

Daniel Muthukrishna

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MIT Kavli Institute, 70 Vassar St, Cambridge, MA 02139, USA

Education

Institute of Astronomy, University of Cambridge

PHD IN ASTROPHYSICS

Cambridge, UK

Oct. 2017 - Jun. 2021

- **Thesis:** Data-driven Discovery of Transients in the New Era of Time-Domain Astronomy
- **Advisers:** Prof Kaisey Mandel, Prof Gautham Narayan

University of Queensland

BACHELOR OF SCIENCE, PHYSICS

Brisbane, Australia

Mar. 2012 - Dec. 2016

High Distinction Average

University of Queensland

BACHELOR OF ENGINEERING, ELECTRICAL AND AEROSPACE

Brisbane, Australia

Mar. 2012 - Dec. 2016

Awarded 1st Class Honours (High Distinction Average)

- **Thesis:** Deep Learning for the Spectral Classification of Supernovae
- **Advisers:** Prof David Parkinson, Dr Brad Tucker

Research and Work Experience

Kavli Institute for Astrophysics, Massachusetts Institute of Technology

POSTDOCTORAL RESEARCHER

Cambridge, MA, USA

Sep. 2021 - Present

- Applying machine learning and statistical methods to astronomical time-series data from the Transiting Exoplanet Survey Satellite (TESS).
- Manage a team of five undergraduate research assistants. Assign research projects and supervise them to develop novel astrophysical models with the latest data analysis and machine learning packages.

Institute of Astronomy, University of Cambridge

PHD CANDIDATE

Cambridge, UK

Oct. 2017 - Jun. 2021

- Developed a real-time anomaly detection framework for identifying unusual and interesting astronomical time-series data using Bayesian models and temporal convolutional neural networks.
- Developed a real-time photometric identification (**RAPID**: <https://astrorapid.readthedocs.io>) algorithm for classifying astronomical time-series in large-scale telescope surveys using recurrent neural networks.
- Published a novel spectroscopic classification tool for supernovae (**DASH**: <https://astrodash.readthedocs.io>) that used CNNs.

University of California, Santa Cruz

KAVLI STUDENT FELLOW

Santa Cruz, California, USA

Jul. 2019 - Aug. 2019

- Used deep neural networks for regression over time-series astronomical data.
- Developed generative models of common astronomical objects and used the model predictions for real-time anomaly detection.

Mount Stromlo Observatory, Australian National University

RESEARCH ASSISTANT

Canberra, Australia

Mar. 2017 - Aug. 2017

- Part of large international Dark Energy Survey collaboration (OzDES) and the SkyMapper Transient Survey Telescope.
- Helped develop software pipeline in the SkyMapper search for Planet 9 and the BBC Stargazing living citizen science project.

Gemini South Observatory

RESEARCH INTERNSHIP

La Serena, Chile

Dec. 2016 - Feb. 2017

- Analysed the internal kinematics of giant star-forming regions in interacting galaxies.
- Developed spectral emission line fitting tool called **FitELP** (<https://fitelp.readthedocs.io/>).

University of Queensland

RESEARCH ASSISTANT

Brisbane, Australia

Jan. 2014 - Feb. 2016

- Analysed cosmological data (Type Ia Supernovae and Baryonic Acoustic Oscillations) with Bayesian statistics. Modelled cosmic acceleration without invoking a theory of gravity by using a Taylor expansion of the scale-factor.

Micreo Limited

RADIO FREQUENCY ENGINEER

Brisbane, Australia

Dec. 2014 - Sep. 2015

- Radio Frequency Engineer at a leading Microwave and Electro-optic engineering company focused on electronic warfare for defence contracts.
- Researched, designed, simulated, and manufactured various Microwave Frequency equipment.
- Tested equipment using Vector Network Analysers, Spectrum Analysers, Oscilloscopes, and soldered components onto Printed Circuit Boards.

Selected Seminars & Conference Presentations

May. 2022	ESO Garching , SciOps 2022: Artificial Intelligence for Science in Astronomy, Contributed	<i>Garching, Germany</i>
Mar. 2022	Korea Astronomy and Space Science Institute , Cosmology Seminar Series, <i>Invited speaker</i>	<i>Online</i>
Jun. 2021	Dark Energy Science Collaboration , Machine Learning Topical Team, <i>Invited speaker</i>	<i>Online</i>
Mar. 2021	Telstra Telecommunications Company , AI ML forum, <i>Invited speaker</i>	<i>Online</i>
Dec. 2020	University of Sheffield , Astronomy Seminar, <i>Invited speaker</i>	<i>Online</i>
Feb. 2020	Stanford University, SLAC National Accelerator Laboratory , AI Seminar Series, <i>Invited</i>	<i>Stanford, CA, USA</i>
Feb. 2020	MIT , Kavli Institute's Brown Bag Lunch Talk Series	<i>Cambridge, MA, USA</i>
Feb. 2020	University of California Berkeley, SETI , Search for Extraterrestrial Intelligence Weekly Meeting	<i>Berkeley, CA, USA</i>
Feb. 2020	Texas A&M University , Astronomical Data Science Workshop, <i>Invited speaker</i>	<i>Texas, USA</i>
Nov. 2019	DESY (Deutsches Elektronen-Synchrotron) , Astroparticle Seminar, <i>Invited speaker</i>	<i>Hamburg, Germany</i>
Sep. 2019	ESO Garching , The extragalactic explosive Universe, Contributed	<i>Garching, Germany</i>
Aug. 2019	Northwestern University , Hotwiring the transient universe workshop, <i>Invited speaker</i>	<i>Evanston, IL, USA</i>
Jul. 2019	Joint Statistical Meeting , Astrostatistics Best Student Paper Session	<i>Denver, CO, USA</i>
Jun. 2019	Institute of Astronomy, University of Cambridge , Wednesday Seminar	<i>Cambridge, UK</i>
Apr. 2019	Space Telescope Science Institute , Enabling Multi-messenger Astrophysics in the Big Data Era	<i>Baltimore, MD, USA</i>
Mar. 2019	Royal Astronomical Society , Machine Learning and AI applied to Astronomy, Contributed	<i>London, UK</i>
Mar. 2019	University of California, Santa Cruz , Invited Talk to Transient group	<i>Santa Cruz, CA, USA</i>
Jan. 2019	Harvard University , CHASC Topics in Astrostatistics group	<i>Online seminar</i>
Oct. 2018	Clare College, University of Cambridge , Clarity Evening Talk to non-scientific audience	<i>Cambridge, UK</i>
Jun. 2018	University of Oxford , Planning for Surprises in the era of Data-Driven Astronomy, Contributed	<i>Oxford, UK</i>
Jul. 2017	Australian National University , Astronomical Society of Australia Annual Meeting, Contributed	<i>Canberra, Australia</i>
Jan. 2017	University of Chile , Machine Learning and transient group	<i>Santiago, Chile</i>

Selected Awards

2021	Paul Murdin Prize , Best Published Journal Paper by an Astronomy PhD Student	<i>University of Cambridge</i>
2019	Kavli Student Fellow , Selected fellow of the Kavli Summer Program in Astrophysics	<i>UC Santa Cruz</i>
2017	Bok Prize Highly Commended , Awarded to top three astronomy Masters theses in Australia	<i>Astronomical Society of Australia</i>
2017	Cambridge Australia Poynton Scholarship , Awarded to top applicants from Australia	<i>Cambridge Trust</i>
2017	President's PhD Scholarship , Awarded to the top applicants across Imperial College	<i>Imperial College</i>
2017	AAO Scholarship , Awarded to top astrophysics graduate students	<i>Australian Astro. Observatory</i>
2016	IEEE Student Thesis Prize , Best Engineering thesis from all undergraduates in Queensland	<i>Institute of Electrical Engineers</i>
2016	GBST Best Software Project , Best software-related thesis at the University of Queensland	<i>GBST and University of Queensland</i>
2016	Gemini Studentship , Two students from Australia selected	<i>Australian Astro. Observatory</i>
2016	Dean's Commendations for High Achievement , Awarded to students with top-ranking GPAs	<i>University of Queensland</i>
2015	RSAA Astronomy Winter School , Four students from Australia and New Zealand were selected	<i>RSAA, Canberra</i>
2014	Micreo Scholarship in Electrical Engineering , Awarded to one student each year in Queensland	<i>University of Queensland</i>
2013	Mpemba Effect Competition , Selected in the top 10 out of 22000 entrants	<i>Royal Society of Chemistry</i>
2012	Students for the Future Award , Awarded to the top 100 engineering students in Queensland	<i>Queensland Resource Council</i>
2011	Titration National Finalist and Regional Winner , Queensland Resource Council	<i>Royal Australian Chemical Institute</i>

Skills

Experienced researcher working at the intersection of astronomy and data intensive science. I use deep learning and Bayesian modelling for data-driven astrophysics. I'm enthusiastic about applying novel machine learning methods to new datasets.

Expert Python: Tensorflow, Keras, Numpy, Pandas, Scipy, Scikit-learn, PyMC3.
Experience with: C, C++, Matlab, SQL, HTML, Fortran, IDL, Java

Developer Developed widely used packages based on convolutional and recurrent neural networks:
astrodash <https://astrodash.readthedocs.io> and astrorapid <https://astrorapid.readthedocs.io>

Other Deep learning, data augmentation, Bayesian statistics, massive observational datasets, data visualisation, multi-collaborator git version control, teaching, supervising students, managing teams in local and international collaborations, electronics design.

Academic Referee Reviewer for NeurIPS, AAS (ApJ), MNRAS, and IEEE Journals.

Teaching Experience

DPMMS, Centre for Mathematical Sciences, University of Cambridge

Cambridge, UK

COURSE ORGANISER AND SUMMER LECTURER

Jul. 2018, Jul. 2019

- Prepared and lectured an intensive computer training course for Part II and Part III (third and fourth year undergraduate) students.
- The summer course began from an introduction to Python and shell environments, and extended to big-data analysis, Markov Chain Monte Carlo sampling, solving ODEs, visualising data, and machine learning architectures using scikit-learn and Tensorflow.

School of Mathematics & Physics and School of Engineering, University of Queensland

Brisbane, Australia

UNIVERSITY TUTOR

Mar. 2013 - Nov. 2016

- Led classes of 20-70 students and graded coursework for higher undergraduate level engineering, physics, and calculus courses.
 - ELEC3100: Fundamentals of Electromagnetic Fields & Waves
 - ENGG1300: Introduction to Electrical Systems
 - MATH1051: Calculus and Linear Algebra
 - MATH1052: Multivariate Calculus & ODEs
 - PHYS1002: Electromagnetism and Modern Physics
 - PHYS1001: Mechanics and Thermal Physics
 - ENGG1500: Engineering Thermodynamics

Mentoring

Hali Huang

MIT

COMPUTER SCIENCE, 2ND YEAR UNDERGRADUATE

Jun. 2022 - Present

- Paper in preparation on the development of a probabilistic recurrent neural network to predict the epoch time of transients from the Transiting Exoplanet Survey Satellite (TESS) and Zwicky Transient Facility (ZTF) data.

Zimi Zhang

MIT

COMPUTER SCIENCE AND PHYSICS, 2ND YEAR UNDERGRADUATE

Jun. 2022 - Present

- Modelling multi-channel light curves using a 2D Gaussian Process over time and wavelength. Using model for data augmentation to help train the other student's machine learning algorithms.

Prajna Nair

MIT

ASTROPHYSICS, 2ND YEAR UNDERGRADUATE

Mar. 2022 - Present

- Paper in preparation with Hali Huang on the development of a Bayesian parametric model of early-time observations of supernovae to accurately predict the epoch time.

Torsha Majumder

University of Texas, Verizon

DATA SCIENTIST, PROSPECTIVE PHD

Dec. 2021 - Present

- Paper in preparation on the development of unsupervised learning algorithms to identify anomalies in supernovae data from the TESS and ZTF.

Andrew Jenkins

MIT, Tesla

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, 3RD YEAR UNDERGRADUATE

Jun. - Sep. 2022

- Developed a semi-supervised classification algorithm using a neural network variational autoencoder and random forest to classify transient light curves with a small number of labelled data. This work is being continued by Miguel Chacon, a 2nd year computer science undergraduate at MIT.

Saul Balcarcel

MIT

ASTROPHYSICS, 2ND YEAR UNDERGRADUATE

Mar. - Jun. 2022

- Searched the TESS TOI catalog for multi-planet systems using a Bayesian model of Transit Time Variations in TESS light curves.

Anahita Srinivasan

MIT

COMPUTER SCIENCE, 2ND YEAR UNDERGRADUATE

Dec. 2021 - May. 2022

- Used unsupervised machine learning using a neural network autoencoder and HDBSCAN to search for anomalies in the TESS TOI catalog.

Jaya Chand

University College London

ASTRONOMY, 3RD YEAR UNDERGRADUATE

Jun. - Aug. 2021

- Developed a convolutional neural network to identify the redshift of supernova spectra from the Dark Energy Survey.

Selected Publications

See [full publication list on ADS](#).

FIRST THREE AUTHORS

1. **Muthukrishna, D.**, Mandel, K., Lochner, M., Webb, S., & Narayan, G. *Real-time detection of anomalies in large-scale transient surveys*. 2022, MNRAS. [[ads](#)]
2. **Muthukrishna, D.**, Mandel, K., Lochner, M., Webb, S., & Narayan, G. *Real-time Detection of Anomalies in Multivariate Time Series of Astronomical Data*. 2021, NeurIPS 2021. [[ads](#)]
3. Webb, S., Lochner, M., **Muthukrishna, D.**, et al., *Unsupervised machine learning for transient discovery in Deeper, Wider, Faster light curves*. 2020, MNRAS, 498, 3077. [[ads](#)][[doi](#)]
4. **Muthukrishna, D.**, Narayan, G., Mandel, K., Biswas, R., & Hložek, R. *RAPID: Early classification of explosive transients using Recurrent Neural Networks*. 2019, PASP, 131, 118002. [[ads](#)][[doi](#)]
5. **Muthukrishna, D.**, Parkinson, D., & Tucker, B. *DASH: Deep Learning for the Automated Spectral Classification of Supernovae and their Hosts*. 2019, ApJ, 885, 85. [[ads](#)][[doi](#)]

6. **Muthukrishna, D.** & Parkinson. D. *A cosmographic analysis of the transition to acceleration using SN-Ia and BAO*. 2016, J. Cosmol. Astropart. Phys, 11, 052. [[ads](#)][[doi](#)]
7. **Muthukrishna, D.**, Huang, H., Nair, P., Fausnaugh, M., Ricker, G., *Real-time prediction of the epoch time of transients in large-scale transient surveys*. 2023, in prep.
8. Majumder, T., **Muthukrishna, D.**, Huang, H., Fausnaugh, M., Ricker, G., *Anomaly detection and unsupervised classification of transients in TESS and ZTF*. 2023, in prep.
9. **Muthukrishna, D.**, Zhang, Z., Jenkins, A., Huang, H., Fausnaugh, M., Ricker, G., *semi-supervised classification of transients in real-time transient surveys*. 2023, in prep.

OTHER CO-AUTHOR

10. Tey, E., et al. (incl **Muthukrishna, D.**), *Identifying Exoplanets with Deep Learning. V. Improved Light Curve Classification for TESS Full Frame Image Observations*. 2022, submitted to ApJ.
11. Fausnaugh, M., et al. (incl **Muthukrishna, D.**), *Four years of Type Ia Supernovae Observed by TESS*. 2022, submitted to ApJ.
12. Biswas, E., Ishida, E., et al. (incl **Muthukrishna, D.**), *Enabling the discovery of fast transients: A science module for the Fink broker*. 2022, submitted to A&A.
13. Chatterjee, D., Narayan, D., Aleo, P. D., Malanchev, K., **Muthukrishna, D.**, *Electromagnetic Counterpart Identification of Gravitational-wave candidates using deep-learning*. 2021, Accepted in NeurIPS 2021. [[ads](#)]
14. Chatterjee, D., Narayan, D., Aleo, P. D., Malanchev, K., **Muthukrishna, D.**, *El-CID: A filter for Gravitational-wave Electromagnetic Identification*. 2021, MNRAS, 509, 914. [[ads](#)]
15. Hložek, R., et al. (incl **Muthukrishna, D.**), *Results of the Photometric LSST Astronomical Time-series Classification Challenge (PLAsTiCC)*. 2021, submitted to ApJS. [[ads](#)]
16. Jones, D. O., et al. (incl **Muthukrishna, D.**), *The Young Supernova Experiment: Survey Goals, Overview, and Operations*. 2020, ApJ, 908, 24. [[ads](#)][[doi](#)]
17. Stachie, C., Coughlin, M., Christensen, N. & **Muthukrishna, D.**, *Differentiating the signal from the noise: towards optimal choices of wide field-of-view telescope transient follow-up*. 2019, MNRAS, 497, 1320. [[ads](#)][[doi](#)]
Contribution: Machine learning and classification code.
18. Malz, A. I., et al. (incl **Muthukrishna, D.**), *The Photometric LSST Astronomical Time-series Classification Challenge PLAsTiCC: Selection of a Performance Metric for Classification Probabilities Balancing Diverse Science Goals*. 2019, AJ, 158, 171. [[ads](#)][[doi](#)]
Contribution: Assisted with the validation and curation of the PLAsTiCC dataset.
19. Campuzano Castro, F., Hagele, G. F., Bosch, G., Firpo, V., Cardaci, M., **Muthukrishna, D.**, Morrell, N. *Chemodynamics in Blue Compact Dwarf galaxies: II Zw 33 and Mrk 600*. 2019, Boletín de la Asociación Argentina de Astronomía, 61A. [[ads](#)][[doi](#)]
Contribution: Scripted emission line analysis tool to analyse the kinematics and abundances of spectral features.
20. Kessler, R., et al. (incl **Muthukrishna, D.**), LSST Dark Energy Science Collaboration, Transient and Variable Stars Science Collaboration *Models and Simulations for the Photometric LSST Astronomical Time Series Classification Challenge (PLAsTiCC)*. 2019, PASP, 131, 094501. [[ads](#)][[doi](#)]
Contribution: Performed detailed validation of the PLAsTiCC simulations.
21. Kessler, R., et al. (incl **Muthukrishna, D.**), *First cosmology results using Type Ia supernova from the Dark Energy Survey: simulations to correct supernova distance biases*. 2019, MNRAS, 485, 1171. [[ads](#)][[doi](#)]
Contribution: assisted with the classification of the cosmological sample.
22. Brout, D., et al. (incl **Muthukrishna, D.**), *First Cosmology Results Using SNe Ia from the Dark Energy Survey: Analysis, Systematic Uncertainties, and Validation*. 2019, ApJ, 874, 150. [[ads](#)][[doi](#)]
Contribution: assisted with the classification of the cosmological sample.
23. Abbott, T., et al. (incl **Muthukrishna, D.**), *First Cosmology Results using Type Ia Supernovae from the Dark Energy Survey: Constraints on Cosmological Parameters*. 2019, ApJL, 872, L30. [[ads](#)][[doi](#)]
Contribution: assisted with the classification of the cosmological sample.
24. D'Andrea, R., et al. (incl **Muthukrishna, D.**), *First Cosmology Results Using Type Ia Supernovae From the Dark Energy Survey: Survey Overview and Supernova Spectroscopy*. arXiv:1811.09565. [[ads](#)]

Contribution: assisted with the classification of the cosmological sample.

25. Campuzano Castro, F., Bosch, G., Hagele, G., Firpo, V., **Muthukrishna, D.**, Cardaci, M. *Estudio en galaxias BCD: Mrk 600 y IIZw 33*. 2018, Boletín de la Asociación Argentina de Astronomía, 60, 148. [[ads](#)]

Contribution: Scripted emission line analysis tool to analyse the kinematics and abundances of spectral features.

26. Childress, M., et al. (incl **Muthukrishna, D.**), *OzDES multifibre spectroscopy for the Dark Energy Survey: 3-yr results and first data release*. 2017, MNRAS, 472, 273. [[ads](#)][[doi](#)]

Contribution: classified the supernovae in the 3-yr data.

SELECTED WHITE PAPERS, NOTES, AND ASTRONOMICAL TELEGRAMS

27. de Jong, R., et al. (incl **Muthukrishna, D.**), *4MOST: Project overview and information for the First Call for Proposals*. 2019, The Messenger, 175, 3. [[ads](#)][[doi](#)]

28. Allen, G., et al. *Multi-Messenger Astrophysics: Harnessing the Data Revolution*. 2018, arXiv:1807.04780. [[ads](#)]

29. The PLAsTiCC team, et al. *The Photometric LSST Astronomical Time-series Classification Challenge (PLAsTiCC): Data set*. 2018, arXiv:1810.00001. [[ads](#)]

30. **Muthukrishna, D.**, Sharp, R. G., Tucker, B. E., et al., *Classification of 17 DES supernova with OzDES*, *The Astronomer's Telegram*. 2017, ATel, 10759. [[ads](#)]

THESES

31. **Muthukrishna, D.** *Data-driven Discovery of Transients in the New Era of Time-Domain Astronomy*. 2021, PhD Thesis, University of Cambridge. [[Online Thesis](#)][[doi](#)]

32. **Muthukrishna, D.** *Deep Learning for the Spectral Classification of Supernovae*. 2016, Unpublished Honours Thesis, University of Queensland, Brisbane, Australia. [[Online Thesis](#)]

Awarded IEEE General Student Thesis prize for the best Electrical Engineering thesis in Queensland.

Awarded GBST prize for the best software thesis at the University of Queensland.

Awarded Bok Prize Highly Commended for the top three ranked astronomy Honours or Masters theses in Australia.