MC 316 (Keith Spalding Building) 1200 E California Blvd
Pasadena, CA 91125, USA
shaoyu@ipac.caltech.edu
thomassylai.github.io
ThomasSYLai
0000-0001-8490-6632
last update: May, 2024

Thomas Lai

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

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*

Posters:

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

Article

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

Workshops:

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*

Thomas Lai
MC 316 (Keith Spalding Building) 1200 E California Blvd
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last update: May, 2024

Dear ESA/AURA astronomer selection committee, Monday 13th May, 2024

I am writing with great enthusiasm to apply for the ESA/AURA Astronomer position at STScI. As a current Caltech/IPAC postdoctoral researcher with substantial expertise in JWST IFU analysis, pipeline implementation, and software development, I am excited about the prospect of contributing to your team in a more significant capacity, with a preference to work on the JWST team.

In my role as a postdoctoral researcher at IPAC, I have been deeply involved in the international GOALS collaboration, focusing on the analysis of spectroscopic data from the JWST ERS program. Particularly, I have been the lead of all MIRI/MRS data processing for the GOALS/ERS team. My active participation in this collaboration has led to significant contributions to 11 published papers (as of Mar. 2024), including papers on finding evidence for highly ionized winds, dust processing and feedback, and buried clusters. Notably, I have first-authored two papers delving into the intricate nature of interstellar dust in starburst and AGN environments. I have also been supervising other postdocs and graduate students to learn the JWST pipelines, analyze data, and work on their first IFU papers.

Apart from the GOALS collaboration, I PI'ed both JWST Cyc2 and HST Cyc30 programs, which focused on understanding the nature of dust in dwarf galaxies. I have also participated in several large JWST programs, where I brought in my reduction/analysis skills, including the M51 treasury team (PI: Sandstrom, K), the M82 team (PI: Bolatto, A), and the PAHs in z$\sim$1 main sequence galaxies team (PI: Faisst, A). These experiences have not only sharpened my analytical skills but also enhanced my ability to collaborate and communicate effectively with diverse teams.

I have been instrumental in leading the development of the CAFE software, a key delivery of the GOALS ERS program. CAFE is a sophisticated mid-infrared spectral decomposition tool, which has been optimized for JWST integral field spectroscopy. My responsibilities encompassed the comprehensive design, thorough documentation, and rigorous testing of this software. My initiative to transition the codebase from IDL to Python, adhering to the object-oriented programming paradigm, has substantially improved its readability and maintainability. My proficiency with the GitHub workflow aligns perfectly with the coding practice at STScI. I am also responsible for developing the Jupyter tutorial notebooks for the CAFE software. Additionally, my creation of extensive documentation for CAFE using Sphinx has made the software more accessible and user-friendly. In addition to CAFE, I have also been heavily involved in the development of another spectral decomposition tool PAHFIT, which has been integrated as an astropy package. I am confident that my knowledge of the NIR/MIR spectroscopy and interpretation positions me uniquely to provide substantial value to the JWST tasks undertaken by STScI.

During my doctoral studies, I focused on the properties of small dust grains across various galactic environments and how the ISM plays a role in galaxy evolution. I published two papers centered on understanding the nature of the extended red emission and diffuse interstellar band using optical spectroscopy. The third paper is on a complete comparison between the AKARI and Spitzer spectroscopic data. In 2018, I was a Keck visiting scholar working on the DEIMOS spectroscopy, focusing on studying the

throughput of the instrument in various gratings. These research experiences, in particular, using the space and ground-based facilities have equipped me with invaluable insights and skills directly applicable to this astronomer position.

Embracing the ethos of diversity, equity, inclusion, and accessibility (DEIA), my personal and professional journey is a reflection of the rich diversity inherent in my upbringing in Taiwan and my experiences in the United States since 2014. This journey, notably marked by my significant role in the organizing committee of the Conferences for Undergraduate Women in Physics (CUWiP) in 2020, has deepened my understanding of diversity's pivotal role in fostering academic and societal advancement. The CUWiP experience highlighted the challenges female undergraduates face in physics, often stemming from inadequate encouragement, and emphasized the importance of mentorship in overcoming gender disparities in STEM fields. In all my roles, I have worked towards creating spaces that celebrate diversity, ensure equitable decision-making, and promote accessibility, particularly through mentoring female students in STEM, thereby reinforcing my dedication to dismantling academic barriers. These experiences underscore my dedication to fostering an inclusive academic community and contributing to the broader discourse on DEIA within and beyond the scientific realm.

Additionally, my engagement in community service and outreach has been diverse, including organizing the first Python visualization workshop during my PhD-a now yearly event, serving on the SOC for the 2023 GOALS workshop, and volunteering at the Sequoia Dark Sky Festival.

In conclusion, my comprehensive experience in spectroscopy, combined with my extensive background in software development and data analysis, positions me uniquely for the ESA/AURA astronomer position. The scientific objectives of JWST, particularly its focus on unraveling the mysteries of galaxy formation and evolution across cosmic time, resonate closely with my professional interests and research pursuits. Moreover, my proven ability to work effectively in team settings, coupled with a deep understanding of pipeline development processes, makes me an ideal candidate for this position. STScI's pivotal role in advancing our understanding of the Universe and making astronomy accessible to the community has always inspired me, and I am eager to contribute further to this transformative journey in the JWST era.

I have enclosed the necessary documents to support my application:

- Curriculum Vitae and Bibliography
- Research statement with a description of technical skills

In addition, here is the contact information for my references:

- Lee Armus (Staff Scientist, Caltech/IPAC) - lee@ipac.caltech.edu
- JD Smith (Professor, University of Toledo) - JD.Smith@utoledo.edu
- Aaron Evans (Professor, University of Virginia) - aevans@virginia.edu

Should you have any questions, or need any additional information, please feel free to contact me. I appreciate your consideration and look forward to hearing from you soon.

Sincerely,

Thomas (Shao-Yu) Lai