

Shivan Khullar

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Education

University of Toronto

PH.D. (DIRECT ENTRY) IN ASTRONOMY AND ASTROPHYSICS

Toronto, Canada

2019 -

BITS Pilani University

B.E. (HONS.) ELECTRONICS AND INSTRUMENTATION AND MSc. (HONS.) PHYSICS

Goa, India

Aug 2014 - July 2019

Publications

- 'The density structure of supersonic self-gravitating turbulence', **Shivan Khullar**, Christoph Federrath, Mark R. Krumholz, Christopher D. Matzner, 2021, MNRAS [ADS Link](#) [arXiv Link](#)
- 'Probing the high-z IGM with the hyperfine transition of $^3\text{He}^+$ ', **Shivan Khullar**, Qingbo Ma, Philipp Busch, Benedetta Ciardi, Marius B. Eide and Koki Kakiichi, 2020, MNRAS [ADS Link](#) [arXiv Link](#)
- 'Determining star formation thresholds from observations', **Shivan Khullar**, Mark R. Krumholz, Christoph Federrath, Andrew J. Cunningham, 2019, MNRAS [ADS Link](#) [arXiv Link](#)
- 'The Single-Cloud Star Formation Relation', Riwaj Pokhrel, Robert A. Gutermuth, Mark R. Krumholz, Christoph Federrath, Mark Heyer, **Shivan Khullar**, S. Thomas Megeath, Philip C. Myers, Stella S. R. Offner, Judith L. Pipher, William J. Fischer, Thomas Henning, Joseph L. Hora, 2021, APJ Letters [ADS Link](#) [arXiv Link](#)

Technical Skills and Coursework

Technical Skills

- Languages - Python, C, C++, R, Mathematica; English, Hindi, Punjabi, Bengali
- High Performance Computing - Use Gadi/Raijin supercomputer at NCI Australia, Niagara supercomputer at SciNet, Compute Canada.

Graduate coursework

- Stars, Cosmology, Radiation, Astrophysical Fluid Dynamics, Scientific Computing for Physicists, Quantitative Data Science.

Undergraduate: Physics and Mathematics coursework

- **Theory** - Mechanics, Oscillations and Waves; Thermodynamics, Vector Calculus, Linear Algebra and Complex Analysis, Probability and Statistics, Ordinary Differential Equations, Electromagnetic Theory I, Introduction to Astronomy and Astrophysics, Theory of Relativity, Optics, Classical Mechanics, General Theory of Relativity and Cosmology, Electromagnetic Theory II, Quantum Mechanics I, Mathematical Methods of Physics, Quantum Mechanics II, Statistical Mechanics, Group Theory and Applications, Non-linear Dynamics and Chaos, Atomic and Molecular Physics, Nuclear and Particle Physics, Solid State Physics, Quantum Field Theory, Particle Physics.
- **Lab coursework** - Computational Physics, Physics Laboratory I, Electricity Magnetism and Optics Laboratory, Modern Physics Laboratory, Advanced Physics Lab, Computer Programming

Awards

International Graduate Student Fellowship for Excellence in Doctoral Studies

DEPARTMENT OF ASTRONOMY AND ASTROPHYSICS, UNIVERSITY OF TORONTO

\$3,000

2020,2021,2022

Department of Astronomy and Astrophysics International Entrance Award

DEPARTMENT OF ASTRONOMY AND ASTROPHYSICS, UNIVERSITY OF TORONTO

\$5,000

2019,2020

Workshops, Talks and Conferences

- McMaster University, Journal club seminar
Talk (invited) - — **November 2022**
- A Holistic View of Stellar Feedback and Galaxy Evolution, Ascona 2022
Contributed Talk - Playing with FIRE: Molecular clouds and star formation in a galactic feedback-halting experiment — **July 2022**
- International High Performance Computing Summer School, Athens 2022
Poster, Lightning talk - Combining multiple scales in star formation simulations — **June 2022**
- Canadian Astronomical Society (CASCA), Annual Meeting 2022
Poster - GMCs on FIRE: The impact of feedback on star formation rates, efficiencies, and laws — **May 2022**
- Princeton University, Star Formation/ISM Rendezvous
Talk (invited) - Star formation thresholds and the density PDF — **October 2021**
- Canadian Astronomical Society (CASCA), Annual Meeting 2021
Poster - The density structure of supersonic self-gravitating turbulence — **May 2021**
- Canadian Astronomical Society (CASCA), Annual Meeting 2020
Poster - Star Formation Thresholds: Real or Illusory? — **May 2020**
- International Max Planck Research School on Astrophysics at the Ludwig Maximilians University, Munich
Talk (invited) - Star Formation Thresholds: Real and Illusory — **Feb 2019**

Teaching

Teaching Assistantship

- *Fall 2022* — AST101 The Sun and Its Neighbours — University of Toronto
- *Summer 2022* — AST101 Stars and Galaxies — University of Toronto
- *Winter 2022* — AST320 Introduction to Astrophysics — University of Toronto
- *Fall 2021* — AST325/326 Introduction to Practical Astronomy — University of Toronto
- *Summer 2021* — AST101 Stars and Galaxies — University of Toronto
- *Winter 2021* — AST201 Stars and Galaxies — University of Toronto
- *Fall 2020* — AST101 The Sun and Its Neighbours — University of Toronto
- *Winter 2020* — AST201 Stars and Galaxies — University of Toronto
- *Fall 2019* — AST101 The Sun and Its Neighbours — University of Toronto
- *Semester I 2017-18* — Electro-Magnetic Theory I — BITS Pilani, Goa
- *Semester II 2017-18* — Mathematical Methods of Physics — BITS Pilani Goa

DUTIES -

- LEADING TUTORIALS, PLANETARIUM SHOWS, OBSERVING NIGHTS, MARKING PROJECTS AND EXAMS (AST 101/201, UoFT)
- DESIGNING AND LEADING TUTORIALS, GRADING LAB REPORTS (AST 325/326, UoFT)
- MAKING ASSIGNMENT SOLUTIONS, HOLDING OFFICE HOURS AND GRADING ASSIGNMENTS (AST 320, UoFT)
- DESIGNING LECTURE SLIDES, MARKING QUIZZES (BITS)

Undergraduate Research Experience

Determining Star Formation Thresholds from Observations

RSAA, ANU, Canberra, Australia

SUPERVISORS - PROF. MARK KRUMHOLZ AND DR. CHRISTOPH FEDERRATH (RSAA, AUSTRALIAN NATIONAL UNIVERSITY, CANBERRA, AUSTRALIA)

August 2018 - Dec 2018

We created mock observations from simulations of star formation and wrote a pipeline to analyze these mock observations. Using these mock observations, we found that the interpretation of a star formation threshold from certain observational data is misleading and presented a method to find such a threshold (if it exists) from observations.

Gravitational Decoherence

RRI, Bangalore, India

SUPERVISOR - PROF. JOSEPH SAMUEL (RRI, BANGALORE, INDIA)

Jan 2019 - June 2019

I studied the Aharonov-Bohm effect, theory of quantum decoherence, quantum field theory in curved space time, the Unruh effect, and the phenomenon of gravitational decoherence following Samuel (2018). Wrote a Mathematica code to calculate the form factor for a given path configuration of a quantum particle in the double slit experiment.

The $^3\text{He}+$ hyperfine transition line signal at high redshifts

MPA, Garching, Germany

SUPERVISOR - PROF. BENEDETTA CIARDI (MAX PLANCK INSTITUTE FOR ASTROPHYSICS, GARCHING, GERMANY)

June 2018 - July 2018

We used simulations of cosmic reionization and a high- z QSO environment to calculate the differential brightness temperature of the $^3\text{He}+$ 3.46 cm line from these simulations. If detectable, the $^3\text{He}+$ signal could be used to probe the high redshift universe. We analysed whether the $^3\text{He}+$ signal could be found using current or future radio telescopes.

Determining the size distribution of H II regions during Reionization using granulometry

NCRA-TIFR, Pune, India

SUPERVISOR - PROF. TIRTHANKAR ROY CHOUDHURY (NCRA-TIFR, PUNE)

May - June 2017

I wrote a code in Python to implement the granulometry technique on image data from hydro-dynamical simulations of HII bubble growth based on excursion set models. These simulations violated photon number conservation and the granulometry technique would help in pin-pointing the reason for this violation by giving information on the size distribution of HII regions.

Mass Modelling of galaxies using HI 21-cm line observations

IUCAA, Pune, India

SUPERVISOR - DR. NEERAJ GUPTA (IUCAA, PUNE)

May - July 2016

Using observational data from NED, we created moment maps in CASA and then plotted rotation curves of galaxies. The rotation curves were then fitted to the velocity curves obtained using the gas, stellar and dark matter contributions and the dark matter distribution (densities) were obtained.