade, and J. Wang, "Metric assisted stochastic sampling search for gravitational waves from binary black hole mergers", *Physical Review D*, vol. 106, no. 8, 2022.

[11] C. Hanna, J. Kennington, S. Sakon, S. Privitera, M. Fernandez, J. Wang, C. Messick, A. Pace, K. Cannon, P. Joshi, R. Huxford, S. Caudill, C. Chan, B. Cousins, J. D. E. Creighton, B. Ewing, H. Fong, P. Godwin, R. Magee, D. Meacher, S. Morisaki, D. Mukherjee, H. Ohta, S. Sachdev, D. Singh, R. Tapia, **L. Tsukada**, D. Tsuna, T. Tsutsui, K. Ueno, A. Viets, L. Wade, and M. Wade, *A binary tree approach to template placement for searches for gravitational waves from compact binary mergers*, 2022. arXiv: 2209.11298 [gr-qc].

[12] K. Cannon, S. Caudill, C. Chan, B. Cousins, J. D. Creighton, B. Ewing, H. Fong, P. Godwin, C. Hanna, S. Hooper, R. Huxford, R. Magee, D. Meacher, C. Messick, S. Morisaki, D. Mukherjee, H. Ohta, A. Pace, S. Privitera, I. de Ruiter, S. Sachdev, L. Singer, D. Singh, R. Tapia, **L. Tsukada**, D. Tsuna, T. Tsutsui, K. Ueno, A. Viets, L. Wade, and M. Wade, "Gstlal: A software framework for gravitational wave discovery", *SoftwareX*, vol. 14, p. 100 680, 2021, ISSN: 2352-7110.

[13] D. Mukherjee, S. Caudill, R. Magee, C. Messick, S. Privitera, S. Sachdev, K. Blackburn, P. Brady, P. Brockill, K. Cannon, S. J. Chamberlin, D. Chatterjee, J. D. Creighton, H. Fong, P. Godwin, C. Hanna, S. Kapadia, R. N. Lang, T. G. Li, R. K. Lo, D. Meacher, A. Pace, L. Sadeghian, **L. Tsukada**, L. Wade, M. Wade, A. Weinstein, and L. Xiao, "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, 2021.

[14] **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.

[15] 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.

[16] C. Chan, K. Cannon, S. Caudill, H. Fong, P. Godwin, C. Hanna, S. Kapadia, R. Magee, D. Meacher, C. Messick, S. R. Mohite, S. Morisaki, D. Mukherjee, A. Nishizawa, H. Ohta, A. Pace, S. Sachdev, M. Shikauchi, L. Singer, **L. Tsukada**, D. Tsuna, T. Tsutsui, and K. Ueno, "Improving the background estimation technique in the gstlal inspiral pipeline with the time-reversed template bank", Sep. 2020. eprint: 2009.03025.

[17] P. Godwin, R. Essick, C. Hanna, K. Cannon, S. Caudill, C. Chan, J. D. E. Creighton, H. Fong, E. Katsavounidis, R. Magee, D. Meacher, C. Messick, S. Morisaki, D. Mukherjee, H. Ohta, A. Pace, I. de Ruiter, S. Sachdev, **L. Tsukada**, T. Tsutsui, K. Ueno, L. Wade, and M. Wade, *Incorporation of statistical data quality information into the gstlal search analysis*, 2020. arXiv: 2010.15282 [gr-qc].

[18] C. Hanna, S. Caudill, C. Messick, A. Reza, S. Sachdev, **L. Tsukada**, K. Cannon, K. Blackburn, J. D. E. Creighton, H. Fong, P. Godwin, S. Kapadia, T. G. F. Li, R. Magee, D. Meacher, D. Mukherjee, A. Pace, S. Privitera, R. K. L. Lo, and L. Wade, "Fast evaluation of multidetector consistency for real-time gravitational wave searches", *Physical Review D*, vol. 101, no. 2, 2020.

[19] C. Messick, S. Sachdev, K. Cannon, S. Caudill, C. Chan, J. D. E. Creighton, R. Everett, B. Ewing, H. Fong, P. Godwin, C. Hanna, R. Huxford, S. Kapadia, A. K. Y. Li, R. K. L. Lo, R. Magee, D. Meacher, S. R. Mohite, D. Mukherjee, A. Nishizawa, H. Ohta, A. Pace, A. Reza, M. Shikauchi, L. Singer, D. Singh, J. R. SK, **L. Tsukada**, D. Tsuna, T. Tsutsui, K. Ueno, and A. Zimmerman, *Automating the inclusion of subthreshold signal-to-noise ratios for rapid gravitational-wave localization*, 2020. arXiv: 2011.02457 [astro-ph.IM].

[20] S. Sachdev, R. Magee, C. Hanna, K. Cannon, L. Singer, J. R. SK, D. Mukherjee, S. Caudill, C. Chan, J. D. E. Creighton, B. Ewing, H. Fong, P. Godwin, R. Huxford, S. Kapadia, A. K. Y. Li, R. K. L. Lo, D. Meacher, C. Messick, S. R. Mohite, A. Nishizawa, H. Ohta, A. Pace, A. Reza, B. S. Sathyaprakash, M. Shikauchi, D. Singh, **L. Tsukada**, D. Tsuna, T. Tsutsui, and K. Ueno, "An early-warning system for electromagnetic follow-up of gravitational-wave events", *The Astrophysical Journal*, vol. 905, no. 2, p. L25, Dec. 2020.

[21] S. Sachdev, S. Caudill, H. Fong, R. K. L. Lo, C. Messick, D. Mukherjee, R. Magee, **L. Tsukada**, K. Blackburn, P. Brady, P. Brockill, K. Cannon, S. J. Chamberlin, D. Chatterjee, J. D. E. Creighton, P. Godwin, A. Gupta, C. Hanna, S. Kapadia, R. N. Lang, T. G. F. Li, D. Meacher, A. Pace, S. Privitera, L. Sadeghian, L. Wade, M. Wade, A. Weinstein, and S. L. Xiao, *The gstlal search analysis methods for compact binary mergers in advanced ligo's second and advanced virgo's first observing runs*, 2019. arXiv: 1901.08580 `[gr-qc]`.

[22] **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, 2019.

[23] **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, 2018.

Collaboration Publications (major contribution)

[24] 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, 2021.

[25] 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.

[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.