# Thomas Lai

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last update: May, 2024

## Research Interests

- Investigating the physics and properties of the interstellar medium (ISM) using multi-wavelength observations from UV to far infrared, including facilities like HST, AKARI, Spitzer, JWST, Keck, and Lowell Discovery Telescope
- Exploring the connection between AGN and starburst phenomena in nearby luminous infrared galaxies, focusing on their outflow impact on the ISM by analyzing dust and gas properties
- Examining the properties of the ISM in low metallicity dwarf galaxies, providing insights into the conditions of high redshift galaxies
- Developing state-of-the-art spectral decomposition models for mid-infrared emissions, particularly from polycyclic aromatic hydrocarbon (PAH) molecules, to enhance infrared spectroscopy diagnostics, especially for JWST integral field spectroscopy (IFS)
- Addressing fundamental questions in ISM studies, including the nature of diffuse interstellar bands (DIBs) and extended red emission (ERE)

## Employment/Professional Experience

**Sep 2021 – present**  **Postdoctoral Scholar**, Caltech/IPAC, CA, USA
PI: Dr. Lee Armus; in collaboration with the GOALS team

**2018**  **Keck Visiting Scholar**, Keck Observatory, HI, USA
Mentor: Dr. Carlos Alvarez
Project: *Updating DEIMOS Throughput Curves with 16 Years of Observations*

**2015 – 2019**  **University Fellow**, University of Toledo, OH, USA
Advisor: Dr. J.D.T Smith; the highest award from the UT graduate school
Project: *Exploring Small Dust Grains in Different Galaxy Environments*

**2014**  **Doreen and Lyman Spitzer Graduate Fellow**, University of Toledo, OH, USA
Advisor: Dr. Adolf Witt; award for incoming graduate student from the department of Physics & Astronomy
Project: *The Extended Red Emission in IC 59 and IC 63*
*The Connection between DIBs and ERE*

**2013 – 2014**  **Research Assistant**, ASIAA, Taipei, Taiwan
Advisor: Dr. Ciska Kemper, Dr. Sundar Srinivasan, and Dr. Masaaki Otsuka
Project: *Near-infrared Photometry of Evolved Asymptotic Giant Branch Stars in M33*

**2012**  **Corporal**, The Republic of China Army, Taiwan

**2011 – 2012**  **Research Assistant**, National Central University, Taoyuan, Taiwan
Advisor: Dr. Chung-Ming Ko
Project: *2MASS Whole Sky Star Count*

## Education

**2014–2021**  **Ph.D. in Astronomy & Physics**, *University of Toledo, OH, USA*
Advisors: Dr. J.D.T. Smith and Dr. Adolf Witt
Thesis Title: *"Exploring Small Dust Grains in Different Galaxy Environments"*

2007–2011  **B.A. in Space Science**, *National Central University*, *Taoyuan, Taiwan*

## Honors and Awards

2023  **AAS Travel Grant**, American Astronomical Society

2022  **HST GO30 Grant**, STScI

2022  **JWST GO1 Grant**, STScI

2019  **Award for Best Graduate Student Presentation ($125)**, University of Toledo

2019  **FAMOUS travel grant ($500)**, American Astronomical Society

2019  **Graduate Research Scholar Travel Award ($500)**, College of Natural Science & Mathematics, University of Toledo

2018  **AAS Travel Grant ($1,607)**, American Astronomical Society

2016  **Award for Best Graduate Student Presentation ($250)**, University of Toledo

2015–2019  **University Fellowship (4 years - $72,000 + tuition)**, Highest award from Graduate School, University of Toledo

2014  **Doreen and Lyman Spitzer Graduate Fellowship in Astrophysics ($9,000)**, Department of Physics and Astronomy, University of Toledo

2008  **Outstanding Award**, National Central University

## Publications

**Author of 30 refereed publications (including 6 submitted papers)**

First/Second author with major contribution:

10.  **Lai, T.S.-Y.**, Smith, J.D.T. et al., (ApJ in press)

     *Spectroscopic Constraints on the Mid-Infrared Attenuation Curve: I - Attenuation Model using PAH Emissions*

9.   **Lai, T.S.-Y.**, Armus, L. et al., 2023, ApJL, 957L, 26L
     *GOALS-JWST: Small neutral grains and enhanced 3.3 micron PAH emission in the Seyfert galaxy NGC 7469*

8.   Armus, L., **Lai, T.S.-Y.** et al., 2023, ApJL, 942L, 37A
     *GOALS-JWST: Mid-Infrared Spectroscopy of the Nucleus of NGC 7469*

7.   **Lai, T.S.-Y.**, Armus, L. et al., 2022, ApJL, 940, L5
     *GOALS-JWST: Tracing AGN Feedback on the Star-Forming ISM in NGC 7469*

6.   U, V, **Lai, T.S.-Y.** et al., 2022, ApJL, 941L, 36L
     *GOALS-JWST: Resolving the Circumnuclear Gas Dynamics in NGC 7469 in the Mid-infrared*

5.   **Lai, T.S.-Y.**, Smith, J.D.T, Baba, S, Spoon, H.W.W, Imanishi, 2020, ApJ, 905, 55
     *All the PAHs: an AKARI-Spitzer Cross-Archival Spectroscopic Survey of Aromatic Emission in Galaxies*

4.   Witt, A.N, **Lai, T.S.-Y.**, Astrophysics and Space Science Journal, 2020Ap&SS.365.58W
     *The Observational Constraints of the Extended Red Emission*

3.   **Lai, T.S.-Y.**, Witt, A.N, Alvarez, C, Cami, J, 2020, MNRAS, 492, 5853L
     *Are the Carriers of Diffuse Interstellar Bands and Extended Red Emission the Same?*

2.   **Lai, T.S.-Y.**, Witt, A.N, Crawford, K, 2017, MNRAS, 469, 4933L
     *Extended Red Emission in IC59 and IC63*

1.   Chang, C.K., **Lai, T.S.-Y.**, Ko, C.M. & Peng, T.H., 2012, ApJ, 759, 94
     *The Information of The Milky Way from Two Micron All Sky Survey Whole Sky Star Count: The Bimodal Color Distributions*

     Others:

20.  Chown, R.,..., **Lai, T.S.-Y.**, (submitted to A&A)
     *PDRs4All IV. An embarrassment of riches: Aromatic infrared bands in the Orion Bar*

19. Bolatto, A.,..., **Lai, T.S.-Y.**, (in press)
    *JWST Observations of Starbursts: Polycyclic Aromatic Hydrocarbon Emission at the base of the M82 Galactic Wind*

18. Van De Putte, D.,..., **Lai, T.S.-Y.**, (submitted to A&A)

    *PDRs4All VIII: Mid-IR emission line inventory of the Orion Bar*

17. Schroetter, I.,..., **Lai, T.S.-Y.**, (in press)
    *PDRs4All VII. The 3.3 um aromatic infrared band as a tracer of physical properties of the ISM in galaxies*

16. Buiten, V.,..., **Lai, T.S.-Y.**, (in press)
    *GOALS-JWST: Mid-Infrared Molecular Gas Excitation Probes the Local Conditions of Nuclear Star Clusters and the AGN in the LIRG VV 114*

15. Bianchin, M.,..., **Lai, T.S.-Y.**, (in press)
    *GOALS-JWST: Gas Dynamics and Excitation in NGC7469 revealed by NIRSpec*

14. Pasquini, S.,..., **Lai, T.S.-Y.**, (in press)
    *PDRs4All VI: Probing the Photochemical Evolution of PAHs in the Orion Bar Using Machine Learning Techniques*

13. Peeters, E.,..., **Lai, T.S.-Y.**, (submitted to A&A)
    *PDRs4All III: JWST's NIR spectroscopic view of the Orion Bar*

12. Habart, E.,..., **Lai, T.S.-Y.**, (submitted to A&A)
    *PDRs4All II: JWST's NIR and MIR imaging view of the Orion Nebula*

11. Eiermann, J.,..., **Lai, T.S.-Y.**, 2024MNRAS.tmp..301E
    *The 3D Geometry of Reflection Nebulae IC 59 and IC 63 with their illuminating Star Gamma Cas*

10. Kader, J.,..., **Lai, T.S.-Y.**, (submitted to Nature)

    *The Past, Present, and Future of a Precessing Jet-Driven Outflow in Early Interaction Pair VV 340*

9. Berné, O.,..., **Lai, T.S.-Y.**, 2024Sci, 383, 988P
   *A far-ultraviolet–driven photoevaporation flow observed in a protoplanetary disk*

8. Donnelly, G.,..., **Lai, T.S.-Y.**, (in press)
   *The Impact of an AGN on PAH Emission in Galaxies: the Case of Ring Galaxy NGC 4138*

7. Linden, S.,..., **Lai, T.S.-Y.**, 2023, ApJ, 944L, 55L
   *GOALS-JWST: Revealing the Buried Star Clusters in the Luminous Infrared Galaxy VV 114*

6. Bohn, T.,..., **Lai, T.S.-Y.**, 2023, ApJ, 942L, 36B
   *GOALS-JWST: NIRCam and MIRI Imaging of the Circumnuclear Starburst Ring in NGC 7469*

5. Rich, J.,..., **Lai, T.S.-Y.**, 2022, ApJ, 944L, 50R
   *GOALS-JWST: Pulling Back the Curtain on the AGN and Star Formation in VV 114*

4. Evans, E.,..., **Lai, T.S.-Y.**, 2022, ApJ, 940L, 8E
   *GOALS-JWST: Hidden Star Formation and Extended PAH Emission in the Luminous Infrared Galaxy VV 114*

3. Inami, H.,..., **Lai, T.S.-Y.**, 2022, ApJ, 940L, 6I
   *GOALS-JWST: Unveiling Dusty Compact Sources in the Merging Galaxy IIZw096*

2. Song, Y.,..., **Lai, T.S.-Y.**, 2022, ApJ, 940, 52S
   *Characterizing Compact 15-33 GHz Radio Continuum Sources in Local U/LIRGs*

1. Berné, O.,..., **Lai, T.S.-Y.**, 2022, PASP, 134, 054301,
   *PDRs4All: A JWST Early Release Science Program on Radiative Feedback from Massive Stars*

## Successful Observing Proposals

- **JWST GO3:** A Deep Look into PAHs: Resolved PAH and Fine-Structure Emission in z=1 Main-Sequence Galaxies, 2024, 48 hrs (PI: Faisst, A; Technical Lead: **Lai, T.**)

- **JWST GO3:** A Systematic Study of the 3.3—3.5 micron PAH Features at z∼0 with Archival NIRSpec Observations, 2024, AR (PI: Sandstrom, K)
- **JWST GO2:** Measuring Dust Evolution Over the Past 10 Billion Years With 3-12 micron Spectra for 60 High-Redshift Galaxies, 2023, 42 hrs (PI: McKinney, J)
- **JWST GO2:** A JWST Survey of Ultraluminous Infrared Galaxies, 2023, 98 hrs (PI: Armus, L)
- **JWST GO2:** The JWST Whirlpool Galaxy Treasury, 2023, 62 hrs (PI: Sandstrom, K)
- **JWST GO2:** Big Impact in Little Galaxies? A JWST Investigation of AGN Outflows in Dwarf Galaxies, 2023, 22 hrs (PI: Bohn, T)
- **HST GO30-mid:** From Galactic Cores to the Cosmic Web – A Study of Feedback and Multiphase Galactic Winds with HST and JWST, 2022 (PI: U, V)
- **ALMA Cyc9:** Heating and Cooling of the Interstellar Medium in Dusty Galaxies at Cosmic Noon, 2022 (PI: McKinney, J)
- **HST GO30:** Linking the UV Bump with PAHs in Low Metallicity Starburst II Zw 40, 2022 **(PI: Lai, T)**
- **HST GO29:** In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs, 2021 (PI: Evans, A)
- **JWST GO1:** How Do the Small Survive: PAH's in Low Metallicity Starburst II Zw 40, 2020 **(PI: Lai, T)**
- **JWST GO1:** The Vanishing Act: PAHs and Heavy Element Abundance in M101, 2020 (PI: Smith, JD)
- **JWST ERS 1288:** Radiative Feedback from Massive Stars as Traced by Multiband Imaging and Spectroscopic Mosaics, 2018 (PI: Berne, O)
- **Discovery Channel Telescope / DeVeny Spectrograph:** The search of connection between Diffuse Interstellar Bands and Extend Red Emission, 2017 (2017Q4T01), 1 full night **(PI: Lai, T)**
- **Keck/DEIMOS:** Potential Connection Between DIBs and ERE in the Reflection/Emission Nebula IC 63, 20170716, 1 full night (PI: Alvarez, C)
- **Discovery Channel Telescope / DeVeny Spectrograph:** The search of connection between Diffuse Interstellar Bands and Extend Red Emission, 2016 (2016Q3T02), 2 full nights **(PI: Lai, T)**
- **SMA:** Using SMA to observe FU Orionis stars RNO 1C/1B, 1 full night **(PI: Lai, T)**

## Mentoring Experience

2024–*present*  **Grant Donnelly**, *IPAC Visiting Graduate Fellow*
2023–*present*  **Sara Duval**, *U of Toledo*

## Service

Aug, 2023  **SOC**, *2023 GOALS Workshop*
Aug, 2021  **Coordinator**, *Python Visualization Workshop*
2020–*present*  **Referee**, *The Astrophysical Journal*
2020–*present*  **Builder**, *AKARI-Spitzer Extragalactic Spectral Survey (ASESS)*
Jun 2020  Conference for Undergraduate Women in Physics (CUWiP), *U of Toledo*
Oct 2017  50th anniversary of the Ritter Observatory

## Outreach

| Sep 8–10, 2023 | **Volunteer**, *Sequoia Dark Sky Festival* |
| May 2016 | **Volunteer**, *Cedar Point Physics, Science and Math Week* |
| Sep 2015 | **Volunteer**, *Total Lunar Eclipse Outreach Program* |

## Teaching Experience

- **Graduate Teaching Assistant**, *Fall 2014, Summer 2016, Summer 2018, and Summer 2019*

## Skills

- **Programming:** Python, IDL, Git, Markdown, HTML, LaTeX, IRAF, SExtractor, SQL
- **Software Development:** Developer of CAFE and PAHFIT
- **Software:** Astropy, JWST pipeline, Cubeviz, Jupyter notebooks, lmfit, MCMC, sphinx
- **Operating System:** Mac OS, Linux, Windows
- **Tools:** APT and ETC for both JWST and HST

## Talks & Posters

**Talks:**

| Apr 10, 2024 | **Probing the Smallest Interstellar Dust Grains with JWST in Various Galaxy Environments (invited)**, *IPAC Seminar*, Pasadena, CA |
| Mar 5, 2024 | **Probing the Smallest PAH Population with JWST in Different Galaxy Environments**, *The Physics and Impact of Astrophysical Dust*, Aspen, CO |
| Nov 3, 2023 | **Tracing AGN Feedback on the Star-Forming ISM with JWST NIRspec & MIRI IFU**, *Illuminating the Dusty Universe*, Florence, Italy |
| Sep 1, 2023 | **Tracing AGN Feedback on the Star-Forming ISM with JWST NIRspec & MIRI IFU (invited)**, *GISS, Caltech/IPAC*, Pasadena, CA |
| Apr 17, 2023 | **Tea Talk (invited)**, *Caltech*, Pasadena, CA |
| Feb 23, 2023 | **Tracing AGN Feedback on the Star-Forming ISM in NGC 7469 with JWST (invited)**, *ASIAA Seminar*, Taipei |
| Dec 14, 2022 | **Tracing AGN Feedback on the Star-Forming ISM in NGC 7469 with JWST**, *STScI JWST First Result Conference* |
| Nov 7, 2022 | **Tracing AGN Feedback on the Star-Forming ISM in NGC 7469 with JWST**, *IRSTIG Webinar (invited)*, virtual |
| Jan 4, 2022 | **Probing the Resolved Dusty Universe with JWST (invited)**, *NTU seminar*, virtual |
| Aug 2, 2021 | **How to Make Good Plots**, *Python Visualization Workshop*, Toledo, OH |
| Jul 21, 2021 | **All the PAHs: Exploring Small Dust Grains In Galaxies**, *GOALS workshop*, virtual |
| Jan 6, 2020 | **Understanding small dust grains in different interstellar environments**, *AAS dissertation talk*, Hawaii |
| Dec 6, 2018 | **Outreach talk: DEIMOS Throughput After 16 Years of Operations (invited)**, *Keck Visiting Scholar Party*, Keck observatory |
| Dec 5, 2018 | **DEIMOS Throughput After 16 Years of Operations**, *Keck Visiting Scholar Presentation*, Keck observatory |
| Nov 19, 2018 | **Exploring Small Dust Grains Across Different Interstellar Environments (invited)**, *Astronomy Seminar*, Keck observatory |
| Jun 13, 2017 | **Extended Red Emission in IC 59 and IC 63 (invited)**, *Astronomy Seminar*, JAXA, Japan |

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| Dec 31, 2015 | **Extended Red Emission in IC63 & IC59: How Does it Produce? (invited)**, *Astronomy Seminar*, National Central University |
| May 23–25, 2014 | **The Mass Loss from Asymptotic Giant Branch Stars in M33**, *The Astronomical Society of the Republic of China Annual Meeting* |
| Aug 29, 2013 | **Near-Infrared Photometry of Evolved Stars in the Nearby Galaxy M33**, *ASIAA Summer Student Presentation* |

<u>**Posters:**</u>

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| Jun 12–16, 2022 | **A JWST Study of the Starburst-AGN Connection in Merging Luminous Infrared Galaxies**, *AAS240*, Pasadena, CA |
| Mar 4–8, 2019 | **All the PAHs: a Spitzer–AKARI Cross-Archival Spectroscopic Survey of Aromatic Emission in Galaxies**, *Dusting the Universe*, The University of Arizona, Tucson, AZ |
| Nov 11–15, 2013 | **Near-Infrared Photometry of Evolved Stars in The Nearby Galaxy M33**, *Science Eyes and Minds towards Cosmic Horizon*, Sokendai, Japan |
| Aug 20–24, 2012 | **The Information of Milky Way from 2MASS Whole Sky Star Counts: the Bimodal Color Distributions**, *IAU 28th General Assembly*, Beijing, China |

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| - | **Revealing All the PAHs in Galaxies with an AKARI-Spitzer Survey**, *IRSIG newsletter* |

──── Workshops:

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| Apr, 2022 | **PAH Fest**, *University of Florida*, FL |
| Apr 30–May 4, 2018 | **Python in Astronomy 2018**, *Flatiron Institute*, NY |
| Apr 2–6, 2018 | **PAHs in the ISM: Observational, Experimental and Computational Tools**, *Les Houches*, France |
| Mar 7, 2017 | **ALMA/VLA/VLBA workshop**, *University of Michigan* |
| Aug 1–5, 2016 | **SciCoder 8**, *Yale University* |