Dr. Viraja C. Khatu

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Education

Sept. 2017- Aug. 2022 **Doctor of Philosophy, Astronomy (Planetary Science and Exploration)**
The University of Western Ontario, London, Ontario
Project: Probing the Inner Structure of Active Galactic Nuclei Through Reverberation Mapping

Sept. 2015- Aug. 2017 **Master of Science, Astronomy**
The University of Western Ontario, London, Ontario

Sept. 2011- Apr. 2015 **Honours Bachelor of Science, Astronomical Sciences**
University of Toronto Mississauga, Mississauga, Ontario

Awards

May 2019- Apr. 2022 **New Technologies for Canadian Observatories (NTCO) Fellowship**
(various), $40,000 CAD
Completed two, three-month internships at Gemini Observatory (Hilo, Hawai'i) and Teledyne FLIR (Richmond, British Columbia) as part of the fellowship program.

Sept. 2018- Aug. 2019 **Ontario Graduate Scholarship**
The University of Western Ontario, London, Ontario, $15,000 CAD

Apr. 2019 **Robert and Ruth Lumsden Graduate Fellowship**
The University of Western Ontario, London, Ontario, $1,500 CAD

Jul. 2018 **Dunlap Institute Summer School Travel Scholarship**
University of Toronto, Toronto, Ontario, $500 CAD

Aug. 2017 **La Serena School for Data Science Travel Scholarship**
Association of Universities for Research in Astronomy (AURA), La Serena, Chile, $2,000 CAD

Jul. 2017 **PSAC 610 Academic Achievement Scholarship**
The University of Western Ontario, London, Ontario, $400 CAD

May 2014- Aug. 2014 **Summer Undergraduate Research Program Fellowship**
University of Toronto, Toronto, Ontario, $8,000 CAD

Research

The University of Western Ontario, London, Ontario

Sept. 2022- Oct. 2023 **Postdoctoral Researcher**
Co-Lead of the Active Galactic Nuclei (AGN) and Supermassive Black Holes Science Working Group for the *Cosmological Advanced Survey Telescope for Optical and ultraviolet Research (CASTOR)* working on building a survey simulation pipeline to design large-scale AGN variability surveys with next-generation observatories.

Sept. 2017- Aug. 2022 **Doctoral Research Student**
Led three projects in international collaborations: (1) Supermassive Black Holes with High Accretion Rates in Active Galactic Nuclei. XIII. Ultraviolet Time Lag of Hβ Emission in Mrk 142 (paper under review); (2) Revisiting Emission-Line Measurement Methods for Narrow-Line Active Galactic Nuclei (paper accepted); and (3) Designing Large-Scale Variability Surveys of Active Galactic Nuclei (project ongoing).
Supervisor: Prof. Sarah Gallagher

Sept. 2015- Aug. 2017 **Master's Research Student**
Project: Optical Spectral Analysis of Mini Low-Ionization Broad Absorption Line Quasars.
Reduced and calibrated optical spectra from the Mayall 4-metre Telescope at the Kitt Peak National Observatory (KPNO), and analyzed spectra of the same objects from the Sloan Digital Sky Survey (SDSS) catalog to decipher the physical properties of quasars showing mini-broad absorption-line features.
Supervisor: Prof. Sarah Gallagher

National Research Council Canada's Herzberg Astronomy and Astrophysics Research Centre, Victoria, British Columbia

Sept. 2022- Oct. 2022 **Visiting Scholar**
Led planning of the Active Galactic Nuclei Reverberation Mapping Legacy Program for *CASTOR* Phase 0 Study.
Supervisor: Dr. Patrick Côté

Oct. 2018- Dec. 2018 **Visiting Student**
Led planning of the Active Galactic Nuclei Reverberation Mapping Legacy Program for *CASTOR* Science Maturation Study.
Supervisor: Dr. Patrick Côté

York University, Toronto, Ontario

May 2015- Jul. 2015 **Summer Research Student**
Project: Survey of Extremely High-velocity Outflows in Sloan Digital Sky Survey Quasars
Developed and tested an interactive Python code to generate power-law fits to the continuum in ultraviolet quasar spectra from the SDSS catalog.
Supervisors: Prof. Patrick Hall and Prof. Paola Rodríguez Hidalgo

University of Toronto
(Mississauga, Ontario)

May 2015- Aug. 2015 **Summer Research Assistant**
Project: Indicators of Stellar Mass in the Photometric H-band
Calculated computer models of stellar atmospheres in FORTRAN and computed the infrared spectral radiation of Red Supergiant stars to study the dependence of stellar radiation on treatment of convection.
Supervisor: Prof. John Lester, Emeritus

(Toronto, Ontario)

Sept. 2014- Apr. 2015 **Research Student**
Project: Extremely High Velocity Outflows in Low-Redshift Active Galactic Nuclei
Developed and tested a Python code to generate power-law fits to the continuum in ultraviolet AGN spectra from the *Hubble Space Telescope* Spectroscopic Legacy Archive (HSLA), and analyzed the spectra to search for extremely high-velocity broad absorption-line features.
Supervisors: Prof. Paola Rodríguez Hidalgo and Prof. Roberto Abraham

May 2014- Aug. 2014 **Summer Research Assistant**
Project: Gas at the Center of the Milky Way Galaxy
Reduced and calibrated data from the Karl G. Jansky Very Large Array (VLA) showing the circumnuclear disk region at the center of the Milky Way using Astronomical Image Processing System (AIPS), and generated velocity-integrated moment maps of the same region to study the movement of the gas in the circumnuclear disk.
Supervisor: Dr. María Montero-Castaño

Jun. 2013- Aug. 2013 **Summer Research Student**
Project: Amplitude Variations in Pulsating Red Supergiants
Performed period analysis on light curves of the Red Supergiant stars from the American Association of Variable Star Observers (AAVSO) International Database, in VStar, to analyze variations in the amplitude of pulsation and deduce possible periods of pulsation for the stars.
Supervisor: Prof. John Percy, Emeritus

Employment

Jan. 2024- Present **Resident Astronomer**
Canada-France-Hawai'i Telescope Corporation, Kamuela, Hawai'i

Jan. 2017- Dec. 2021 **Lead Teaching Assistant and Outreach Coordinator**
The Hume Cronyn Memorial Observatory, *The University of Western Ontario*, London, Ontario
Supervisor: Prof. Jan Cami

Sept. 2015- Dec. 2021 **Graduate Teaching Assistant** (Astronomy, Physics, and Applied Mathematics)
The University of Western Ontario, London, Ontario
Supervisors: *(various)*

Aug. 2020 **Course Developer** (Physics and Astronomy Undergraduate Seminar; virtual)
The University of Western Ontario, London, Ontario
Supervisor: Prof. Sarah Gallagher

Feb. 2021- Apr. 2021 **NTCO Intern for Barcode Scanner Accessory Counting Project** (virtual)
Teledyne FLIR, Richmond, British Columbia
Devised a barcode scanning and decoding system with a team of engineers by combining machine vision and deep learning methods to reduce manual labour costs and shipment processing time in the company.
Supervisor: Stephen Se, Ph.D., P.Eng.

May 2019- Aug. 2019 **NTCO Intern for GNIRS Data-Reduction Pipeline Development**
Gemini Observatory, Hilo, Hawai'i
Developed a full-featured reduction pipeline, using Python as a wrapper for Image Reduction and Analysis Facility (IRAF) tools, for the cross-dispersed data taken with the Gemini Near-InfraRed Spectrograph (GNIRS) to offer the user community with a flexible, user-friendly data processing pipeline.
Supervisors: Dr. Marie Lemoine-Busserolle and Dr. Andrew Stephens

Publications

Thesis by Defense

2022 **Khatu, V. C.**, PhD thesis, The University of Western Ontario, Canada. https://ir.lib.uwo.ca/etd/8685/

Refereed Publications

2022 **Khatu, V. C.**, Gallagher, S. C., Horne, K., et al. Supermassive Black Holes with High Accretion Rates in Active Galactic Nuclei. XIII. Ultraviolet Time Lag of Hβ Emission in Mrk 142. *The Astrophysical Journal*, 958, 127. https://iopscience.iop.org/article/10.3847/1538-4357/acfb72

2023 **Khatu, V. C.**, Gallagher, S. C., Horne, K., et al. Revisiting Emission-Line Measurement Methods for Narrow-Line Active Galactic Nuclei. *Publications of the Astronomical Society of the Pacific*, 135, 044504. https://iopscience.iop.org/article/10.1088/1538-3873/acc973

2020 Rodríguez Hidalgo, P., Khatri, A. M., Hall, P. B., Haas, S., Quintero, C., **Khatu, V.**, et al. Survey of Extremely High-velocity Outflows in Sloan Digital Sky Survey Quasars. *The Astrophysical Journal*, 896, 151. https://iopscience.iop.org/article/10.3847/1538-4357/ab9198

2020 Cackett, E. M., Gelbord, J., Li, Y.-R. Li, Horne, K., Wang, J.-M., Barth, A. J., Bai, J.-M., Bian, W.-H., Carroll, R. W., Du, P., Edelson, R., Goad, M. R., Ho, L. C., Hu, C., **Khatu, V. C.**, et al. Supermassive black holes with high accretion rates in active galactic nuclei. XI. Accretion disk reverberation mapping of Mrk 142. *The Astrophysical Journal*, 896, 1. https://iopscience.iop.org/article/10.3847/1538-4357/ab91b5

2017 Lester, J., **Khatu, V**., and Neilson, H. Indicators of Stellar Mass in the Photometric *H*-band. *Publications of the Astronomical Society of the Pacific*, 129, 024201. https://iopscience.iop.org/article/10.1088/1538-3873/129/972/024201

2014 Percy, J. R. and **Khatu, V**. Amplitude Variations in Pulsating Red Supergiants. *The Journal of the American Association of Variable Star Observers*, 42, 1. http://www.aavso.org/sites/default/files/jaavso/v42n1/1.pdf

White Papers

2019 Côté, P., Abraham, R., Balogh, M., Capak, P., Carlberg, R., Cowan, N., Djazovski, O., Drissen. L., Drout, M., Dupuis, J., Evans, C., Fantin, N., Ferrarese, L., Fraser, W., Gallagher, S., Girard, T., Gleisinger, R., Grandmont, F., Hall, P., Hellmich, M., Hardy, T., Harrison, P., Hložek, R., Haggard, D., Hénault-Brunet, V., Hutchings, J., **Khatu, V.**, et al. CASTOR: A Flagship Canadian Space Telescope. *Canadian Long Range Plan for Astronomy and Astrophysics White Papers, 2020* (ID:18). https://www.zenodo.org/record/3758463#.Xw82p5NKi_U

2019 Woods, T. E., Alexandroff, R. M., Ellison, S. L., Ferrarese, L., Gallagher, S., Gallo, L., Haggard, D., Hall, P., Hlavacek-Larrondo, J., **Khatu, V. C.**, et al. Revealing the Origins and Cosmic Evolution of Supermassive Black Holes. *Canadian Long Range Plan for Astronomy and Astrophysics White Papers, 2020* (ID: 34). https://zenodo.org/record/3765791#.Xw8zepNKi_U

2019 Hall, P., Balogh, M., Barmby, P., Blakeslee, J., Bovy, J., Bradley, C., Bridges, T., Cami, J., Chapman, S., Chateauneuf, F., Cowan, N., Côté, P., Damjanov, I., Drout, M. Eadie, G., Ellison, S., Ferrarese, L., Fraser, W., Gaensler, B., Gallagher, Haggard, D., Hénault-Brunet, V., Herwig, F., Hill, A., Hlavacek-Larrondo, J., Hudson, M., Johnson, M., **Khatu, V.**, et al. (2019). The Maunakea Spectroscopic Explorer. *Canadian Long Range Plan for Astronomy and Astrophysics White Papers, 2020* (ID: 30). https://www.zenodo.org/record/3765452#.Xw809pNKi_U

Observing Experience and Proposals

2019 **Proposal Reviewer**, Gemini Observatory Fast Turnaround Programs
2 cycles/Gemini Observatory, Hawai'i and Chile

2019 **Co-Principal Investigator (Co-P.I.)**, "Mapping the Broad Line Region of the Supermassive Binary Black Hole Mrk 6"
∼1 hour/Gemini Multi-Object Spectrograph (GMOS) on the Gemini North Telescope, Maunakea, Hawai'i (Program ID: GN-2019B-FT-214)

2019 **P.I.**, "Identifying a Highly Variable Active Galactic Nucleus"
∼0.6 hours/GMOS on the Gemini North Telescope, Maunakea, Hawai'i (Program ID: GN-2019B-Q-313)

2018 **P.I.**, "Mapping the Accretion Disk and Broad Line Region of the Super-Eddington Active Galactic Nucleus Mrk 142"
18 hours/GMOS on the Gemini North Telescope, Maunakea, Hawai'i (Program ID: GN-2019A-Q-121)

2015 **Co-Observer**
5 nights/Kitt Peak Ohio State Multi-Object Spectrograph on the Mayall 4-meter Telescope, KPNO, Tucson, Arizona

Science Teams

Jan. 2023-Present **Member**, AGN and Supermassive Black Holes, Maunakea Spectroscopic Explorer

May 2022-Present **Member**, High Energy Astrophysics and Gravitational Waves, Space Exploration Topical Teams Initiative, Canadian Space Agency (CSA)

May 2018-Present **Co-Lead**, AGN and Supermassive Black Holes, *CASTOR*

Service and Outreach

May 2023-Present **Member**, Education and Public Outreach Committee, Canadian Astronomical Society (CASCA)

Jan. 2023 ***Speed* Mentor**, Women in Science-Technology-Engineering-Mathematics (STEM), *Assumption College School*, Brantford, Ontario

Jul. 2022 **Speaker** (virtual), Mini-University 2022 (an Indigenous student initiative), *The University of Western Ontario*, London, Ontario

Jun. 2021 **Activity Facilitator**, AstroComm2021 Workshop (virtual), Centre for Research in Astrophysics of Québec (CRAQ), *McGill University*, Montréal, Québec

Jun. 2020-May 2021 **Education and Public Outreach Representative**, Graduate Student Committee and Education and Public Outreach Committee, CASCA

Feb. 2019-Feb. 2020 **Co-Organizer**, Girls and Women in Space Night, *The University of Western Ontario*, London, Ontario

Jan. 2018-May 2019 **Lead Organizing Committee Member for Astronomy**, Science Rendezvous, *The University of Western Ontario*, London, Ontario

May 2017-May 2019 **Telescope Operator**, Science Rendezvous, *The University of Western Ontario*, London, Ontario

Feb. 2018-Aug. 2018 **Activity Facilitator**, Space Explorers Program (Summer Camp and Academy), Institute for Earth and Space Exploration, *The University of Western Ontario*, London, Ontario

May 2016-Aug. 2018 **Speaker, Telescope Operator, and Crowd Manager**, The Hume Cronyn Memorial Observatory Summer Public Nights, *The University of Western Ontario*, London, Ontario

May 2016 **Member of the Local Organizing Committee**, Great Lakes Quasar Symposium, *The University of Western Ontario*, London, Ontario

Jul. 2015 **Activity Facilitator**, Astronomy Teachers' Workshop, *York University*, Toronto, Ontario

May 2014-Apr. 2015 **Planetarium Operator and Presenter**, AstroTours and AstroKeynote Events, *University of Toronto*, Toronto, Ontario

Jan. 2015 **Event Coordinator**, Astronomy & Space Exploration Society Symposium, *University of Toronto*, Toronto, Ontario

Sept. 2011-Sept. 2013 **Outreach Assistant and Event Coordinator**, Accessibility Services, *University of Toronto Mississauga*, Mississauga, Ontario

Selected Presentations

Conference Presentations

Jan. 2023 **Oral (Dissertation Talk)**, "Probing the Inner Structure of Active Galactic Nuclei Through Reverberation Mapping", 241$^{\text{st}}$ American Astronomical Society (AAS) Meeting, Seattle, Washington

Nov. 2022 **Oral**, "CASTOR: The First Canadian Flagship Space Astronomy Mission", Space as a National Asset for Canada, *The University of Western Ontario*, London, Ontario

Jul. 2022 **Poster**, "Tracing Gas Flows in a Highly Accreting Active Galactic Nucleus, Markarian 142", Gemini Science Meeting (virtual), *Gemini Observatory*, Seoul, Republic of Korea

Jun. 2022 **Poster**, "How To Design Large-scale Active Galactic Nuclei Variability Surveys", Canadian Space Exploration Workshop (virtual), *CSA*, Montréal, Québec

May 2022 **Oral**, "Probing Structure of Gas Flows in a Highly Accreting Active Galactic Nucleus, Markarian 142", CASCA Annual General Meeting (virtual), *University of Waterloo*, Waterloo, Ontario

May 2021 **Oral**, "Mapping Gas Motions in a Highly Accreting Active Galactic Nucleus Markarian 142", Zooming In on Compact Objects 2021 (virtual), *Wayne State University*, Detroit, Michigan

May 2020 **iPoster**, "Tracing Accretion Flow in the Highly Accreting Active Galactic Nucleus, Markarian 142", CASCA Annual General Meeting (virtual), *York University*, Toronto, Ontario

Nov. 2019 **Oral**, "Experiencing Gemini...*from the perspectives of a user and an intern*", NTCO Annual General Meeting, *Dominion Radio Astrophysical Observatory (DRAO)*, Kaleden, British Columbia

Sept. 2019 **Oral**, "Weighing 1000 Supermassive Black Holes with CASTOR", Mapping Central Regions of Active Galactic Nuclei, *Institute of High Energy Physics*, Guilin, China

Feb. 2019 **Oral**, "Mapping the Inner Parsec of Quasars", Massively Multiplexed Spectroscopy with Maunakea Spectroscopic Explorer, Tucson, Arizona

Feb. 2018 **Poster**, "How can we probe the Physics of Energetic Quasar Outflows?", Women in Planetary Science and Exploration, *University of Toronto*, Toronto, Ontario

Jun. 2017 **Poster**, "X-ray Insights into Mini Low-Ionization Broad Absorption Line Quasars", AGN Winds on the Georgia Coast, *Georgia State University*, Jekyll Island, Georgia

Jan. 2017 **Poster**, "Rare He I* Transition traces Thick Gas Outflows in Quasars", Fallona Family Interdisciplinary Showcase, *The University of Western Ontario*, London, Ontario

Invited Talks

Apr. 2023 "Mapping the Interiors of Gigantic Black Hole Systems", Astrophysical Sciences and Technology, *Rochester Institute of Technology*, Rochester, New York

Mar. 2023 "Light Echoes in Gigantic Black Holes Narrate the Story of Black Hole Growth", Physics and Astronomy Colloquium, *McMaster University*, Hamilton, Ontario

Sept. 2022 "UV Time Lag for Hβ Emission in a Highly Accreting AGN, Markarian 142", Dominion Astrophysical Observatory Colloquium, *National Research Council Canada's Herzberg Astronomy and Astrophysics Research Centre*, Victoria, British Columbia

Apr. 2021 "Face of the Next-Generation Astronomy Facilities", Lunch and Learn, *Teledyne FLIR*, Richmond, British Columbia

Jul. 2019 "Weighing 1000 Supermassive Black Holes with CASTOR", Special Science Coffee, *Gemini Observatory*, Hilo, Hawai'i

Sept. 2018 "The Supermassive Black Hole Show - *a thriller performance in the densest environments of the universe*", Royal Astronomical Society of Canada London Centre Monthly Meeting, *The University of Western Ontario*, London, Ontario

Other Presentations

May 2023 **Oral**, "Role of *CASTOR* in Active Galactic Nuclei Science", CASTOR Phase 0 Final Review Meeting, *CSA*, Montréal, Québec

Apr. 2021 **Oral**, "Barcode Scanner for Accessory Counting", *Teledyne FLIR*, Richmond, British Columbia

Jan. 2020 **Oral**, "How can Internships Enhance Graduate Learning Experience?", Western Space Research Forum, *The University of Western Ontario*, London, Ontario

Aug. 2019 **Oral**, "GNIRS Cross-dispersion Python-based Pipeline (GNIRS-Pype)", Special Science Seminar, *Gemini Observatory*, Hilo, Hawai'i

Mar. 2019 **Oral**, "What can CASTOR do for Active Galactic Nuclei?", CASTOR Final Review Meeting, *CSA*, Montréal, Québec

Research Supervision and Mentorship

Sept. 2022-
Dec. 2022 **Sana Momin** (Physics and Astronomy)
Undergraduate Co-op Student

May 2022-
Aug. 2022 **William Yuan** (Medical Sciences)
Undergraduate Summer Student

Sept. 2020-
Jun. 2021 **Amelia West**
Grade 12 Student

Sept. 2020-
Apr. 2021 **David MacLean** (Computer Science)
Undergraduate Thesis Student

Sept. 2020-
Apr. 2021 **Amir Yalamov** (Computer Science)
Undergraduate Thesis Student

Jan. 2019-
Dec. 2019 **Sofia Pasquini** (Physics and Astronomy)
Undergraduate Student

Languages

Computing Languages

Python, IRAF, Sherpa, PrepSpec, Python-based Running Optimal Average (PyROA), Git, bash, LaTeX, FORTRAN, Aperture Photometry Tool (APT)

Spoken Languages

Marathi (native), English (fluent), Hindi (fluent)

Selected Professional Training

Astronomy and Data Science Training

Sept. 2021 **Using Python and Astropy for Astronomical Data Analysis**, *AAS*, Seattle, Washington

Aug. 2020 **Rubin Observatory Project and Community Workshop** (virtual), *Vera C. Rubin Observatory*, Cerro Pachón, Chile

Jul. 2018 **Introduction to Astronomical Instrumentation**, Dunlap Institute, *University of Toronto*, Toronto, Ontario

Jun. 2018 **Large Scale Astrophysics: galaxies and beyond**, CRAQ, *McGill University*, Montréal, Québec

Aug. 2017 **La Serena School for Data Science**, *AURA*, La Serena, Chile

Jul. 2017 **Compute Ontario Summer School on Scientific and High Performance Computing**, SciNet, *University of Toronto*, Toronto, Ontario

Oct. 2016 **Data Carpentry Workshop**, SHARCNET, *The University of Western Ontario*, London, Ontario

Educational Training

Sept. 2015-Aug. 2022 **Western Certificate in University Teaching and Learning** (in-person and virtual), *The University of Western Ontario*, London, Ontario

Aug. 2020 **Space Educators Institute** (virtual), *The University of Western Ontario*, London, Ontario

Feb. 2020 **Fostering a Problem-Solving Mindset in Your STEM Students**, Centre for Teaching and Learning, *The University of Western Ontario*, London, Ontario

Sept. 2017-Dec. 2017 **Teaching Mentor Program**, Centre for Teaching and Learning, *The University of Western Ontario*, London, Ontario

Oct. 2017-Nov. 2017 **Advanced Teaching Program**, Centre for Teaching and Learning, *The University of Western Ontario*, London, Ontario

Nov. 2016 **Threshold Concepts: Teaching Troublesome Knowledge in the Disciplines**, Centre for Teaching and Learning, *The University of Western Ontario*, London, Ontario

Professional Membership

Sept. 2022-Present AAS

Sept. 2015-Present CASCA

Sept. 2022-Aug. 2023 The International Society for Optics and Photonics (SPIE)

Apr. 2021-Aug. 2022 Student Representative, Program Committee, NTCO