Benny T.-H. Tsang

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Professional Experience

Theoretical Astrophysics Center (TAC), UC Berkeley **Berkeley, CA**
Postdoctoral Scholar *Sep 2020 – Present*

Kavli Institute for Theoretical Physics (KITP), UC Santa Barbara **Santa Barbara, CA**
Postdoctoral Scholar *Sep 2018 – Aug 2020*

Education

University of Texas at Austin **Austin, TX**
Ph.D. in Astronomy *2018 Aug*

Dissertation: Monte Carlo Radiation Hydrodynamics in the Super-Eddington Regime

University of Hong Kong **Hong Kong**
MPhil. and B.S. in Physics *2012, 2010 Aug*

Research Interests

Computational Astrophysics – Radiation Hydrodynamics – Radiation Transport – Massive Stars and Supernovae – Machine Learning in Astronomy

Software Contributions

Fornax-Flash Model Pipeline 2022 – present
- Develop and deploy the software pipeline to simulate shock propagation from core-collapse supernova cores to the convective envelopes of their red supergiant progenitors.

Mesa-Flash Model Pipeline 2021 – 2022
- Developed and deployed the software pipeline to map 1D Mesa profiles to Flash, enabling hydrodynamical simulations of pre-supernova outbursts in convective red supergiant envelopes.

Unsupervised Feature Extraction Algorithms 2019 – 2022
- Implemented unsupervised feature extraction algorithms using (recurrent) neural network-based autoencoders, applied to light curve and core-collapse supernova progenitor model analyses.

Monte Carlo Radiation Transport with Sedona 2019 – present
- Accelerate Sedona for light curve and spectral synthesis of supernovae and stellar envelopes, optimize its performance on GPU-enabled computing platforms.

Mesa/Stella Type II-P Supernova Modeling Pipelie 2018 – 2020
- Bug fixes and improvement of Mesa's Type II-P supernova modeling pipeline.

Monte Carlo Radiation Hydrodynamics in Arepo 2018 – 2020
- Assisted the implementation of acceleration schemes for Monte Carlo radiation transport in the moving-mesh hydrodynamic code Arepo.

Monte Carlo Radiation Hydrodynamics Module in Flash 2012 – present
- Develop and maintain a generic Monte Carlo radiation hydrodynamics module in Flash.

Software Skills

- Parallel computing on high-performance computing platforms using CPUs and GPUs (in Fortran/C++; with MPI, OpenMP, OpenACC, and CUDA).
- Monte Carlo radiation transport and related acceleration and variance reduction schemes (e.g., discrete diffusion Mote Carlo, opacity-regrouping for non-gray transport, modified random walk).
- Classification, regression, novelty detection, and clustering of sequential data and images with Scikit-learn and deep neural networks. Dimension reduction with recurrent and convolutional neural networks (RNNs and CNNs), fluent in PyTorch and Keras.
- Data visualization using Matplotlib, yt and VisIt; experienced in using neural radiance fields (NeRFs) for data-driven visualization.
- Experienced with simulation-based, likelihood-free inference with invertible neural networks.
- Data analysis in Numpy, Scipy. Experienced in deploying task-based parallelization using taskflow.
- Astrophysics software packages: expert in Flash, Mesa/Stella, Sedona; experienced in Fornax, Arepo, Athena++, Tardis.

Publications

Full citation record can be found on Google Scholar.

- Pascale, M., Dai, L., McKee, C. F., **Tsang, B. T.-H.**, 2023, *ApJ*, submitted:
  The Lyman-continuum-leaking Super Star Cluster in the Sunburst Arc and its Surrounding Nebula
- Schultz, W. C., **Tsang, B. T.-H.**, Bildsten, L., Jiang Y.-F., 2022, *ApJS*, in press:
  Synthesizing Spectra from 3D Radiation Hydrodynamic Models of Massive Stars using Monte Carlo Radiation Transport
- **Tsang, B. T.-H.**, Vartanyan, D., Burrows, A., 2022, *ApJL*, **937**, L15:
  Applications of Machine Learning to Predicting Core-collapse Supernova Explosion Outcomes
- **Tsang, B. T.-H.**, Kasen, D., Bildsten, L., 2022, *ApJ*, **936**, 28:
  3D Hydrodynamics of Pre-supernova Outbursts in Convective Red Supergiant Envelopes
- Smith, A., Kannan, R., **Tsang, B. T.-H.**, Vogelsberger, M., Pakmor, R., 2020, *ApJ*, **905**, 27:
  Arepo-MCRT: Monte Carlo Radiation Hydrodynamics on a Moving Mesh
- **Tsang, B. T.-H.**, Goldberg, J. A., Bildsten, L., Kasen, D., 2020, *ApJ*, **898**, 29:
  Comparing Moment-Based and Monte Carlo Methods of Radiation Transport Modeling for Type II-Plateau Supernova Light Curves
- Zevin, M., ..., **Tsang, B. T.-H.**, et. al., 2019, *ApJ*, **886**, 4:
  Can Neutron-Star Mergers Explain the r-Process Enrichment in Globular Clusters?
- **Tsang, B. T.-H.**, Schultz C. W., 2019, *ApJL*, **877**, 14:
  Deep Neural Network Classifier for Variable Stars with Novelty Detection Capability
- Smith, A., **Tsang, B. T.-H.**, Bromm, V., Milosavljević M., 2018, *MNRAS*, **479**, 2065:
  Discrete diffusion Lyman α radiative transfer
- **Tsang, B. T.-H.**, Milosavljević M., 2018, *MNRAS*, **478**, 4142:
  Radiation pressure in super star cluster formation
- **Tsang, B. T.-H.**, Milosavljević M., 2015, *MNRAS*, **453**, 1108:
  Radiation pressure driving of a dusty atmosphere
- **Tsang, B. T.-H.**, et al., 2012, *ApJ*, **754**, 107:
  The Discovery of an X-ray/UV Stellar Flare from the Late-K/Early-M dwarf LMC 335

Selected Scientific Talks

Astronomy Colloquium [invited] — Carnegie Observatories, Pasadena
TBD — Apr 2023

Physics Astro/Particle-ML Seminar [invited] — University of California, Irvine
TBD — March 2023

SIAM Comp. Sci. and Eng. Conference [invited] — RAI Congress Center, Amsterdam
Simulating the Life and Death of Massive Stars with Efficient Radiation Transport — March 2023

N3AS Seminar [invited] — University of California, Berkeley
Predicting the Outcomes of CCSN Explosion Simulations with Machine Learning — Oct 2022

Zwicky Transient Facility (ZTF) Theory Network Meeting — Oak Creek Ranch
3D Hydrodynamics of Pre-SN Outbursts in Convective Red Supergiant Envelopes — Sep 2022

Astronomy Colloquium [invited] — University of Florida, Gainesville
Understanding Massive Stars in the Machine Learning Era — March 2021

ExplosiveAstro Talk Series [invited] — UC Berkeley
Modeling of Type-II Plateau Supernova Light Curves and Spectra — July 2020

Hernquist Research Group Meeting — Harvard University
Understanding the Life and Death of Massive Stars using Numerical Rad. Hydro. — Nov 2019

Astrophysics Brown Bag Lunch Talk — MIT
Understanding the Life and Death of Massive Stars using Numerical Rad. Hydro. — Nov 2019

Time-domain Astrophysics Seminar [invited] — New York University
Modeling of Type II-P SN Light Curves and Neural Network Class. of Variable Stars — Oct 2019

ZTF Theory Network Meeting — Oak Creek Ranch
Modeling Type II-Plateau Supernova Light Curves — Sep 2019

Astro-lunch Talk — UC Santa Barbara
Simulating the Intense Star Formation in Super Star Clusters — Nov 2018

Locals Chalk Talk — KITP
Modeling Radiation in Massive Stars — Nov 2018

ZTF Theory Network Meeting — Santa Margarita
Deep Learning applied to Periodic Light Curve Classification — Dec 2018

ZTF Theory Network Meeting — KITP Residence
Monte Carlo Radiation Hydrodynamics in Super-Eddington Systems — July 2018

231st AAS Meeting — Washington DC
Radiation Hydrodynamics of Super Star Cluster Formation — Jan 2018

Awards & Grants

Co-PI, ERCAP Supercomputing Allocation, NERSC — 2023 – 2024
Gordon & Betty Moore Time-domain Research Fellow, KITP & UC Berkeley — 2018 – 2023
David Alan Benfield Memorial Fellowship in Astronomy, UT Austin — 2018
PI, Education & Professional Development Mini-Grant, AAS — 2017 – 2018
First Place, Visualizing Science Contest, College of Natural Sciences, UT Austin — 2017
Graduate School Continuing Fellowship, UT Austin — 2015 – 2016
Hui Pun Hing Scholarship for Postgraduate Research Overseas, University of Hong Kong — 2012 – 2015

Mentoring Experience

Graduate Student:
† William Schultz (UC Santa Barbara) 2018 – present
Undergraduate Student:
Siddhant Solanki (UC Santa Barbara) 2019 – 2020
Abhay Agarwal (UC Berkeley) 2020 – 2021
(†: whose projects led to or will soon lead to refereed publications.)

Teaching Experience

Graduate teaching assistant for the following undergraduate courses (14 semesters total) – conducting weekly review session, grading homework, holding office hours, and overseeing course communications.
University of Texas at Austin

AST 353: Astrophysics	Spring 2015-2018
AST 352K: Stellar Astronomy	Fall 2016
AST 309C: Births of Stars and Planets	Fall 2015
AST 309G: Popular Astronomy	Fall 2015
AST 301: Introduction to Astronomy	Fall 2012-2015, 2017
AST 309L: The Search for Extraterrestrial Life and Intelligence	Spring 2013

Memberships & Community Service

Reviewer, *ApJ*, *AJ*, *A&A*, *MNRAS*, *IEEE Access* 2018 – present
Member, AAS 2016 – present
Member, SIAM 2023 – present
Member, National Association of Science Writers 2017 – present
Chair, Astronomy Educational Workshop, 231^{st} AAS Meeting 2018 Jan

Outreach & Science Communication

(Remote) Moderator, KITP Teachers Conference 2021 Apr
(Remote) Guest Lecturer, Laguna High School, 'Life as a computational astrophysicist' 2020 Nov
Curator, Santa Barbara Newcomers' Open House 2020 March (Canceled)
Guest Lecturer, Laguna High School, 'The Science in Our Stars' 2019 Feb, Dec
Speaker, Cafe KITP, 'Order from Chaos: Tracing the Life and Death of Stars' 2019 Aug
Speaker, Astronomy on Tap SB, 'Forming Super Star Clusters in Supercomputers' 2018 Sep
Speaker, Astronomy on Tap ATX #41, 'Forming Super Star Clusters' 2018 Feb
Speaker, Astronomy Student Association (ASA) talk, UT Austin 2018 Feb
AAS Astronomy Ambassador, 231^{st} AAS Meeting 2018 Jan
AAS Media intern, 230^{th} AAS Meeting 2017 Jun
Author & administrator, Astrobites.org (my articles) 2015 – 2020
Contributor, AAS NOVA 2015 – 2017