



2024 Annual Report



Trotter
Space Institute
at McGill

Institut spatial
Trotter
de McGill

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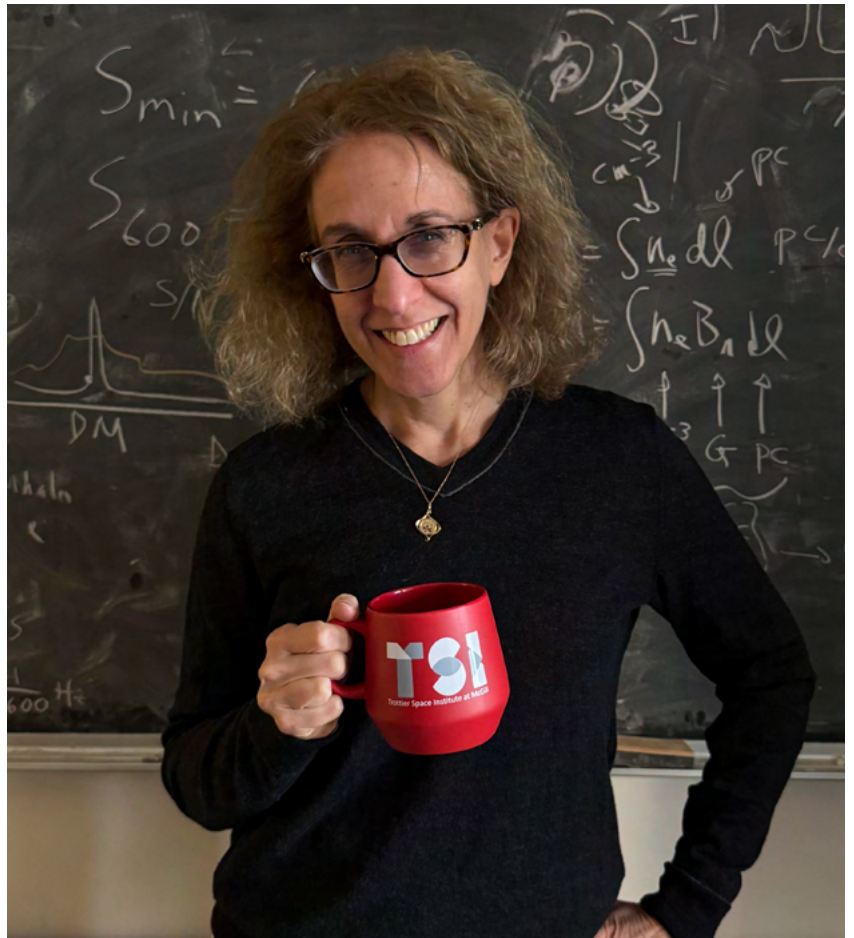
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| DIRECTOR'S WELCOME

Our Trottier Space Institute, now in its second year with its new name, is in full swing. A fly on the wall visiting our beloved 3550 University space would see and hear the sounds of interactions on a myriad of different space-related topics, from the latest on supermassive black holes to what's new in cosmology, to the likelihood of detecting biosignatures from extrasolar planets, to astrophysical transients, all the way to discussions on what is new in our understanding of our own planet's atmosphere. These interactions take on many forms, from weekly seminars by and esteemed guest to group discussions over coffee, to impromptu blackboard debates and conference-room group meetings – all supported and encouraged by generous resources from the Trottier Family Foundation, and from the wide variety of research funds that our faculty are awarded.

As Director, my paramount goal in ensuring TSI has maximum research and training impact is fostering an environment of mutual respect and appreciation of the importance of listening to and considering many different perspectives. Science progresses best when ideas are expressed freely – when even the most junior students feel comfortable engaging and asking questions and challenging norms. Sometimes the simplest questions are the toughest to answer, and learning to nurture dialog and train the next generation of scientific thought leaders – particularly in an interesting time when AI is on the rise – is, in my opinion, key to ensuring a bright scientific future. And the future is what TSI is all about today.

Indeed the TSI future is arriving now. We are on the cusp of a major expansion of our “space shack,” again thanks to the generosity of the Trottier Family Foundation. In Summer of 2025 we will witness the ground-breaking for our new TSI annex building, behind 3550 and adjacent to the Rutherford building, a project that will see a new, modern five-floor building appear in our backyard over the next 18 months. This building will give us even more space to interact, with multiple conference rooms, many new offices, and interesting nooks to encourage creativity and thought. Though growing pains will surely be part of the process, we are very fortunate to have this opportunity and I am committed to ensuring business as usual within 3550 continues unabated throughout the construction period. I'm looking forward to sharing with all TSI members this exciting upcoming adventure -- the sky is the limit!



| ABOUT TSI

The Trottier Space Institute at McGill (TSI) is an interdisciplinary research centre that brings together researchers engaged in astrophysics, planetary science, atmospheric science, astrobiology and other space-related research at McGill University. We have a vibrant and interactive community of over 120 researchers at all levels, including faculty members, postdoctoral researchers, graduate students, and undergraduate students. TSI was established in 2015 thanks to a generous gift from the Trottier Family Foundation.

The main goals of the Institute are to:

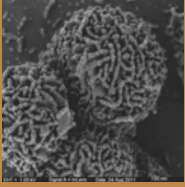
- Provide an intellectual home for faculty, research staff, and students engaged in astrophysics, planetary science, and other space-related research at McGill
- Support the development of technology and instrumentation for space-related research
- Foster cross-fertilization and interdisciplinary interactions and collaborations among Institute members in Institute-relevant research areas.
- Share with students, educators, and the public an understanding of and an appreciation for the goals, techniques and results of the Institute's research.

The intellectual hub of the Institute is at 3550 University, where many of the Institute members work, collaborate with visitors, and Institute events are held.



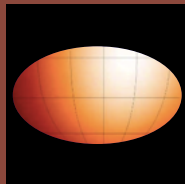
TSI RESEARCH AREAS

Astrobiology & Extraterrestrial Biosignatures • *Nicolas Cowan, Nagissa Mahmoudi, Lyle Whyte*



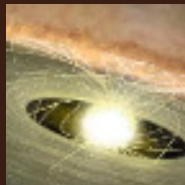
The Astrobiology and Extraterrestrial Biosignatures group examines microbial biodiversity and ecology in unique ecosystems like the Canadian High Arctic and the Antarctic dry valleys, studying microbial communities using classical microbiology and novel genomics-based molecular techniques. Understanding what types of microorganisms survive in these types of soils and detecting biosignatures provides insight into what to look for in near surface water ice on Mars or other cold, rocky places in the solar system. Members of the group also use cutting-edge telescopes to establish the habitability of nearby temperate terrestrial exoplanets and to search their atmospheres for signs of life.

Climates and Atmospheres of Exoplanets • *Nicolas Cowan, Andrew Cumming, Yi Huang*



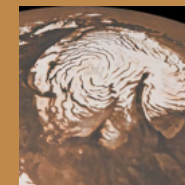
The extrasolar planet climate and atmosphere group characterizes exoplanets using observational evidence and climate modelling. Observational evidence for exoplanetary atmospheres comes from a variety of sources, including changes in brightness of the planet over time, spectroscopy, and upcoming next-generation direct-imaging experiments. Members also use computer models to expose the physical mechanisms of planet atmospheres by expanding climate models beyond the conditions found on Earth, to simulate the wide range of possibilities of atmospheres on exoplanets. Much of this work is carried out as part of the Institute for Research on Exoplanets (iREx).

Formation and Evolution of Stars and Planets • *Andrew Cumming, Eve Lee*



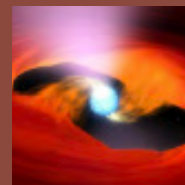
The quantity and diversity of known exoplanets provides an opportunity to learn about planetary formation, evolution, and the physical processes that operate in their atmosphere and interiors. The challenge is to connect observed properties of planets with theories of their formation, structure, and evolution. The group uses theoretical tools to identify the key physical processes behind the observed diversity of planetary systems, from super-Earths to gas giants. They study the earliest evolution of star-forming environments, protoplanetary disk evolution, disk-star-planet interaction, formation of planetary atmospheres, and dynamical interactions within planetary systems.

Planetary Surfaces • *Natalya Gomez*



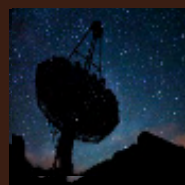
Members of the planetary surface group, led by Natalya Gomez, research models of the interactions between ice, water, climate and planetary interiors, and how these connections change planets' surfaces through time. These models are applicable to both the Earth and other rocky, icy planets and moons in the Solar System.

Nuclear Astrophysics • *Andrew Cumming*



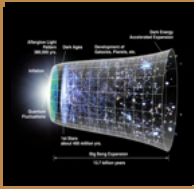
Nuclear astrophysics is the study of the origin of the chemical elements in stars and supernovae, explosive events such as supernovae, classical novae, and X-ray bursts, and the properties of matter at high densities as found in the interiors of neutron stars. We focus on developing connections between nuclear properties and astrophysical observations through the study of neutron stars, in particular by modelling the transient behaviour of accreting neutron stars on timescales of seconds to years. McGill is an Associate Member of the Joint Institute for Nuclear Astrophysics - Centre for Evolution of the Elements (JINA/CEE).

Experimental Particle Astrophysics • *David Hanna, Ken Ragan*



The Gamma Ray Astrophysics group is part of the VERITAS collaboration, which operates an array of four 12-m imaging atmospheric Cherenkov telescopes in southern Arizona. They carry out a program of very-high-energy (VHE) gamma-ray astronomy, observing photons with energy in the range from 50 GeV to 50 TeV. Sources of such photons are among the most violent and exotic in the Universe and include supernova remnants and pulsar wind nebulae in our galaxy, as well as blazar-class active galactic nuclei (AGNs) at cosmological distances. They also develop instrumentation for the VERITAS detector including calibration and characterization devices.

Early Universe and Theoretical Cosmology • *Robert Brandenberger, Jim Cline, Katelin Schutz*



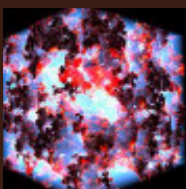
The theoretical cosmology group works to explain the history of the very early Universe and to provide an explanation of the large scale structure in the Universe. They create models using input from new fundamental physics such as superstring theory, dark matter particle theories, and particle physics beyond the standard model. They also explore ways to test these new models with cutting-edge observations of the cosmic microwave background, large-scale structure, the neutral hydrogen 21-cm line, cosmic rays, and data from the Large Hadron Collider.

Experimental and Observational Cosmology • *Cynthia Chiang, Matt Dobbs, Adrian Liu, Jonathan Sievers*



The McGill Experimental Cosmology group designs and builds new instrumentation for observational cosmology and develops analysis techniques for upcoming large cosmological surveys, including surveys of the cosmic microwave background and the 21 cm line of neutral hydrogen. They deploy and operate instruments wherever the observing conditions are best — from the geographic South Pole to the top of the stratosphere to the South African desert, as well as analyze and interpret the data from these experiments to gain a better understanding of the origin, fate, and fundamental constituents of the Universe.

Low Frequency Cosmology • *Cynthia Chiang, Adrian Liu, Jon Sievers*



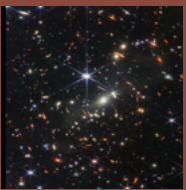
The low-frequency radio sky represents a new frontier in observational astrophysics and cosmology. This regime is a largely unobserved band of the electromagnetic spectrum, and holds the promise of revealing new astrophysical phenomenology. Our 21cm cosmology telescopes (ALBATROS, HERA, MIST, PRISM) targeting this band have the potential to provide the first observations of a poorly understood portion of the cosmic timeline: Cosmic Dawn, when the first stars and galaxies lit up our Universe, and the Epoch of Reionization, when they dramatically transformed our Universe by ionizing almost all the hydrogen in the intergalactic medium.

Compact Objects • *Andrew Cumming, Daryl Haggard, Vicky Kaspi*



The compact object group studies white dwarfs, pulsars and other highly magnetized neutron stars, and stellar-mass black holes. The observational pulsar group's work includes searches for radio pulsars, pulsar timing, and X-ray observations of energetic pulsars and magnetars. The multi-messenger group identifies and characterizes kilonova and other electromagnetic counterparts to gravitational wave sources. The theory group studies neutron stars' structure and how to use observations to constrain the physical processes operating in their interiors. They also investigate the origin and evolution of neutron stars' spin and magnetism and the properties of neutron stars in close binary systems.

Galaxy Evolution, Active Galactic Nuclei • *Daryl Haggard, Tracy Webb*



The galaxy evolution group is interested in understanding when galaxies form the bulk of their stellar mass; what drives and later shuts down this process; how the local environment of galaxies affect their evolution and growth; and how growing supermassive black holes (AGN) interact with their host galaxies and within galaxy clusters. We also study our own supermassive black hole, SgrA*, and its interactions with the Milky Way galaxy.

Radio Transients • *Matt Dobbs, Vicky Kaspi, Jon Sievers*



The radio transients group studies short-duration flashes of radio waves from new and unexpected astrophysical phenomena. Their most active area of research is in Fast Radio Bursts (FRBs), mysterious, powerful, millisecond-long flashes of radio waves that originate outside of the Milky Way galaxy. To study these phenomena, the group uses several world-class radio observatories, particularly the CHIME telescope located in Penticton, British Columbia.

Supermassive Black Holes • *Daryl Haggard, Tracy Webb*



Our studies of supermassive black holes span from their large scale environments to photons circling at the edge of the event horizon. The supermassive black hole group is a part of the Event Horizon Telescope Collaboration and the LISA Consortium, along with several international teams that coordinate multi-wavelength (and soon multi-messenger) programs to characterize these systems and probe fundamental questions including: is general relativity valid in the strong-gravity regime? How are jets launched? What physics governs accretion flows near the event horizon?

02

RESEARCH HIGHLIGHTS

- **CHIME Studies the Nature of Fast Radio Bursts Polarized Light from Over 100 Discoveries**
- **Seeing the Dark Side of an Ultra-Hot Jupiter from Earth**
- **Can Carbon Dioxide Increase Earth's Thermal Radiation?**
- **The First Mid-Infrared Detection of a Flare from Sagittarius A* with JWST**
- **Isolating Sound Wave Fossils in our Universe's History**
- **Measuring Cosmic Dawn on Arctic Soil**
- **A Multi-Wavelength Study to Decipher the 2017 Flare of the Blazar OJ 287**
- **A Hidden Cosmic Background of Millicharged Particles Could Soon Be Revealed**

CHIME Studies the Nature of Fast Radio Bursts Polarized Light from Over 100 Discoveries

Contributing author: Ayush Pandhi obtained his PhD from University of Toronto and is an incoming postdoctoral fellow at TSI. The CHIME/FRB Collaboration is led by McGill and involves nearly two dozen TSI undergraduates, graduate students, postdocs and staff, led by TSI Professors Vicky Kaspi and Matt Dobbs.

Fast radio bursts (FRBs) are extremely energetic explosions of radio light originating from other galaxies millions or billions of light years away. In less than a thousandth of a second, FRBs release millions of times more energy than the meteor that struck Earth and led to the extinction of the dinosaurs. While astronomers have some idea of the type of objects that have enough energy to produce FRBs, the specifics of how they are made are still a mystery. We observe FRBs using radio telescopes, among which the Canadian Hydrogen Intensity Mapping Experiment (CHIME), located in Penticton, British Columbia, is the preeminent FRB finder in the world.

The light we see from FRBs is often linearly polarized -- most if not all of the light waves oscillate in the same direction. When these light waves pass through clouds of charged particles (e.g., electrons) or through magnetic fields, their angle of oscillation becomes twisted. The more charged particles they pass by or the stronger the magnetic fields, the more twisted that light becomes. By studying this twisting of the polarized FRB light, we can figure out how dense and magnetized their environments and host galaxies are, providing information about where and how FRBs are produced.

In a recent paper published by The Astrophysical Journal, we characterized the properties of polarized light coming from 128 non-repeating FRBs (FRBs that have gone off only once). This is by far the largest study of its kind, more than tripling the number of known polarized FRB sources to date. We observed a large diversity in the degree of polarization in FRB sources. By studying how twisted their polarized light is, we found that most of these FRBs appear to originate from galaxies similar to our own Milky Way. However, repeating FRBs (sources which have produced more than one FRB) might originate from environments with stronger magnetic fields than non-repeating sources, which may suggest that the two types of FRBs are created in different settings or by different objects.

Radio pulsars in our own Galaxy produce similar pulses of radio light (though they are much less energetic than FRBs), which we observe

periodically as they rotate once every few seconds or less. We compared the polarized light from FRBs to that from pulsars and found that they are different, suggesting that FRBs are likely not produced by the same mechanism. This goes to show that FRBs are unlike anything else we've seen in the Universe.

This study pushes us one step closer to understanding what FRBs are and where they come from. CHIME continues to find FRBs every single day, and soon we will be able to extend our research to thousands of FRBs.

Citation: Pandhi, A. et al.. (2024). Polarization properties of 128 nonrepeating fast radio bursts from the first CHIME/FRB baseband catalog. The Astrophysical Journal, 968(2), 50.

Why this matters

This study provides the first large-scale analysis of the polarization properties of 128 nonrepeating fast radio bursts (FRBs) using high-resolution data from the CHIME/FRB baseband catalog. These findings reveal diverse polarization behaviours that offer new clues about the origins and mechanisms of FRBs.



Night time view of CHIME telescope with artist's concept of rotating polarization vector from an FRB source. (credit: Dunlap Institute, original picture by Andre Renard)

Seeing the Dark Side of an Ultra-Hot Jupiter from Earth

Contributing author: Georgia Mraz is a second-year PhD student in the McGill Physics Department and TSI working with Nicolas Cowan. She holds a BSc in Physics from Union College and an MSc in Astronomy and Astrophysics from the University of Amsterdam. Her research focuses on the atmospheric dynamics of giant planets that orbit close to their host stars. Using high-resolution ground-based spectrographs, such as SPIRou on the Canada-France-Hawaii Telescope and the European Southern Observatory's NIRPS, she studies how these planets redistribute heat, interact with their host stars, and evolve over time.

Ultra-hot Jupiters are giant planets the size of Jupiter that orbit their stars extremely closely—completing a full orbit in less than two days. Because they are so close to their stars, they experience intense gravitational forces that cause them to be tidally locked. This means that one side of the planet always faces the star (the “dayside”), while the other side remains in permanent darkness (the “nightside”).

The dayside gets bombarded with intense radiation, making it incredibly hot, sometimes more than 1000 degrees hotter than the nightside. This extreme temperature difference changes the planet’s atmosphere. The hot side has a temperature inversion, where temperature increases as you move higher in the atmosphere. In contrast, the cooler nightside follows the expected pattern—temperature decreases with altitude.

We can study these differences using spectroscopy, which analyzes how a planet’s atmosphere absorbs and emits light. A temperature inversion on the dayside produces emission lines, while the nightside shows absorption features. Until recently, detecting these features was only possible with expensive space telescopes that required days of observations.

We observed the ultra-hot Jupiter WASP-33b with SPIRou on five different occasions: three just before it transited in front of its star and two afterward. These timings allowed us to capture infrared light from the planet’s nightside using ground-based telescopes, something that was previously thought to be impossible.

Our observations revealed the presence of carbon monoxide (CO) as an absorption feature, confirming that it originates from the

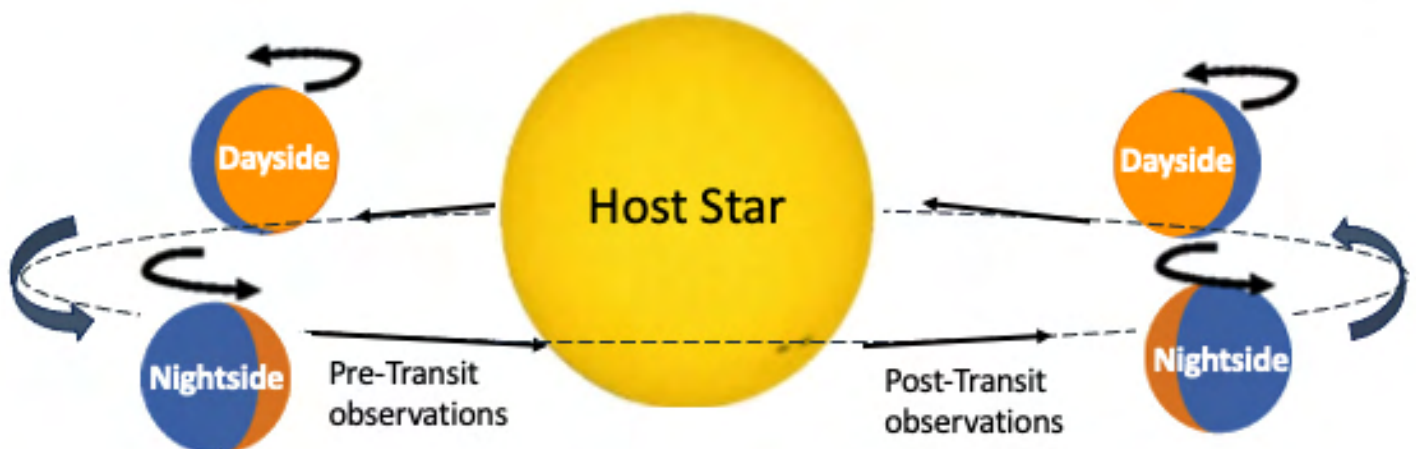
planet’s nightside atmosphere. Notably, this marks the first definitive detection of a planet’s nightside from the ground, demonstrating that high-resolution spectroscopy can effectively characterize exoplanet atmospheres without relying solely on space-based observatories.

Additionally, this detection brings us one step closer to achieving a fully ground-based phase curve, which allows us to track atmospheric changes across an exoplanet’s entire orbit. A high-resolution phase curve provides more detailed information than the low-resolution phase curves obtained with space-based instruments, offering deeper insights into atmospheric dynamics, temperature variations, and chemical composition. Furthermore, this method can be applied to future observations with next-generation telescopes, such as the Extremely Large Telescope, which is expected to begin operations in the early 2030s.

Citation: Mraz, G., Darveau-Bernier, A., Boucher, A., Cowan, N. B., Lafrenière, D., & Cadieux, C. (2024). Out of the Darkness: High-resolution detection of CO absorption on the nightside of WASP-33b. *ApJL*, 975(2), L42.

Why this matters

This is the first definitive detection of a planet’s nightside from the ground, bringing us closer to achieving a fully ground-based, high-resolution phase curve. A ground-based phase curve could provide more detailed insights into atmospheric dynamics, temperature variations, and chemical composition across an exoplanet’s entire orbit than the low-resolution curves obtained from space-based instruments.



Can Carbon Dioxide Increase Earth's Thermal Radiation?

Contributing author: Yan-Ting Chen is a PhD candidate in the Department of Atmospheric and Oceanic Sciences at McGill University, supervised by Prof. Yi Huang. His research delves into the intersection of radiation and climate change

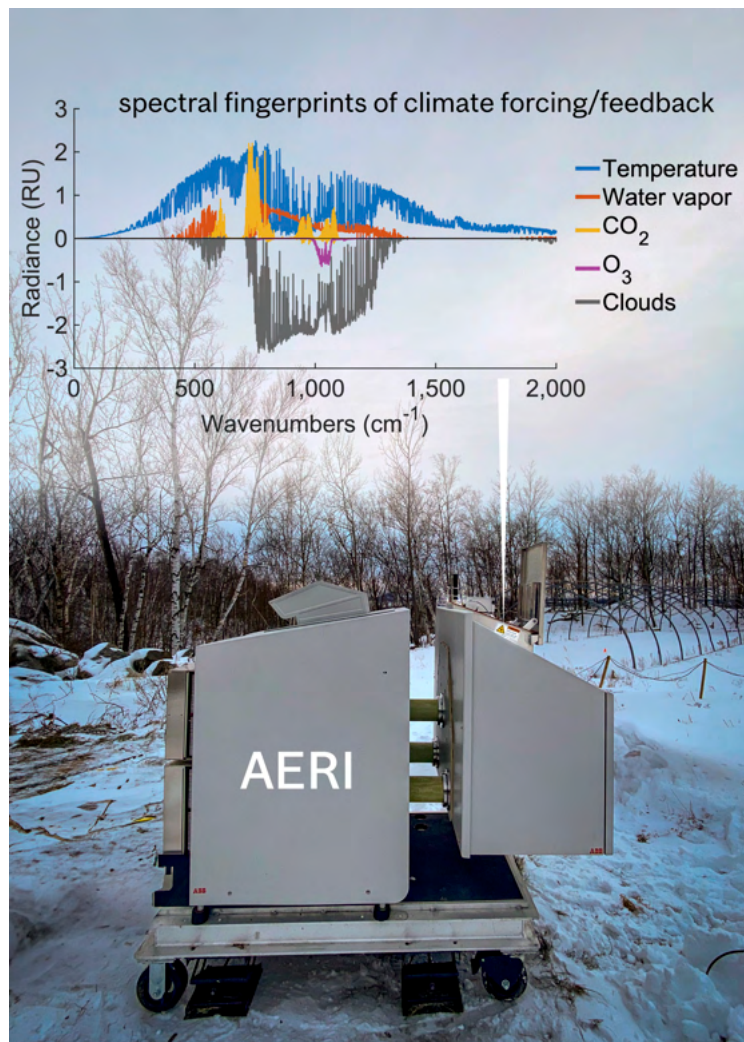
Earth's surface is heated not only by sunlight but also by invisible infrared radiation emitted from the atmosphere back to the ground—a process called downwelling longwave radiation. This radiation acts like a thermal blanket, primarily influenced by greenhouse gases, air temperature, and clouds. While rising CO₂ concentrations and warmer temperatures are known to amplify downwelling longwave radiation (and thus surface warming), the role of clouds has remained unclear.

Under global warming, multiple atmospheric factors – including air temperature, greenhouse gases, and clouds – shift simultaneously, complicating efforts to pinpoint their individual effects on downwelling longwave radiation. To solve this, we analyzed decades of detailed spectral downwelling longwave radiance (DLR) measurements from the Southern Great Plains (SGP) observatory in the U.S. These data revealed long-term trends in DLR and its role in the surface energy budget.

Using a novel spectral fingerprinting method developed for this study, we quantified how specific factors — air temperature, carbon dioxide, water vapor, ozone, and clouds — contribute to changes in DLR. The results exposed a striking discovery: clouds over land reduce the amount of downwelling longwave radiation reaching the surface, partially counteracting warming from rising temperatures and greenhouse gases. This negative surface longwave cloud feedback is primarily induced by decreasing low cloud cover.

Further analysis confirmed this effect is not unique to the SGP site. Satellite observations and global climate datasets show similar patterns over continents, where declining low cloud cover reduce the downwelling longwave radiation under global warming. While this negative feedback slightly tempers land surface warming, it does not negate the broader impacts of global warming. Our results highlight the surprising role of clouds in modulating Earth's energy balance and underscore the importance of long-term, spectrally detailed observations of Earth's radiation for understanding climate impacts.

Citations: 1) Liu, L., Huang Y., & Gyakum R.J. (2025). Clouds reduce downwelling longwave radiation over land in a warming climate. *Nature*, 637, 868–874. 2) Liu, L., Huang, Y., Gyakum, R.J., Turner, D.D., & Gero, P.J. (2022). Trends in downwelling longwave radiance over the Southern Great Plains. *Journal of Geophysical Research: Atmospheres*, 127, e2021JD035949.



Credit: Lei Liu, adapted from Fig. 1d in Liu et al. (2025)

Why this matters

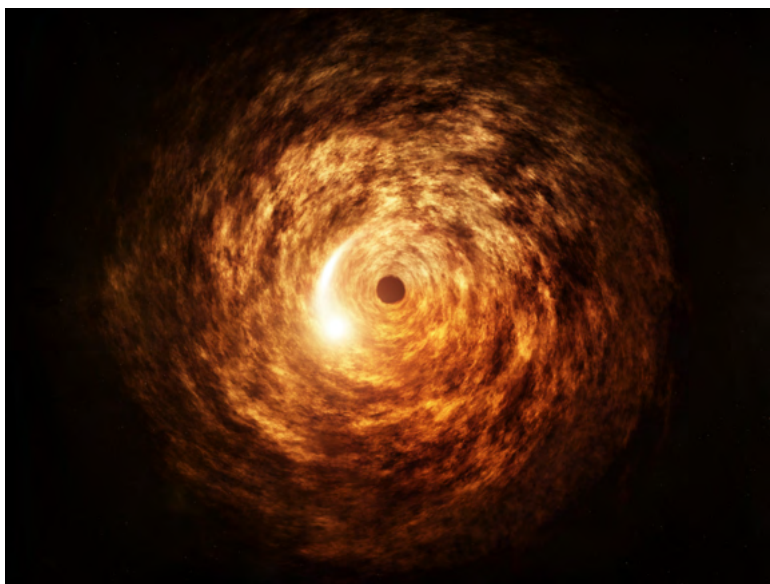
As the climate system adjusts to global warming, its responses unfold in complex and interconnected ways. Our research uncovers a surprising mechanism: decreases in cloud cover over land reduce the longwave radiation emitted back to the surface, effectively acting as a natural brake on surface warming.

The First Mid-Infrared Detection of a Flare from Sagittarius A* with JWST

Contributing authors: Prof. Daryl Haggard is an Associate Professor of Physics at McGill University and the TSI and holds a CRC in Multi-messenger Astrophysics and NSERC's Arthur B. McDonald Fellowship. She leads the McGill Extreme Gravity and Accretion (MEGA) research group. Nicole Ford is a PhD student in the Physics Department and TSI studying supermassive black holes across the electromagnetic spectrum; she is also a member of the Event Horizon Telescope (EHT) collaboration. Zach Sumners is a Masters student in the Physics Department and TSI investigating how recent advances in generative machine learning may contribute to making more precise detections of Sagittarius A* flares and improving our understanding of the Galactic Center.

Sagittarius A* (Sgr A*), the supermassive black hole at the center of the Milky Way Galaxy, is the closest massive black hole to Earth and offers one of the best laboratories to study what happens to mass and light in an extreme gravity environment. Sgr A* exhibits hours-long flares that have been observed across a wide range of the electromagnetic spectrum including in X-ray, radio, far-infrared and near-infrared. The exact origin of these flares is unknown; to truly understand the flare emission mechanism, scientists must track how the flares behave at different wavelengths of light and compare the observations with simulated models.

In April 2024, a team of international scientists, including TSI members Professor Daryl Haggard and graduate students Nicole Ford and Zach Sumners, collected simultaneous observations of Sgr A* with sub-millimeter, mid-infrared (MIR), and X-ray telescopes. Previously, no telescopes had been able to see Sgr A* flaring in mid-infrared light due to the Earth's atmosphere blocking the light and the unusually crowded Galactic Center environment. Using the new James Webb Space Telescope (JWST), the team looked for changes in Sgr A*'s mid-infrared emission over the course of several days. They detected an hour-long flare with JWST and found that the flare behaved differently depending on exactly which wavelength of MIR light they looked at. They also saw a flare appear slightly later in lower energy sub-millimeter light (using the Submillimeter Array), but no flare in higher energy X-rays (using the Chandra and NuSTAR telescopes).



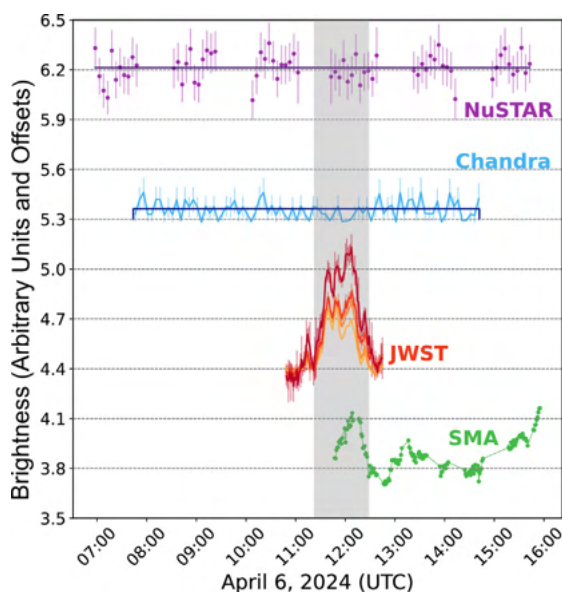
Left: Artist's conception of the MIR flare in Sgr A*, capturing a bright hotspot orbiting the central black hole. The emission seen in the flare intensifies as energized electrons travel at close to the speed of light along twisted magnetic field lines in the hotspot (credit: CFA/Mel Weiss) Right: Light curves tracking Sgr A*'s brightness over time at different wavelengths on 2024 April 6. From bottom, the green is the Submillimeter Array, the superposed yellow to red curves show different JWST MIR wavelengths, blue is Chandra, purple curve is NuSTAR. The gray region highlights the MIR flare interval seen by JWST. (credit: von Fellenberg et al 2025)

Why this matters

This first-ever detection of a mid-infrared flare from Sgr A provides a crucial missing link in the electromagnetic coverage of the black hole at the center of the Milky Way. It shows unambiguously that the flares are detectable across the mid-infrared regime, and points to very strong magnetic fields as an important driver for the flare emission.*

The team's simulated models suggest that this flare could originate from magnetic fields becoming tightly twisted, causing material to collect in "hotspots" near the black hole where it is squeezed and then rapidly ejected – similar to the solar flares that cause aurora on Earth. The discovery of a mid-infrared flare forms a valuable bridge between the lower and higher energy light emitted by Sgr A*, providing a fuller picture of the black hole's emission behavior and underlying physical mechanism driving flares. These new data and modeling constraints are useful to theorists studying how black holes impact their surroundings and also proves the unique capabilities of JWST for studying black holes in the infrared!

Citation: von Fellenberg, S.D., Roychowdhury, T., Michail, J.M., et al.: First Mid-infrared Detection and Modeling of a Flare from Sgr A*, *The Astrophysical Journal Letters*, 979, L20, January 20 2025



Isolating Sound Wave Fossils in our Universe's History

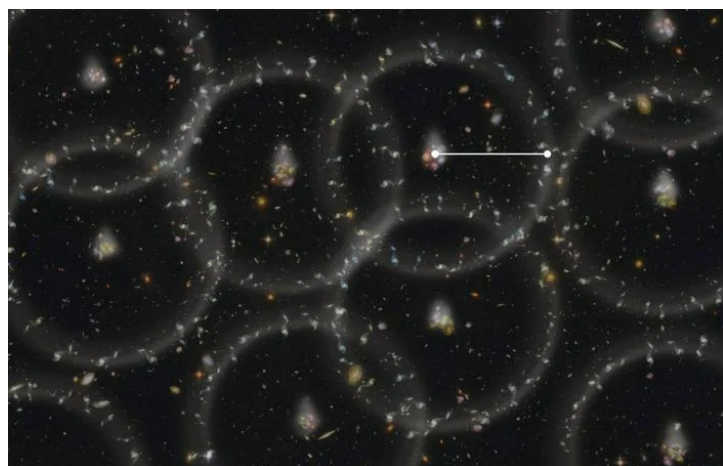
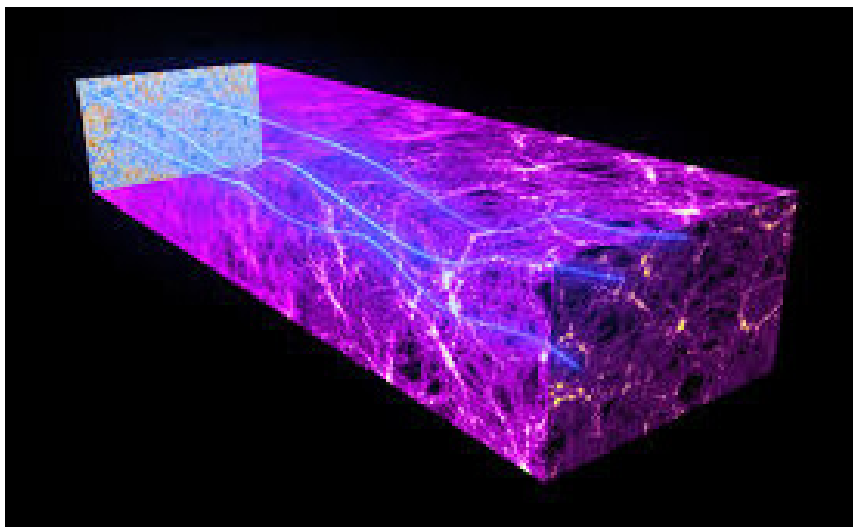
Contributing authors: Prof. Adrian Liu is an Associate Professor in the Department of Physics and a William Dawson Scholar. Hannah Fronenberg is an FRQNT-funded student who will receive her PhD in May 2025. In Sept. 2025 she will be a prize postdoctoral fellow at the University of Chicago's Kavli Institute for Cosmological Physics.

Try to compress a fluid, be it air or water or something else, and it will resist and push back out. The fight between your push and the backreacting pressure creates an undulating accordion-like pattern of oscillations. This is what makes a sound wave. Sound waves can arise in mundane situations, such as when someone's vocal cords push on air molecules. Or they can be created under much more dramatic circumstances, such as when our Universe's primordial soup resists gravity's attempts to pull everything together. These exotic sound waves of our early Universe are known as baryonic acoustic oscillations (BAOs).

In a dusty room, sound waves can push particles around and dictate where the dust eventually settles. Analogously, BAO sound waves imprint themselves in the spatial distribution of galaxies, since it is out of our Universe's primordial soup that galaxies form. This signature of BAOs therefore serves as a fossil record of our early Universe, teaching us about how our Universe came to be.

BAO fossils have been previously studied in the early Universe (400,000 years after the Big Bang) and in today's universe (roughly 14 billion years later). In a paper published in *Physical Review Letters*, PhD student Hannah Fronenberg and TSI Prof. Adrian Liu showed that BAO fossils can also be isolated at any instant along our cosmic timeline, from 300 million years after the Big Bang to 3 billion years later. Their proposed technique relies on the gravitational lensing—the bending of light by matter—of leftover light from the Big Bang. Traditionally, such lensing measurements mix together the fossil records from all epochs of our Universe's history, muddling the signals and making the fossils impossible to identify. In their paper, Fronenberg and Liu worked with collaborators at New York University (NYU) to show that a clever combination of lensing signals allows one to zoom in on a particular time by cancelling out the fossil signals from all other time periods. As such, their technique could be used to make a detailed timeline of our Universe's geometry and expansion rate.

The key insight that enabled clean, isolated BAO measurements came from Fronenberg in a remarkable example of TSI graduate student ingenuity. In fact, Fronenberg's NYU collaborators were initially skeptical of the idea and had to be convinced that it would work! For this, Fronenberg was honoured as the winner of the Mitacs Award for Outstanding Innovation—International.



Top: As light travels from cosmological distances to our telescopes, their paths are deflected by the gravitational effects of the intervening matter. Bottom: Sound waves in the primordial universe survive as a fossil record in today's distribution of galaxies, in the form of subtle rings of extra-abundant galaxies.

Why this matters

A new technique enables the geometry and expansion rate of our Universe to be measured at any instant between 300 million years and 3 billion years after the Big Bang.

Citation: Fronenberg, Maniyar, Liu, Pullen (2024), *Physical Review Letters* 132, 241001

Measuring Cosmic Dawn on Arctic Soil

Contributing authors: Francis McGee is a PhD student at McGill Physics and TSI in Prof. Cynthia Chiang's group. He is applying cutting edge engineering research to fundamental problems in early universe astrophysics, developing open-source ground penetrating radar systems for soil characterization in the service of astronomy instrumentation development. Ian Hendricksen is a PhD student at McGill Physics and TSI working at the intersection of radio cosmology and cryospheric science. His research applies techniques developed in geophysics in order to calibrate antennas used to study some of the oldest light in the Universe.

We are searching for hints about a very early part of the Universe's history known as Cosmic Dawn, when the first stars were just beginning to appear. To learn what the universe was like during this time, about 250 to 300 million years after the Big Bang, we measure the very faint signal from the hydrogen that was abundant at that time, which emits at a wavelength of 21 cm. As the universe expands, this 21 cm radiation is stretched into longer radio waves, which we aim to detect. Because these signals are so faint, we must understand and minimize all other sources of emissions to isolate the residual light from the cosmic dawn.

To learn about this era of the universe, we have developed The Mapper of the Intergalactic Medium (IGM) Spin Temperature experiment (MIST), located at one of the most radio-quiet locations in the world: the McGill Arctic Research Station on Axel Heiberg Island in the Canadian High Arctic. But isolating the antenna alone isn't enough, because the soil beneath the antenna also acts as part of the measurement system. At the sensitivity we require, the way the soil interacts with electromagnetic fields, the intrinsic permittivity and conductivity, become vitally important. Two graduate students, Ian Hendricksen and Francis McGee, working alongside our collaborators at UC Berkeley, UCSC, NRAO, and CSIRO, are helping to characterize the complex electromagnetic soil environment in the High Arctic.

This region changes rapidly with the seasons, so we're tackling the soil characterization problem from two fronts. First, we're using the MIST antenna itself as a probe to gain a deep understanding of local soil properties. Second, we're developing an open-source ground-penetrating radar (GPR) drone to map arctic soil conditions throughout the spring season, when our measurements are taken.

Over the past year, we've successfully used the MIST antenna to study the layered structure of the soil beneath our equipment, an important step toward a successful Cosmic Dawn measurement. We've also developed a ground-based version of our GPR system and completed successful field tests. In the coming year, we're excited to launch the fully operational drone. Once airborne, this system will open new opportunities for interdisciplinary research in the Canadian North, with applications in glaciology, geology, and planetary science.

Why this matters

By combining soil science and astronomy in the Canadian High Arctic, we're using ground-penetrating radar and innovative antenna calibration techniques to measure the light from cosmic dawn, when the first stars were forming.



The MIST instrument deployed at the McGill Arctic Research Station in the Canadian Arctic (credit: Raul Monsalves).

A Multi-Wavelength Study to Decipher the 2017 Flare of the Blazar OJ 287

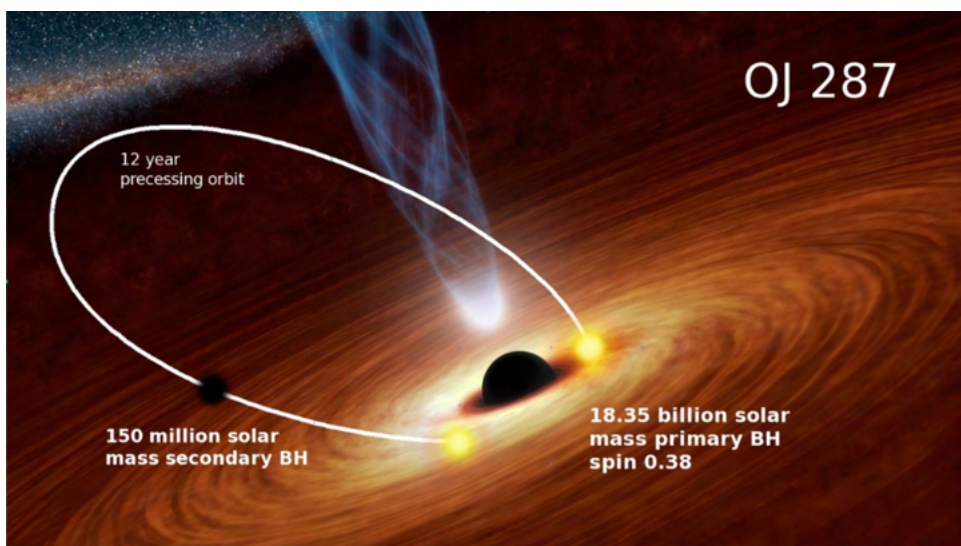
Contributing author: TSI Computing Research Fellow Dr. Stephan O'Brien, along with Prof. Ken Ragan and PhD Students Matthew Lundy and Samanta Wong, are members of the VERITAS collaboration. Dr. O'Brien led the analysis and publication of this multiwavelength study of OJ 287, in the process developing new analysis methods and techniques to bolster VERITAS' analysis tools.

For the first time, researchers have detected very high-energy (VHE) gamma rays from OJ 287, an active galaxy located millions of light-years away. OJ 287 is often referred to as the “Rosetta Stone” of active galactic nuclei (AGN) because studying its complex emissions and behavior has helped scientists test key theories about how these powerful cosmic systems work. The detection of VHE gamma rays adds a new layer of complexity to the puzzle, offering fresh challenges to scientists trying to unravel the mysteries of OJ 287.

OJ 287 has been the focus of astronomers since the 1890s. Over this long history, scientists have observed its unusual behavior, including periodic outbursts of light that occur roughly every 12 years. Various theories have been proposed to explain this unusual behaviour, such as the idea of two supermassive black holes orbiting each other at the center of the galaxy, or a twisted jet of particles spiraling out from the center. These models have proven effective at predicting the timing of outbursts with impressive precision, often to within just a few days. However, in April 2017, OJ 287 surprised researchers by producing a sudden burst of X-rays, well outside the expected 12-year cycle. This event also led to the first-ever detection of VHE gamma rays from the galaxy, thanks to a special telescope array called VERITAS (Very Energetic Radiation Imaging Telescope Array System).

When astronomers studied OJ 287 across different wavelengths of light, from optical to VHE gamma rays, they noticed some unusual patterns. For example, the X-ray emission increased dramatically, but the optical light showed only a moderate increase; meanwhile, the higher-energy gamma rays and hard X-rays remained largely unchanged. This behavior is puzzling because it challenges the usual models of how AGNs emit light across different wavelengths. A closer look at the data revealed that the X-rays and gamma rays showed a strong connection to the optical and ultraviolet emissions, while the hard X-rays appeared unrelated to the VHE gamma rays. This suggests that there may be multiple regions in OJ 287 where light is being emitted, with each region contributing to different types of radiation.

To better understand this complex behavior, researchers created the most detailed map of OJ 287's energy output to date. By combining data from across the electromagnetic spectrum — ranging from



Artist impression of the binary supermassive blackhole system at the centre of OJ 287 (Image Credit: Dey et al 2018 ApJ 866 11).

radio waves to gamma rays — they were able to study the object's emissions during three distinct phases of the April 2017 outburst. The findings revealed that the object's light was not coming from just one source, but from multiple components that each played a role in the outburst. Interestingly, radio observations showed that a new feature appeared in the jet of particles shooting out from the galaxy's center. This feature, labeled “K,” moved outward at the same time that the X-ray flare peaked, suggesting a connection between the two.

Further modeling of the data, which involved simulating the jet's behaviour, revealed that the particle acceleration happening within the jet was likely the cause of the observed increase in energy. This provides valuable insight into the dynamic processes occurring at the heart of OJ 287 and offers a new window into the complex physics of active galactic nuclei.

Citation: Acharyya, A. et al. (2024) A Multiwavelength Study to Decipher the 2017 Flare of the Blazar OJ 287. ApJ, 973, 134.

Why this matters

Studying the jetted emission of AGNs provides excellent laboratories to study fundamental physics such as particle acceleration, magnetic fields, non-standard model physics and relativity. This research of OJ 287 has revealed the location and environment responsible for producing such high-energy emission.

A Hidden Cosmic Background of Millicharged Particles Could Soon Be Revealed

Contributing authors: Ella Iles is McGill Honours Physics undergraduate student who was awarded an NSERC USRA to conduct a summer research project with Prof. Katelin Schutz in Summer 2024. Saniya Heeba is a IPP Connect Fellow and former TSI Fellow in Prof. Schutz's group. Prof. Katelin Schutz is an Assistant Professor in the McGill Physics Department and TSI, and a Canada Research Chair in Astrophysics beyond the Standard Model.

The universe may be filled with a sea of invisible particles known as millicharged particles, and a recent study shows we might be on the brink of detecting them.

You've likely heard of the cosmic microwave background (CMB) — a faint afterglow from the Big Bang that provided one of the most compelling pieces of evidence for the origin of our universe. In this recent study, researchers propose that another type of cosmic background could exist, made up of millicharged particles (MCPs) — particles with tiny, fractional electric charges, far smaller than the electron's. These particles don't exist in the Standard Model of particle physics, but they appear in many beyond the standard model (BSM) theories. Importantly, MCPs are a well-motivated candidate for dark matter — the mysterious, invisible substance that makes up most of the mass in the universe.

This study, recently published in *Physical Review Letters*, shows that if MCPs exist, they would have been created in the early universe because of their tiny electric charge. This work shows that even if the MCPs make up only a small fraction of the dark matter, they would still have been produced in detectable quantities through ordinary particle reactions in the hot, dense plasma following the Big Bang. These particles would still be drifting through the universe today, forming a cosmic background of millicharged particles, much like the CMB.

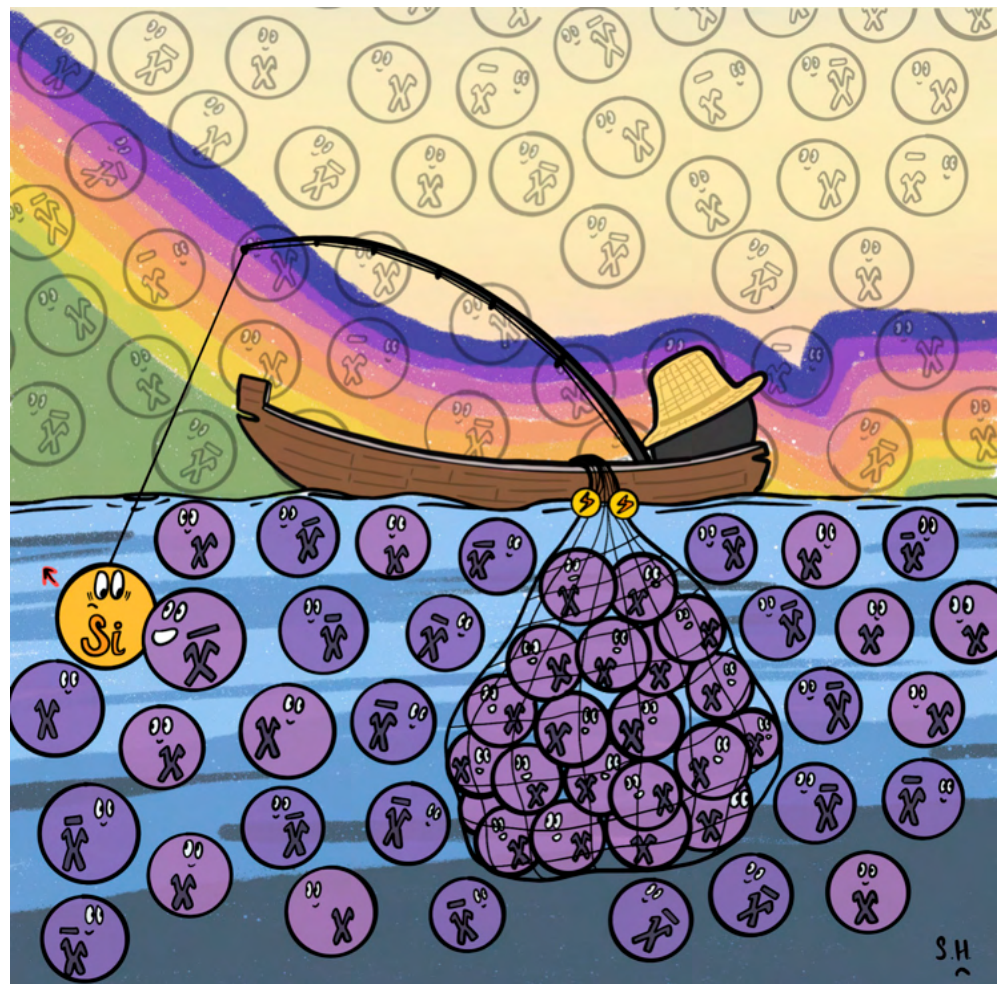
This discovery is especially exciting because, thanks to their tiny electric charge, MCPs could interact with electric fields; they might be detectable in upcoming terrestrial experiments searching for dark matter. Many existing and planned dark matter detectors are already sensitive enough to detect this potential MCP background—or rule it out.

In short, this study shows that a wide array of future experiments could discover or constrain a universal background of MCPs even if their abundance is much smaller than previous works have assumed. This result motivates experiments to search for these beyond the standard model particles.

Citation: Iles, E., Heeba, S., & Schutz, K. "A Cosmic Background of Millicharged Particles," *Physical Review Letters*, 132, 141002 (2024).

Why this matters

Just as the cosmic microwave background revealed the universe's infancy, a new kind of cosmic background—made of exotic "millicharged" particles—might be hiding in plain sight. This research shows that we could soon detect it.



03

EDUCATION & PUBLIC ENGAGEMENT

One of the core tenets of TSI's mission is to communicate astronomy with the public. TSI runs a variety of public outreach programs, from large events targeted at a general audience, to programs tailored to the needs of specific communities. Our approach to outreach emphasizes inclusion, relationship-building, iteration, and co-creation, with the over-arching goal of demystifying astronomy research, showing that science is interesting, accessible, and human. TSI Outreach promotes the research that we do at TSI and the people who do it, providing multiple opportunities for trainees to develop science engagement skills.

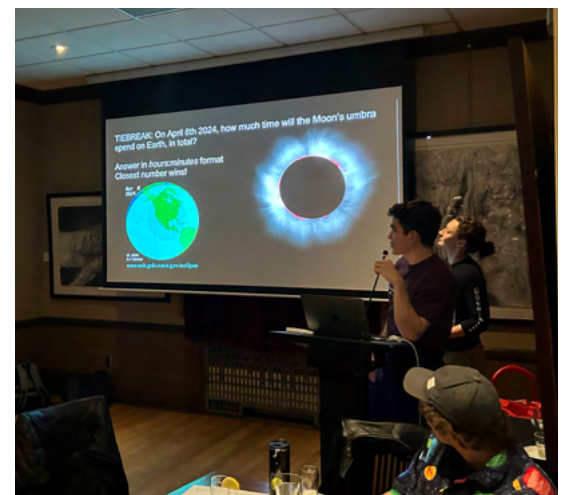
We have forged multiple partnerships with other outreach groups, both within and outside McGill, in order to offer a robust set of education and public engagement activities for the Montreal community. We regularly collaborate with outreach groups in the TSI's member departments (Physics Outreach, SMOres), the Faculty of Science's outreach groups, the Institute for research on exoplanets (iREx), and the Centre de recherche en astrophysique du Québec (CRAQ). TSI has also made a name for itself in the broader Montreal community and is often invited to participate in events organized by various organizations in Montreal and its surroundings.



2024 was a big year for TSI Outreach, with the first third of it dedicated to planning and executing the Eclipse Fair and Viewing Party for the total solar eclipse on April 8th, which brought over 18,000 people to McGill's downtown campus. A full summary of TSI's eclipse-related activities can be found on page 20. We also kept the rest of our outreach program going while planning for the eclipse. Public Astro Nights (see page 17), our public talk series run in collaboration with Physics Outreach featured a broad variety of topics and formats, including traditional talks, Q&As, and panel events from locals and external speakers. Public Observing Nights (see page 19) continued to run at maximum capacity every month, giving the public the opportunity to tour the Anna McPherson Observatory and look through the telescope. Astronomy on Tap's popularity continued to grow, filling their venue at Silboire to capacity every month.

Strong relationships continued to be the backbone of our outreach programming. We worked closely with Physics Outreach, co-organizing the McGill Physics Hackathon (page 27), Science in Space (page 22), and developing new astronomy-themed modules to deploy through Space Explorers (page 30). We also collaborated with McGill's Office of Science Outreach on Family Science Day in September 2024, where we hosted the 2nd edition of our From Planets to Particles activity fair which once again drew hundreds of people to campus. Our collaboration with Branches Community Outreach, based out of Enrolment Services, yielded three events aimed at Black youth, Indigenous youth, and youth in care. We also strengthened our ties to the School of Continuing Studies, organizing a day-long workshop as part of their Explore the World of STEM program in summer 2024. We also worked with Earth & Planetary Sciences Outreach to host two visits for CEGEP students from Dawson College and Marianopolis College in November 2024, organizing lab visits and a Q&A with current undergraduate students in Physics and TSI. We teamed up with our colleagues at the Trottier Institute for Research on Exoplanets (iREx) at the University of Montreal and Discover the Universe to run the first Quebec iterations of Beyond the Stars. Finally, we established new relationships with community partners such as the West Island Black Community Associated, for whom we ran a hands-on program over the course of three weekends in December 2024 (page 23).

The success of TSI's Outreach programs is due in no small part to the team of students, postdocs, faculty, and staff who volunteer their time to make our broad portfolio of programming possible. We would like to thank the over 160 volunteers who gave us their time in 2024. We're thrilled to see where their dedication and ingenuity take TSI Outreach next!



PUBLIC TALKS

Public AstroNights, our monthly public talk series, have been a mainstay of the Montreal astronomy scene since 2011. Originally founded by AstroMcGill in 2011, they are now run by TSI Outreach in collaboration with the Physics Department. Public AstroNights rotate between a variety of formats designed to increase interactivity, including panel events that bring together multiple researchers, Q&As sessions, and traditional talks. Speakers are usually TSI or McGill Physics professors, postdoctoral fellows, or graduate students, although we also welcome invited speakers from other institutions.

Our public talks take place in person on the McGill campus, attracting an average of 200 people each month. The accompanying live-stream provides opportunities for our online audience to actively participate as well. All our talks are posted to our YouTube channel, where they garner hundreds (sometimes thousands) of views. We are continually astonished by the enthusiasm of our audience, who return month after month and engage speakers in lively Q&A sessions!

From exoplanet research to theoretical cosmology to next generation telescopes, we're looking forward to the future of Public AstroNight!

07 Feb	Prof. Duncan Lorimer (<i>West Virginia University</i>) 'The Cosmic Mystery and History of Fast Radio Bursts'
14 Mar	Prof. Nicolas Cowan (<i>TSI & McGill Physics</i>) 'Eclipses: What Are They and What Are They Good For'
01 May	Prof. Jessica Coon (<i>McGill Linguistics</i>), Prof. Rene Doyon (<i>Universite de Montreal</i>), Prof. Jackie Goordial (<i>University of Guelph</i>) 'The Road Map to First Alien Contact'
17 Jun	Prof. Matthew Bailes (<i>Swinburne University of Technology</i>) 'A Virtual Tour of Einstein's Universe'
01 Oct	Prof. Tracy Webb (<i>TSI & McGill Physics</i>) 'From Clouds to Cosmic Giants: The Formation and Evolution of Galaxies'
30 Oct	Prof. Katelin Schutz (<i>TSI, McGill Physics</i>), Prof. Yashar Hezaveh (<i>Universite de Montreal</i>) 'Dark Matter Panel: The Universe's Missing Piece'
28 Nov	Prof. Nikolas Provatat (<i>McGill Physics</i>) 'Materials Science of Disasters'



ASTRONOMY ON TAP MTL



Montreal has been a satellite location of the popular Astronomy on Tap (AoT) series since 2017. Originally established by members of AstroMcGill (now TSI Outreach), AoT MTL events were jointly organized with our colleagues at the Trottier Institute for Research on Exoplanets (iREx) until March 2020 when the COVID-19 pandemic forced AoT MTL into a three-year hiatus. As of Spring 2023, Astronomy On Tap MTL – Astronomie En Fut MTL (AoT MTL) is now organised by a team of postdoctoral researchers and graduate students at McGill and UdeM, in collaboration with the Center for Research in Astrophysics of Quebec (CRAQ), the Trottier Institute for Research on Exoplanets (iREx), and the Trottier Space Institute at McGill (TSI).



AoT are free events aimed at making space-related research more accessible to the community by combining short, engaging science presentations with themed trivia games and prizes in a social venue. Events are held monthly and alternate between English and French nights, with the occasional fully bilingual edition. Unlike most traditional outreach efforts, AoT reaches a more diverse audience of adults in a location where people gather to socialize. AoT is more informal, engaging, and relatable than traditional hour-long lectures, reaching an audience that is new to astronomy and space sciences. In 2024, AoT re-established itself as a fixture of the Montreal astronomy scene and continued to grow its audience; AoT maxed out Siboire's 100-seat capacity every month. Audience members enthusiastically participate in the trivia games and never run out of questions for the astronomers after their 15-minute talks.



TSI graduate students and postdocs are an integral part of the AoT team; half of the members of the AoT organizing committee are from TSI, contributing to everything from recruiting volunteers to coming up with astronomy trivia games. AoT also offers a unique opportunity for scientists at all levels to hone their science communication skills through delivering scientific yet nontechnical presentations for general audiences. Over a dozen TSI researchers spoke at AoT this year, sharing their research in both English and French with the Montreal community.

We're thrilled to say that AoT MTL is here to stay!



OBSERVING NIGHTS

Atop the Rutherford Physics Building at McGill is the Anna I. McPherson Observatory. This consists of a 14-inch Celestron telescope in the observing dome, several smaller optical telescopes, which are portable on tripod mounts, and a small 1400 MHz radio telescope. The rooftop location provides one of the best observing experiences in Montreal for objects such as the moon, Saturn, Jupiter, and even deep-sky objects. The observatory is run by students in the Department of Physics and TSI, led by the Observatory Coordinator, graduate student Samantha Wong. The Observatory Coordinator and a team of dedicated volunteers run a variety of observing nights aimed at different audiences, inside and outside McGill. While a majority of observing nights take place in the Anna McPherson Observatory, our coordinators also host off-site events using our portable telescopes.

In 2024, we hosted roughly 1000 members of the public at our various observing nights, reaching people of all ages and scientific backgrounds. These events were made possible by the help of fifteen volunteers, over half of whom are undergraduate students in the Physics Department.

Public Observing Nights

The observatory also opens its doors every month to the public for Public Observing Nights. These nights feature guided observing of assorted astronomical objects, which change depending on the season, as well as a presentation on what can currently be observed by the naked eye and a tour of the observatory facilities. They have proved wildly popular, with the 70 open slots often filling up within hours of the event being advertised on our social media channels and many participants returning more than once.

McGill Observing Nights

Many participants at our public observing nights are members of the McGill community, including students, staff, and faculty from both physics and external departments. We have used the observatory for dedicated physics groups as well, including classroom visits, use of the observatory for undergraduate lab projects, and “open house” events for physics department members. Most of our volunteers are McGill undergraduate students, graduate students, or postdocs, giving a unique hands-on experience for many early-career researchers to learn more about observational astronomy.

Observing with Schools

Schools and CEGEPs in the Montreal area can also request a guided observing experience either at our observatory, or an observing visit directly at the school with our smaller telescopes directly. For the past three years, we have been invited by JPPS-Bialik, a Jewish primary school, to be a part of a yearly Shabbat event, bringing together understandings of the sky from the Jewish faith with the work that astronomers do. We set up the portable telescopes for the Grade 3 class and their families, who were all delighted to not only look through the telescopes, but also to interact with the graduate student volunteers.



ECLIPSE 2024

On the afternoon of April 8th, Montreal experienced a total solar eclipse for the first time in over 90 years. The path of totality (the region where the eclipse will be total) crossed southern Quebec, including the greater Montreal area, Montréalégie and the Eastern Townships. To celebrate this once-in-a-lifetime celestial event (Montreal won't see another total eclipse for another 200 years), the TSI organized a series of events and activities to engage the public and build enthusiasm for the the eclipse, culminating in an Eclipse Fair and Viewing Party on the McGill campus. All of the eclipse programming was organized an Eclipse Task Force made up TSI graduate students and led by the TSI Program Admin Carolina Cruz-Vinaccia, with the assistance of the grad Outreach Coordinator Hannah Fronenberg, grad Eclipse Coordinator Srobona Basak, and the Physics & TSI Outreach Committee chaired by Prof. Thomas Brunner.

Distribution of Eclipse Glasses

We had 26,000 custom eclipse glasses printed, designed by TSI postdoc Saniya Heeba. Approximately 1600 pairs were distributed to community organizations and elementary schools that we work with regularly in our outreach program in Montreal and beyond – 400 of them made their way to the James Bay Eeyou School in Chisasibi! Another 3000 went to other McGill campuses, including the MacDonald Campus, Campus Outaouais, and the Gault Nature Reserve, which held its own eclipse viewing event. We also provided glasses to McGill faculty and staff; TSI Prof. Adrian Liu spearheaded a campaign to distribute 3000 pairs. The remaining 18500 pairs were meant for the Eclipse Fair and Viewing Party on April 8th, where every last pair was handed out to eager attendees!

Lead-up Events & Programming

In addition to the main event, we prepared programming aimed at different sectors of our community to create awareness of the eclipse, educate the public about the eclipse science, and how to view eclipses safely.

- AstroTrivia Night - Eclipse Edition: Over 80 McGill community members participated in three rounds of eclipse-themed trivia and expanded their knowledge about eclipses through mini-talks featuring TSI astronomers.
- Public Talk: TSI professor Nicolas Cowan dove into the world of eclipses and their connections to exoplanet research, speaking to an audience of over 250 people.
- Eclipse module for elementary schools: In collaboration with McGill Physics Outreach's Space Explorers program, we developed an eclipse module where students in grades 2-6 learned what eclipses are, why they happen, and how to observe them safely. They also made their own pinhole viewers! The module was deployed in 10 classrooms and the Cote St. Luc Library, reaching a total of over 300 children.
- Booth at the Ecomuseum Zoo: Two TSI grad students set up a booth at the Ecomuseum Zoo on the Saturday before the eclipse to educate around 250 children and their families about eclipses.



Eclipse Fair & Viewing Party

The main event was the Eclipse Fair and Viewing Party, which took place on McGill's downtown campus and was open to the McGill community at large and the general public. Enthusiasm for the eclipse was palpable; the crowd started to form hours before the event was slated to begin. By the time the 1pm start time rolled around, thousands of people were lined up at all four of the glasses distribution stations.

The majority of 18,000 pairs of glasses we had reserved for the event were in the hands of participants by 1:45pm; as supplies dwindled, participants began sharing their glasses with strangers so that everyone had a chance to enjoy this spectacular celestial event. The crowd was large and diverse: families with young children, the elderly, people from nearby offices in full business suits, tourists visiting Montreal for the first time, and McGill students, faculty, and staff. Just under 20,000 people stayed for at least part of the eclipse that afternoon.

While TSI was the main organizer, the event was a joint effort that brought together units across McGill, including including the Department of Physics, the Department of Earth & Planetary Sciences, the Redpath Museum, and the McGill Library. There were a total of 10 activities for attendees to enjoy while they waited for totality, including solar observing with our solar telescopes, a pinhole camera crafting station, a trivia booth organized by EPS, samples from the Redpath collection, and much more! All the activity booths were bustling with activity as people waited for totality.

In the minutes leading up to totality, spontaneous applause broke out in the gathered crowd as the sky darkened and the air grew cooler. At 3:26pm, as the moon fully eclipsed the sun, thousands of people erupted into cheers, caught up in the momentous emotions of a once-in-a-lifetime event. After totality, the crowd slowly started to disperse, with a much smaller number staying until 4:30pm to see the last sliver of the Moon leave the Sun's disk.

Almost 100 volunteers helped us share the eclipse with the McGill and Montreal community. While most came from TSI and the McGill Department of Physics, students and staff from other McGill departments also volunteered their time. The community clearly appreciated their effort, as evidenced by the outpouring of positive feedback that we received in the days following the eclipse. The University also recognized the magnitude of what was required to pull off an event of this size; the team received two awards for their efforts.



SCIENCE IN SPACE: HOW TO TELESCOPE

Science in Space: How to Telescope is an informal science learning program co-founded in 2022 by the Trottier Space Institute, McGill Physics, and Dell Technologies/Girls Who Game. The program is aimed at girls and nonbinary children between the ages of 10 and 12 (grades 5-6), as research shows that the years immediately preceding the transition to high school are a crucial determinant of retention of girls in STEM. Science in Space is designed to mitigate girls' attrition from STEM by fostering a sense of belonging and community, thus increasing student engagement and confidence in using STEM to tackle real-world problems. Over the course of 8-10 weeks, students design and build telescopes in Minecraft with the guidance of graduate student mentors (who themselves identify as women or nonbinary people).

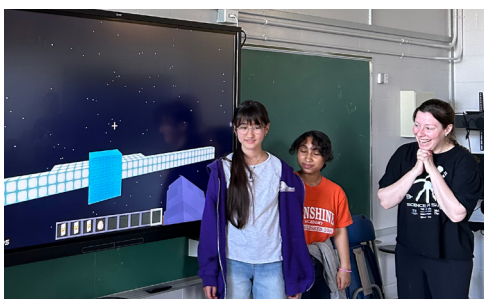
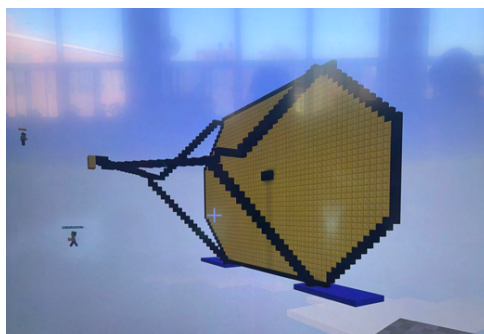
The program is inquiry-based and student driven; students ultimately decide which astronomical phenomena they'd like to study and design a telescope to do so. In the first half of the program, facilitators and mentors deliver the basics of astronomy through game-based activities, giving the students the foundation they need to tackle designing and building their telescope. The program ends with a celebratory pizza party and showcase, where each group presents their telescope to the other groups, mentors, and teachers. Through this program, students gain familiarity with observational astronomy, develop collaborative project design skills, and gain a sense of community in STEM.

2024 was a year of growth and evolution for Science in Space. The program ran in a total of 5 schools across the island of Montreal, including one new school and 4 that asked us to return for the second (and even third) time. We also ran a one-day version of the program for a STEM spring break camp for girls in Toronto, at the invitation of our Dell Girls Who Game partners! Overall, we reached approximately 120 students through around 60 total visits to the schools. Our team of volunteers grew, with approximately 10 graduate and undergraduate students acting as mentors, one of whom was promoted to facilitator and co-organizer.

Having a wider variety of venues gave us the opportunity to experiment with different approaches to delivering content, including in a more compressed fashion. We now have four versions of the original program, ranging from a compressed 1-day version to a more relaxed 12-week version, allowing us to adapt to schools that have longer or shorter lunch periods. We also began developing a 2nd set of modules, focused on exploring habitability on other planets, which we hope to be able to deploy in late 2025.

Feedback gathered from students through "mission logs" (exit tickets) showed that students felt more excited about science and enjoyed the opportunity to learn about space while playing Minecraft. A sense of community continues to be the most notable impact of the program; almost all of the students said that their favourite part of the program was working with each other, making new friends, and having a space of their own.

As 2024 marked our third full year, we decided it was time to get the word out about the program, with a view to expanding the program beyond Montreal. We presented the program at both provincial and national astronomy conferences, garnering interest from colleagues at other Canadian institutions. We also created a video which was shared at the Girls Who Game spring celebration and subsequently published on TSI's social media. Finally, we were interviewed by the McGill Reporter for a feature piece, scheduled for publication in early 2025. We look forward to what 2025 will bring! To learn more about the program, visit <https://www.scienceinspace.ca/>



COMMUNITY OUTREACH WITH MCGILL BRANCHES

Since Fall 2022, TSI has partnered with McGill's Branches Community Outreach program to deliver activities and workshops for Black and Indigenous youth. In 2024, TSI participated in both the Spring and Fall editions of Explore McGill, conducted an on-site visit to the Cree Nation of Chisasibi, and hosted a workshop for high school students from the community. Through our involvement in Explore McGill, TSI connected with the STEM club at the West Island Black Community Association (WIBCA), leading to a three-week astronomy program for their youth (in collaboration with the Outreach Officer at IREx - Université de Montréal).

Reaching Indigenous Students

Building on the success of previous visits to the Cree Nation of Chisasibi, TSI was invited to contribute to the March 2024 on-site event. Although our outreach team was unable to attend due to Eclipse preparations, Physics graduate student Noah Kakekaspan led our Seeing Light in Space workshop for three groups of high school students. This workshop introduces participants to how telescopes observe astronomical objects and includes a hands-on activity exploring the concept of resolution, where students recreate astronomical images using fuse beads. The workshop has since been delivered to Indigenous youth at two additional Branches events.

TSI also contributed to the Explore McGill events organized by Branches in April and October 2024. These events are designed to introduce students to university life through workshops hosted by groups across McGill. In April, TSI hosted a small group for a Q&A session at the Anna McPherson Observatory, led by graduate student Matt Lundy. In October, graduate student Hannah Fronenberg and TSI Program Administrator Carolina Cruz-Vinaccia facilitated an updated version of Seeing Light in Space, which was so well-received that it was offered again in November for a group of over 30 visiting Grade 11 students from Chisasibi. In addition, TSI supported the IMPRESS program, a summer research and mentorship initiative for Indigenous undergraduates, by organizing a visit to the Anna McPherson Observatory in 2024.

Beyond our work with Branches, TSI has been working with iREx at Université de Montréal on an outreach program for Indigenous high school students that will be piloted in January 2025.



West Island Black Community Association (WIBCA)

TSI began collaborating with WIBCA following a connection made at the April 2024 Explore McGill event. Recognizing the wide age range (8–17) of participants in WIBCA's STEM club, we worked with iREx to adapt their Beyond the Stars cultural astronomy program—originally designed for youth aged 18–25—to meet the needs of younger learners.

The adapted program was piloted over three Saturdays in December. During the first two sessions, participants explored cultural astronomy, selected astronomical targets using Stellarium, and engaged in hands-on activities introducing the electromagnetic spectrum and basic astronomical image processing. They also submitted mock telescope observing requests, which were fulfilled using the Las Cumbres Observatory.

In the final session, the students processed their own astronomical images using web-based software, then recreated those images with fuse beads. The program was enthusiastically received—the youth were highly engaged, often asking more questions than time allowed. WIBCA organizers were thrilled and have already invited us to return in 2025.



SCIENCE FESTIVALS AND LARGE EVENTS

In addition to our regular programming, TSI Outreach also participates in events organized by external partners that seek to increase awareness of and access to science in general and astronomy in particular.

Eurêka! Festival

TSI joined forces with IREx and the Centre de Recherche en Astrophysique (CRAQ) for the 2024 edition of the Eurêka! Festival, Quebec's biggest science festival (May 24-26). Our joint booth, "Extraterrestrial Life: Fact or Fiction" featured three hands-on activities where visitors could learn about our solar system, exoplanetary systems, and habitability. TSI's contribution to the booth was our "Life Finds a Way" activity, where children produced a seemingly never-ending supply of fascinating extremophiles. The weather was on our side, and visitors lined up for their turn to gaze through a solar telescope. The booth was busy during all weekend long, with hundreds of visitors stopping by over the 3 days of the Eureka Festival.



AstroFest at the Planetarium

On June 14th and 15th, 2024 Montreal's Planétarium Rio Tinto Alcan hosted Astrofest, a weekend-long event for astronomy enthusiasts of all ages. TSI once again hosted a booth where children could learn about exoplanets and habitability through two complementary hands-on crafting activities – fan-favourite from 2023 "Life Finds a Way" and a brand-new module on planetary systems. In "Make Your Own Planetary System", children learn about the different kinds of planets by making a planetary system mobile; we use our own Solar System as a starting point and then children are asked to imagine and design their own planets. "Life Finds a Way" asks them to take a step further and think about what could live on those planets, introducing the concepts of habitability and extremophiles by designing a creature that could live on one of the planets they created. Both activities proved immensely popular, welcoming over 400 children (and their parents!) over the course of the weekend. A team of 10 graduate and undergraduate students, along with the TSI Program Admin, volunteered their time to ensure the booth's success. We look forward to participating in Astrofest again in 2025!



Family Science Day

On September 28th 2024, McGill's Office for Science Outreach organised Family Science Day, a day of free science activities run by outreach groups across the Faculty of Science. TSI and Physics Outreach joined in on the fun by hosting the 2nd edition of "From Planets to Particles: An Exploration Mini-Fair". Over the course of six hours, we welcomed over 450 people to the Rutherford Physics Building to engage in ten hands-on activities and demos focused on a variety of topics within physics and astronomy, and planetary sciences. Children could design parachutes to experiment with gravity, build their



own space stations out of LEGO, use lessons learned from extremophiles on Earth to design a lifeform that could survive on other planets, use potatoes to power a lightbulb, design their own planetary system,, and observe the sun through our solar telescope. The Physics Department's lab technicians also set up a half-dozen demos, to the delight of parents and children alike!



Children were given “activity passports” that they could get stamped at each station, and many of them stayed for hours trying all the activities in order to fill up their passports! The reactions from attendees were overwhelmingly positive; parents enthusiastically thanked us for putting on the event and told us how much their kids were enjoying the activities. Some of them even told us that they had attended the event last year and that their children had been looking forward to coming back! The energy was palpable and electrifying, and seeing the children’s joy and engagement was well worth the effort that went into planning an event of this size. The event would not have been possible without the invaluable contributions of the over 40 graduate students, undergraduates, postdocs, and staff who volunteered their time on a Saturday, nor without the hard work of the TSI & Physics Outreach Committee. We’re thrilled to count “From Planets to Particles” among our regular annual events from now on!



McGill Open House

TSI joined the Physics Department for McGill’s Open House on October 28, 2024 for the 3rd consecutive year. The Physics & TSI Outreach Committee took the lead in organizing activities in the Rutherford Physics Building to give prospective undergraduates a glimpse into what life is like in the Physics Department and TSI. We coordinated demonstrations and lab tours throughout the day in seven different labs, including the McGill Cosmology Instrumentation Lab (run by volunteers from TSI Prof. Matt Dobbs’ lab). In addition, the Physics lab technicians showcased a variety of demos, and TSI graduate student Sam Wong opened up the Observatory to visitors and their families. Several undergraduate student clubs also ran booths where they showcased their work and talked about their experience in the department. Volunteers guided over 20 visitor groups from lab to lab where they learned about some of the research being done at the department. The event



HIGH SCHOOL & CEGEP OUTREACH

For the past couple of years, TSI has been expanding its outreach program to high school and CEGEP-age students. We reach high school-age audiences mostly through collaborating with STEM summer programs. This year, we also started organizing visits from CEGEP groups during the academi term, in collaboration with the Physics Department and the Department of Earth and Planetary Science.

Explorations Summer Camp

TSI hosted a two-hour visit from a group of twelve students ages 13-15 who were participating in Explorations Summer Camp. Because the group requested a hands-activity, we ran our Seeing Light in Space workshop. The group was enthusiastic and full of questions about telescopes, data processing, and astronomy more generally. They particularly appreciated the beading component, creating intricate astronomical images using fuse beads.

Exploring the World of STEM - School of Continuing Education

For the second consecutive year, McGill's School of Continuing Education organised Exploring the World of STEM, a summer program for high school students who are interested in learning more about STEM careers. Building on the success of last year's collaboration, the Explore students spent a whole day with TSI & Physics Outreach, participating in two 3-hour workshops: 1) A simple lab experiment in the Phycsis undergrad teaching lab, where they experienced a lab environment and did a hands-on experiment to measure the gravitational constant; 2) Seeing Light in Space, a hands-on workshop run by TSI where students learn about the electromagnetic spectrum, telescopes, images processing, and resolution, using NASA's Astrophoto Challenge ,culminating in an activity where they use Perler beads to recreate astronomical images. In order to accommodate the 100+ students, we split them into two groups and cycled them through the two activities. Both the students and their teachers were very satisfied with the activity; some of the students were so focused on beading their astronomical images that they didn't want to leave at the end of the day! We're looking forward to future iterations of Exploring the World of STEM.

CEGEP Visits

Physics and TSI Outreach was contacted by the Department of Earth \& Planetary Sciences (EPS) to host visits from CEGEP students who were interested in science programs. Staff (Cruz-Vinaccia and Metera) led the two visits, which consisted of: 1) a program overview; 2) a conversation with current undergraduate students; and 3) a visit to the undergraduate teaching labs. We organized a visit for 10 students from Marianopolis College (2024-11-04) and 30 students from Dawson College (2024-11-15).



MCGILL PHYSICS HACKATHON

After many years supporting the McGill Physics Hackathon, in 2024 TSI became an official co-organizer of the annual event. The Hackathon is a friendly programming competition where students team up to write programs to visualize or calculate something related to physics. The broad nature of the prompt has given rise to a wide variety of creative projects, from simulations to to visualize space-time distortion and gravitational interaction, to projects that bring quantum principles to classic games. The Hackathon draws students at all levels, from upper high school all the way to graduate school, all of whom have access to mentors who can provide advice on how to design, implement, and present their projects. The caliber of this year's projects was particularly high and the awards were hotly contested, with the Astro Prize ultimately going to To the Moon & Back—a Space Rocket Simulator.

The 2024 Hackathon saw the record-high attendance, with 163 hackers submitting 42 projects.

As co-organizers, TSI staff had a larger role in the organization of the Hackathon than in years past. The TSI Program Admin and the TSI Computing Fellow were both a part of the Hackathon Organizing Committee, along with faculty and students in the Physics department. The TSI Computing Fellow took lead on a series of introduction to coding workshops in the week preceding the Hackathon, which were tailored to Hackathon participants with less coding experience. TSI's Program Admin also ran a short workshop on giving project presentations, providing students with a set of guidelines and tips on how to effectively communicate their hackathon projects to the judges. TSI also had a booth at the sponsors meet and greet on the Hackathon's first night, where TSI professors and staff talked about the opportunities available to undergraduates at the TSI. We also sponsored the Astro Prize for the best astronomy-themed project, for which the prizes were Celestron Firstscope.

Spotlight: Workshops

The TSI Computing Fellow delivered two “Introduction to Python” workshops aimed at potential Hackathon participants who had little to no coding experience, in order to allow them to take part in the Hackathon. Each of these introductory sessions had between 20-30 attendees, most of whom went on to take part in the Hackathon. Additionally, TSI delivered a workshop on “Machine Learning in Astronomy” on the second day of the Hackathon. In this workshop, attendees learn how to read catalog data from a FITS file, clean the data using packages such as numpy and pandas, display the data using packages like matplotlib and seaborn and train a machine learning algorithm before testing it on real data. The goal of the workshop was to classify so-called Unidentified Fermi Objects. These are high energy (>100 MeV) gamma-ray emitters with no known multiwavelength counterpart. In the workshop we achieved results comparable to the state-of-the-art research on these objects by applying an ensemble learning method known as Random Forest classification. This was well attended with about 20 attendees coding along during the session.



TSI IN THE MEDIA

'Meet the AAS 243 keynote speakers: Prof. Eve Lee'; Astrobites, 2024-01-08 [Eve Lee]

'Secrets of a Hot Saturn and its Spotted Star Unlocked'; McGill Newsroom, 2024-01-09 [Nic Cowan]

'M87* One Year Later: Proof of a persistent black hole shadow'; McGill Newsroom, 2024-01-19 [Daryl Haggard]

'Spotlighting McGill's women in STEM'; McGill Reporter, 2024-02-07 [Eve Lee]

'Telescopes Show the Milky Way's Black Hole is Ready for a Kick'; Chandra Press Room, 2024-02-08 [Daryl Haggard & Anan Lu]

'Telescopes Reveal Rapid Spin of Milky Way's Black Hole Warping Spacetime'; SciTechDaily, 2024-02-10 [Daryl Haggard & Anan Lu]

'Demystifying the mysterious fast radio bursts'; The Tribune, 2024-02-13 [TSI]

'\$107.5 million for eight innovative research projects led by McGill'; McGill Reporter/eHealth News, 2024-03-14 [Daryl Haggard]

'A total solar eclipse is coming – are you ready?'; McGill Giving, 2024-03-14 [Carolina Cruz-Vinaccia, Hannah Fronenberg, Srobona Basak]

'Montreal in the Shadow of the Moon'; McGill Daily, 2024-03-15 [Nic Cowan, Carolina Cruz-Vinaccia]

'Eclipse events abound at McGill'; McGill Reporter, 2024-03-20 [Carolina Cruz-Vinaccia]

'Ocean cavity regime shift reversed WestAntarctic grounding line retreat in the lateHolocene'; Nature Communications, 2024-03-25 [Natalya Gomez]

'Andrew Carter Morning Show'; CJAD 800, 2024-03-25 [Nic Cowan]

'Quebec has failed students for the total solar eclipse, astronomers say'; Montreal Gazette, 2024-03-25 [Nic Cowan]

'Missed opportunity': Montreal scientists criticize Quebec government's approach to upcoming solar eclipse, ' ; City News Montreal, 2024-03-25 [Tracy Webb]

'Afraid of the dark? Why Canadian schools are closing for the solar eclipse'; CBC News, 2024-03-31 [Tracy Webb]

'Do you really need eclipse glasses for Quebec's total solar eclipse?'; Montreal Gazette, 2024-04-02 [Nic Cowan]

'Why the April 8 solar eclipse is totally a big deal'; Montreal Gazette, 2024-04-04 [Nic Cowan]

'The magic of a solar eclipse'; McGill Newsroom, 2024-04-04 [Nic Cowan]

'Everything to (try to) pay attention to during Quebec's total solar eclipse'; CJAD 800, 2024-04-04 [Nic Cowan]

'Where can Montrealers watch the eclipse in the city'; CBC News, 2024-04-05 [Hannah Fronenberg, Srobona Basak]

'Everything to (try to) pay attention to during Quebec's total solar eclipse'; Montreal Gazette, 2024-04-07 [Nic Cowan]

'Are you inside the path of totality of Quebec's total solar eclipse?'; Montreal Gazette, 2024-04-08 [Nic Cowan]

'Total solar eclipse viewing tips from Montreal astronomers'; Montreal Gazette, 2024-04-08 [Nic Cowan, Tracy Webb]

'Total solar eclipse: Continent watches in wonder'; BBC News, 2024-04-08 [Carolina Cruz-Vinaccia]

'Radio Noon Quebec with Shawn Appel interview'; Radio Canada, 2024-04-08 [Vicky Kaspi]

'Thousands flock to McGill to take in solar eclipse'; McGill Reporter, 2024-04-09 [Carolina Cruz-Vinaccia, Vicky Kaspi]

'A NASA telescope unlocked the mysteries of black holes. Now it's on the chopping block.'; USA Today, 2024-04-11 [Daryl Haggard]

'#SaveChandra'; Astrobites, 2024-04-11 [Daryl Haggard]

'Repenser notre compréhension des trous noirs et des étoiles à neutrons'; Radio Canada, 2024-04-13 [Daryl Haggard]

'Stillir viðtækið á alheimsdögunina'; Visir, 2024-05-07 [Cynthia Chiang]

'Payé pour scruter le ciel: parcours d'un astronome professionnel'; Profs-ETS, 2024-05-15 [Nic Cowan]

'On Opposite Sides of the Globe, Yet Still Connected'; The Weather Channel, 2024-05-30 [Natalya Gomez]

'Astrophysics award honours student research with nod to pioneer'; McGill Giving, 2024-05-31 [Vicky Kaspi, Daryl Haggard]

'Cosmic Journey II: Voyage into the Abyss'; Smithsonian, 2024-06-05 [Daryl Haggard]

‘McGill doctoral and postdoctoral students earn Vanier Canada Graduate Scholarships and Banting Postdoctoral Fellowships’; McGill Reporter, 2024-06-06 [Mohan Agrawal, Hugo Scherer]

‘Entrevue pour l’exposition permanente du Cosmodôme’; , 2024-06-18 [Nic Cowan]

‘Cynthia Chiang, Cosmologist’; National Geographic , 2024-06-20 [Cynthia Chiang]

‘Exploring the Cosmos from the Ends of the Earth’; National Geographic (Hsin Chiang), 2024-06-21 [Cynthia Chiang]

‘Seventeen McGill researchers honoured with prestigious Canada Research Chairs’; McGill Reporter, 2024-06-25 [Daryl Haggard]

‘Dark Matter Could Bring Black Holes Together’; APS, 2024-07-09 [Jim Cline]

‘La recherche : Un nouveau radiotélescope’; Radio Canada, 2024-07-12 [Mohan Agrawal (Cynthia Chiang, Jonathan Sievers)]

‘Cynthia Chiang is searching for signs of the universe’s first light’; National Geographic, 2024-07-24 [Cynthia Chiang]

‘Dark matter may solve the mystery of how colossal black holes merge’; New Scientist, 2024-07-26 [Jim Cline]

‘The discovery of a new Earth-like planet could shed further light on what makes a planet habitable’; The Conversation, 2024-07-29 [Vigneshwaran Krishnamurthy]

‘Rising land under Antarctica could slow sea level rise’; New Scientist, 2024-08-02 [Natalya Gomez]

‘Can Dark Matter Solve One Of The Biggest Mysteries of Black Holes?’; Fraser Cain, 2024-08-15 [Jim Cline]

‘Émission Trudeau-Landry’; FM 93, 2024-08-19 [Nic Cowan]

‘The nearest midsize black hole might instead be a horde of lightweights’; ScienceNews, 2024-08-20 [Daryl Haggard]

‘Astronomers find nearest massive black hole – study’; The Evening Standard/MSN, 2024-08-20 [Daryl Haggard]

‘A ‘river of experience’: How many ways of knowing feed a course on the climate crisis and actions’; The Conversation, 2024-09-03 [Natalya Gomez]

‘Exoplanète: et si on on trouvait de la vie?’; Curium Magazine, 2024-09-20 [Nic Cowan]

‘Family Science Day: McGill’s Family Friendly Foray into Science’; McGill Faculty of Science, 2024-10-18 [Carolina Cruz-Vinaccia]

‘2024 Prizes: Natural Sciences and Engineering Research Council of Canada’; NSERC Prizes, 2024-11-06 [Natalya Gomez & Daryl Haggard]

‘Natalya Gomez and Daryl Haggard win Arthur B. McDonald Fellowships’; McGill Reporter, 2024-11-06 [Natalya Gomez & Daryl Haggard]

‘A radio burst from a giant “dead” galaxy’; Sky and Telescope , 2024-11-07 [Vishwangi Shah]

‘Five exceptional educators to be honoured at Fall Convocation’; McGill Reporter, 2024-11-27 [Adrian Liu]

‘Admin and support staff honoured for going above and beyond’; McGill Reporter, 2024-11-27 [Carolina Cruz-Vinaccia]

‘McGill-linked AXIS mission is one of two finalists in NASA selection process’; McGill Newsroom, 2024-11-28 [Daryl Haggard]

‘Montreal scientist co-leads project in NASA space probe competition’; CTV News, 2024-12-01 [Daryl Haggard]

‘The Andrew Carter Morning Show: The AXIS Mission’; CJAD 800, 2024-12-04 [Daryl Haggard]

‘Vénus, une planète sèche - Les Années lumière’; Radio Canada, 2024-12-07 [Nic Cowan]

‘Mantle Motion Matters for Mapping Modern (and Ancient) Ice ’; EOS, 2024-12-11 [B. Parazin]

‘Amazing New Discoveries from the M87 Black Hole! It’s a Giant Leap for Astrophysics.’; Science Magazine, 2024-12-13 [Daryl Haggard, Nicole Ford, Ken Ragan, Matt Lundy, Sam Wong]

‘McGill researchers help uncover rare gamma-ray flare from a distant black hole’; McGill Newsroom, 2024-12-14 [Daryl Haggard, Nicole Ford, Ken Ragan, Matt Lundy, Sam Wong]

‘NASA chooses McGill-linked AXIS mission as finalist for 2026 explorers program’; City News MTL, 2024-12-15 [Daryl Haggard]

‘Who’s Home? A Supermassive Black Hole & its Tiny Friends’; Astrobites, 2024-12-30 [Daryl Haggard]

DEVELOPING PEDAGOGICAL SKILLS THROUGH NEW OUTREACH MODULES

One of the core objectives of TSI's outreach program is to provide trainees with the opportunity to hone the science communication skills that they'll need to thrive in their careers. One of the ways that we do this is by providing them assistance in the development of new outreach modules that are informed by their research interests. Below are three classroom modules that Space Explorers coordinator Georgia Mraz worked with the TSI Program Admin to develop, pilot, and implement in 2024.

Planets Module

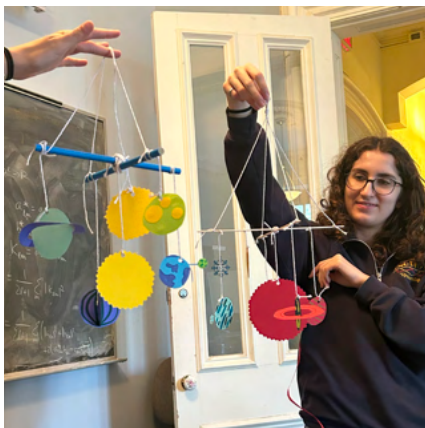
This new module was initially developed for the public AstroFest event in Spring 2024. Its main goal is to introduce young children to the concept of planetary systems, using our own solar system as a starting point. After learning about the components of our solar system, students are encouraged to imagine planets beyond it—exoplanets—and to consider what other planetary systems might look like. Students also explore why some planets have certain characteristics (e.g., being hot because they are close to their star). They then design their own solar system in a mobile-style activity and describe the planets it contains. The module has two versions: one for public events, where children create 2D paper planet mobiles, and a classroom version where students work in groups to build 3D mobiles using clear plastic ornaments filled with clay, pom-poms, and other materials. The classroom version has been successfully tested with four different classrooms of students in grades 3 to 6, demonstrating its adaptability across a range of early learning environments.

Life Finds a Way

Life Finds a Way has consistently been a fan favorite at public events. However, it has recently begun to make an appearance in our classroom visits as well! This module introduces children to the concept of extremophiles—organisms that thrive in extreme environments—and encourages them to think about how life can adapt to harsh conditions. After learning about real-world examples, students are challenged to invent an extremophile that lives in an intense environment, and to consider the adaptations it would need to survive. Like the planetary systems module, this activity has two versions. The public event version invites children to design 2D extremophiles using feathers, pipe cleaners, and other fun craft materials. In the classroom version, students create 3D models of their extremophiles using air-dry clay, which they can take home afterward.

Seeing Light in Space

Seeing Light in Space is an interactive workshop about how we see astronomical objects and how we process images captured by different telescopes. In its first iteration, high school students got to process their own astronomical images using the tools provided by NASA's Astrophoto Challenge. The workshop was well-received by students, but the need for computers restricted the venues where we could run it, as not all the groups who were interested had access to devices that could run the web-based tools. We kept much of the original content about the electromagnetic spectrum and telescopes, but introduced image resolution and developed a new hands-on activity for students to explore that concept. Instead of creating images on a computer, students would instead use fuse beads, which resemble pixels, to recreate astronomical images. The relatively large size of the beads and the limited amount of time require that students think carefully about how to interpret high-resolution astronomical images on the much coarser-resolution beading grids without losing crucial details. They then get to take their finished piece home. Every group we've run this workshop with has loved it, and we've received overwhelmingly positive feedback from their teachers. It was so successful at the high school level that we have now also adapted the content to elementary school audiences and deployed it through Space Explorers, where it has been just as well received.



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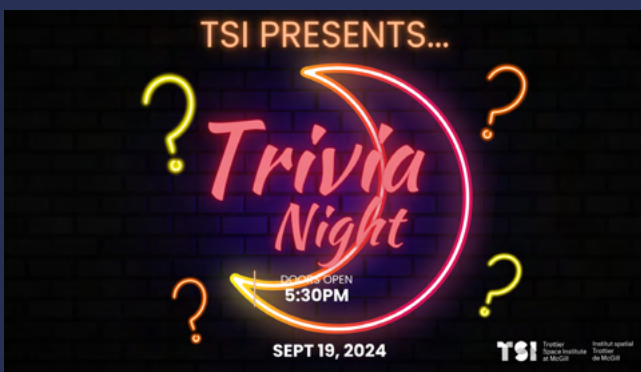
INREACH

Fostering cross-fertilization of ideas, interdisciplinary interactions, and collaborations among Institute members is one of the main missions of TSI. We strive to provide as many opportunities as we can for students, postdoctoral fellows, faculty members, and visiting scholars to share their research and learn from each other. Our approach to inreach has two main tenets: 1) professional development of trainees, and 2) building community and fostering Interactions among TSI members.

TSI was busier than ever in 2024. Our discussion groups and journal clubs kept going strong, experimenting with new formats to increase and maintain engagement from longtime TSI members and newcomers alike. Our portfolio of professional development programs expanded with the implementation of the programming workshops organized by our TSI Computing Fellow. The Debug Den and Writing Circle also became a mainstay, drawing around a dozen attendees every week who either had programming questions to debug or just wanted to work in a collaborative environment with others.

We also experimented with new approaches to old favourites. Instead of the TSI Jamboree at the beginning of the Fall Term, we hosted the first-ever TSI Trivia Night which over 60 TSI members attended, including our newly arrived crop of graduate students. Teams were randomized, giving people an opportunity to interact with TSI members they might not know as well. We played 4 rounds of astronomy themed trivia and puzzle games, with three teams emerging victorious at the end and taking home prizes. The Winter Solstice Party also saw the introduction of new activities, most notably a gingerbread house decorating competition organised by TSI Admin Assistant Max Mutombo. Competition was fierce, and the grand prize ultimately went to a gingerbread recreation of the CHIME telescope.

From seminar series to discussion groups to social events, there's never a dull moment at TSI!

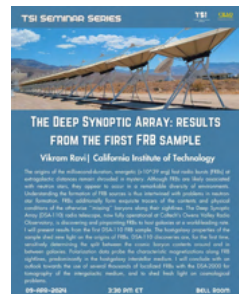
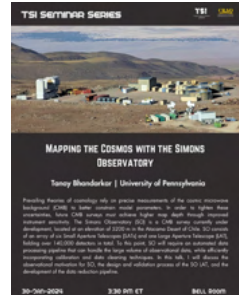


SEMINARS

TSI hosts weekly seminars featuring speakers from across North America and beyond. TSI seminars are intended to be accessible to scientists from the entire breadth of backgrounds at TSI, including physics, planetary science, geology, atmospheric science, and astrobiology. Our seminar series is made possible by a generous gift from the Trottier Family Foundation and by funding from the Centre de recherche en astrophysique du Québec (CRAQ).

Winter/Spring 2024

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|---------------|--|
| 16 Jan | Nicolas Cowan (TSI & McGill Physics/EPS)
‘Surveying Exoplanet Climates with Space Telescopes’ |
| 23 Jan | Laura Thomson (Queen’s University)
‘Under the Radar: Geophysical investigations of Permafrost, Snow, and Glaciers’ |
| 30 Jan | Tanay Bhandarkar (University of Pennsylvania)
‘Mapping the Cosmos with the Simons Observatory’ |
| 06 Feb | Duncan Lorimer (West Virginia University)
‘Making Sense of the Fast Radio Burst Population’ |
| 13 Feb | Sebastiano von Fellenberg (Max Planck Institute for Radio Astronomy)
‘The Galactic Center, Sgr A*, and the Young Stars therein’ |
| 20 Feb | Eve Vavagiakis (Cornell)
‘A New Generation of Millimeter and Submillimeter Observations for Cosmology and Astrophysics’ |
| 27 Feb | Allison Man (UBC)
‘The Rise and Fall of Star Formation in Galaxies’ |
| 12 Mar | Claude-Andre Faucher-Giguere (Northwestern University)
‘The circumgalactic medium: What is it and how does it affect the evolution of galaxies?’ |
| 19 Mar | Anson D’Aloisio (UC Riverside)
‘Cosmological Reionization: New Insights, New Puzzles’ |
| 26 Mar | Roger O’Brien (NASA JPL)
‘Ultra Cold Detectors to Study the Hottest Parts of the Universe’ |
| 02 Apr | Johanna Teske (Carnegie)
‘Reality Check: The Perils and Promise of Observations to Characterize Small Exoplanets’ |
| 09 Apr | Vikram Ravi (Caltech)
‘The Deep Synoptic Array: results from the first FRB sample’ |
| 16 Apr | Christine Chen (Space Telescope Science Institute)
‘Exploring the Environments of Young Planetary Systems’ |



Summer 2024

02 May **Sujay Mate** (*Tata Institute for Fundamental Research*)
‘(Some) New frontiers to study high-energy emissions from compact objects’

13 May **Mark Walker** (*Manly Astrophysics*) (*Special Seminar*)
‘Dark gas and solid H₂ in the Galaxy’

Fall 2024

10 Sep **Karen Alley** (*University of Manitoba*)
Antarctic Tipping Points: How Ice Shelves and the West Antarctic Ice Sheet are Shaping Our Sea-Level Future

17 Sep **Abigail Crites** (*Cornell University*)
‘Unraveling the mysteries of the early universe: next steps in mm-wavelength detection’

24 Oct **Neal Dalal** (*Perimeter Institute*)
‘AGN HBT OMG’

01 Oct **Mustafa Amin** (*Rice University*)
‘A spin on dark matter’

08 Oct **David Kipping** (*Columbia University*)
‘Why Exomoons are So Important and How We’re Going to Find Them’

22 Oct **Andra Stroe** (*STScI & Smithsonian Astrophysical Observatory*)
‘Shocking tales of structure formation: Evolving galaxies and black holes in evolving environments’

29 Oct **Alan McConnachie** (*NRC HIA / University of Victoria*)
‘Microgalaxies, or, how low can we go?’

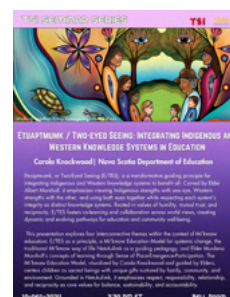
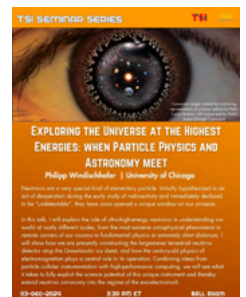
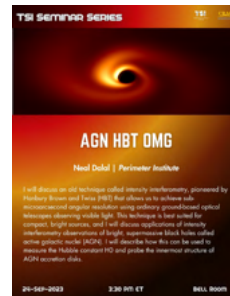
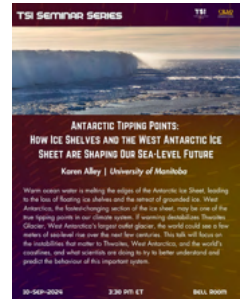
05 Nov **Chris Omelon** (*Queen’s University*)
‘Saline Perennial Springs in the Canadian High Arctic: Why We Still Study Them’

12 Nov **David Themens** (*Birmingham/UNB*)
‘Trials and tribulations in near-Earth Geospace: Extreme events in the Ionosphere and how they impact radio propagation’

19 Nov **David Hanna** (*McGill Physics*)
‘The Launch and Recovery of HELIX - an Arctic Adventure’

03 Dec **Philipp WIndischhofer** (*University of Chicago*)
‘Exploring the Universe at the Highest Energies: when Particle Physics and Astronomy meet’

10 Dec **Carola Knockwood** (*Department of Education - Nova Scotia*)
‘Etuaptmumk / Two-eyed Seeing: Integrating Indigenous and Western Knowledge Systems in Education’



JOURNAL CLUBS

TSI members organise a variety of journal clubs and discussion groups that span across the various disciplines represented at TSI. From general discussions like astro-ph and Random Papers, to more niche groups, there's something for everyone at TSI!

Astro-ph Discussion

Astro-ph is a weekly journal discussion that takes place every Wednesday afternoon at TSI over donuts and coffee. It is an open and intellectual discussion where people can feel free to share something they've learned from an interesting paper without criticism, and where the astronomy community at McGill can learn from one another. It lasts around 30 minutes and is named so because of the arXiv tag from where nearly all our papers come: astro-ph!

Cosmo-ph Discussion

Cosmo-ph is a weekly journal club at TSI focused on keeping up with recent results in observational and theoretical cosmology. Discussions are generally led by graduate students and postdocs, and feature papers that have appeared on the arxiv in the last few weeks. Attendees include researchers at all career stages, with expertise spanning a broad range, from instrumentation, to observations and data analysis, to high-energy particle theory.

Transient Discussion

Transient Discussion is a weekly journal club centred around transients -- astrophysical phenomena that change their brightness over a relatively short time. It brings together researchers from across TSI to discuss any topics that are transients-related e.g., supernovae, pulsars, FRBs, accreting binaries, etc. Each week, a different person walks the group through a relevant paper over the course of about 30 minutes. Transient discussion also occasionally has guest speakers or visitors.

Planet Lunch

Planet Lunch brings together researchers from the Earth & Planetary Sciences, Atmospheric & Oceanic Sciences, and Physics for a weekly lunch discussion. The goal is to apply geology and planetary atmospheres expertise as studied in our Solar System to exoplanets, to achieve a better understanding of what we are learning from the much less detailed observational data on exoplanets. Experience derived from Solar System studies also guides the development of future astronomical facilities to study exoplanets. Each term, the group chooses a theme related to planetary science and each week someone leads a discussion about a paper or a topic related to that theme.

Random Papers Discussion

The goal of Random Papers is to gain a broad view of current astrophysics research. Each week, a script chooses 5 random papers published in the last month in refereed astrophysics journals. This gives a different slice of the literature than the typical astro-ph discussion, with papers that might not otherwise be chosen for discussion. Rather than reading each paper in depth, the goal is to focus on the big picture, with questions such as: How would we summarize the paper in a few sentences? What are the key figures in the paper? What analysis methods are used? Why is this paper being written, and why now?

A WEEK AT TSI

MONDAY

*TSI Lunch Talks
12:00 pm*

*APIERY Discussion
3:30 pm*

TUESDAY

*Grad Student Lunch
with Speaker
3:30 pm*

*TSI Seminar
3:30 pm*

WEDNESDAY

*astro-ph Discussion
3:30 pm*

THURSDAY

*Summer Research
Undergrad Program
12:00 pm*

*Transient Discussion
3:30 pm*

FRIDAY

*cosmo-ph Discussion
3:30 pm*

TSI LUNCH TALKS

The Monday Lunch Talk Series has been a mainstay of TSI's inreach programs since the very beginning, providing a forum for TSI grad students, postdoctoral fellows, and faculty members to give short presentations over lunch and then engage in an extended, informal discussion. Lunch talks are held every other Monday during the Fall and Winter terms, and regularly draw upwards of 35 participants. Any TSI member can give a lunch talk and they also serve as a great opportunity for new students and postdocs to introduce themselves to TSI.

Lunch Talks aim to provide an environment for speakers and attendees alike to explore topics beyond their own research. As such, both the format and content of lunch talks tend to be flexible. Lunch Talks have traditionally welcomed any and all formats of talks, including blackboard talks, interactive workshops, more traditional short research talks; the only "rule" is to be light on prepared material and leave plenty of space for discussion! In terms of content, anything goes as long as it's somewhat under the umbrella of space, space-related topics, or any of the other work we do at TSI, including outreach, education, and EDI. Speakers are welcome to practise a conference talk, tell us about a proposal, brainstorm a new idea, test a workshop, or talk about an interesting side-project or interest.

TSI members appreciate the opportunity to try something new. 2024 started off with a workshop on how to design and populate a research website, led by the TSI Computing Fellow and the TSI Program Admin. Winter 2024 brought us a few talks from external visitors, including professors in other

McGill Faculties and visiting researchers from abroad. We heard from a professor in Medical Physics whose research uncovers the biophysical mechanisms underlying radiation-induced DNA damage and radio-carcinogenesis, which is particularly relevant to astronauts who are exposed to cosmic-ray radiation when they go to space. We also had a fascinating talk from a researcher who uses sunlight during solar eclipses to produce unique photographic images of nature, a particularly timely topic given that it took place the week after the total solar eclipse. TSI members also used the lunch talks as an opportunity to share their outreach projects, with talks about the TSI's plans for the solar eclipse and about an EDI Committee project that highlights contemporary physicists who come from marginalized groups and develops slides on their work that can be incorporate into the syllabi of Physics courses. We also heard from TSI members who had been in the field visiting telescope sites and shared not just their photos, but their insights and lessons learned.

We're thrilled to have TSI Lunch Talks back on our roster, and look forward to the creative topics that TSI members will propose for future iterations!

A Glimpse into TSI Lunch Talks: 2024



- *Workshop: Why you need a research website & how you make one*
- *TSI's Eclipse Day Plans*
- *STAR-DNA: Space Travel Advanced by Research into the Detection of Nucleotide Alterations*
- *Pulsar Timing Arrays : Searching for Gravitational Waves using a Galaxy Sized Detector*
- *New practice of old photography with sunlight.*
- *Contemporary Physicists Project*
- *Observing at l'Observatoire Mont-Mégantic (OMM)*
- *Scintillometry in Steps*
- *Global Warming on the Back of an Envelope*

Left (from top): TSI Lunch Talk avatar, created by the talented Dr. Saniya Heeba; slides for lunch talks; examples of the visualizations created by TSI memebrs during Nicole Ford's lunch talk.

PROFESSIONAL DEVELOPMENT OF TRAINEES

Providing professional development opportunities to ensure that our highly qualified personnel (graduate students, undergraduate students, and postdoctoral researchers) have the skills necessary to succeed in their chosen career paths, either inside and or outside academia, is one of the central tenets of TSI. Our members come from a diversity of institutions, countries, and backgrounds, and bring with them a variety of levels of preparation in the skills necessary to successfully carry out research. We do so through the Undergraduate Summer Researcher Program, the STEADY workshops for graduate students, and the computing workshops offered by the TSI Computing Fellow.

TSI Summer Undergraduate Researcher Program

Every summer since its inception, TSI has hosted undergraduate summer research students from McGill and universities across the world. An integral part of the summer research experience at TSI is the TSI Summer Undergraduate Researcher Program, which consists of weekly professional development discussions and an end-of-the-summer Undergraduate Research Showcase. Due to the success of the program and the impact it has on students, TSI expanded the program to also encompass researchers working in other fields of Physics in 2019, a collaboration that persists to this day. The program is open to all undergraduates conducting summer research with TSI-affiliated or Physics-affiliated professors. In 2024, we hosted over 75 undergraduate summer researchers of which approximately 30 were working with TSI faculty members. Undergraduate researchers are encouraged to take part in all TSI activities, including seminars, journal clubs, and informal discussions. Thanks to the friendly community and welcoming environment of TSI, summer undergraduate researchers gain exposure to many different research areas well beyond their own group.

Professional Development Discussions & Workshops

A unique feature of the TSI summer undergraduate research program is its weekly workshop series. These facilitated discussions are organised by TSI Program Admin Carolina Cruz-Vinaccia and Physics Undergraduate Advisor Kim Metera, in collaboration with TSI and Physics postdocs. The goal of these weekly meetings is twofold: 1) to provide guidance and mentorship for students at the earliest stage of their research careers; and 2) to foster a sense of community amongst the undergraduate summer researchers, providing space for them to connect with peers outside of their immediate research groups.

Discussions centre issues that are relevant to those embarking on their first research experience, focusing on knowledge assumed to be fundamental but that isn't always formally taught. The first set of topics includes an introduction to research life and communicating effectively with your research group, time-management, and structuring a research project. We then target specific skills that are necessary for researchers now and at future stages of their careers, including how to give effective talks, scientific writing, applying to graduate school, and pursuing non-academic careers. Science communication to a variety of audiences is a central focus of our program. Students have multiple opportunities to practise their communication skills to a variety of audiences, from traditional academic talks to fellow physicists to distilling the essence of their research to people outside their field. This year, they also honed their writing skills through workshops on scientific writing and on preparing conference posters. The program takes a holistic approach to what it means to be a researcher, emphasising topics around mental health and workplace climate, such as dealing with frustration, how to tackle impostor syndrome, and equity and inclusion in STEM.



Best Presentation

Ella Iles

Outstanding Presentations

Victory Friesen
Chaitanya Khomar
Laura Reumont

Honourable Mention: Maria Bayder, Audrey Bernier, Mathis Bouffard, Grace Champagne

The community that forms during the summer program is as important as the skills that students learn. Student feedback consistently shows that our summer undergraduate researchers appreciate the opportunity to interact with their peers, especially those in other research groups. Students also form connections to department members further along in their research careers, such as the postdoctoral researchers who facilitate some of the sessions, thus expanding their support networks and their perspectives of what a research career entails.



Summer Undergraduate Research Showcase

We cap off the Summer Program with a Research Showcase, where undergraduate summer researchers present their projects to the entire TSI and Physics Department. This year's showcase took place in person over the course of an entire afternoon, with a Zoom option that also allowed people to attend remotely. This year's showcase was the largest yet; there were four blocks of presentations, where a total of 36 undergraduates gave 5-min talks about their research. The audience was enthusiastic and interactive, asking more questions than we had time for! The showcase was followed by a reception where presenters and audience members alike were able to celebrate a summer of hard work.

The undergraduate research projects covered a wide range of topics that reflected the diverse and interdisciplinary nature of the TSI. The presentations were evaluated by a panel of postdoc and graduate student judges, whose job was made difficult by the impressive quality of the presentations. Eight students received recognitions: one student received the Best Talk award, 3 received Outstanding Presentation, and an additional 4 received honourable mentions!

STEADY Workshop Series

TSI teamed up once again with the McGill Graduate Association of Physics Students (MGAPS) to organise the 2024 edition of the STEADY (Stuff They Don't Teach you in Graduate Physics) workshop series from May 13 to May 17. The STEADY workshop series built on the model of professional development and community-building that has already proven successful for the Summer Undergraduate Researcher Program, adapted to the needs of graduate students. The workshops took place every afternoon for a week, with two 90-minute sessions broken up by a coffee break meant to give students the chance to interact with each other. The workshop leaders were postdoctoral researchers, staff members, and senior PhD students from across Physics and TSI. The sessions covered a range of essential skills, including data management, scientific computing, literature reviews, design, drafting conferencing abstracts, and science communication. The week was capped by a reception on the TSI lawn for workshop participants, instructors, and organizers.

The TSI Program Admin and the TSI Computing Fellow were both part of the organizing team and led a total of 6 workshops between them. The TSI Program Admin ran two workshops on science communication, the first focused on formal academic communication like giving conference talks, and the second on communicating science to people outside of your research field. She also delivered a third workshop on Managing Life as a Researcher,

STEADY 2024 SCHEDULE	
 Bell Room (ERB 103)	
MONDAY MAY 13	
1. Navigating the Command Line	David Gallacher 1:00-2:45PM
2. Formal Science Communication	Cat B. & Carolina CV 3:15-5:00PM
TUESDAY MAY 14	
3. Introduction to Git	Ste O'Brien 1:00-2:45PM
4. Literature Review Fundamentals	April Colosimo 3:15-5:00PM
WEDNESDAY MAY 15	
5. Python Fundamentals - 1	Ste O'Brien 1:00-2:45PM
6. Informal Science Communication	Cat B. & Carolina CV 3:15-5:00PM
THURSDAY MAY 16	
7. Python Fundamentals - 2	Ste O'Brien 1:00-2:45PM
8. Data Visualization	Bobby Pascua 3:15-5:00PM
FRIDAY MAY 17	
9. Data and Its Management	David Gallacher 1:00-2:45PM
10. Doing Science While Being a Human	STEADY Committee 3:15-5:00PM

which addressed topics such as setting expectations, time management, dealing with frustration, and impostor syndrome. The TSI Computing Fellow delivered 3 computational workshops. The first workshop focused on distributed version control with Git. Git is a software that allows developers to maintain a history of a codebase as it evolves over time. This allows developers to track changes to the codebase allowing for versioning, bug tracking and reverting to previous versions of the code without losing one's work. Git also encourages developers to develop aspects of the code in parallel, allowing for contributive code development. This is a critical tool for modern software development. In addition to Git, beginner and intermediate workshops on Python were also delivered. These covered the fundamentals of Python programming, before moving into more complex topics such as multiprocessing, performance and understanding bottlenecks.

Students were able to choose which sessions to attend, and overall 20 students attended the workshop. Feedback from participants for each session was overwhelmingly positive, with a majority expressing satisfaction acknowledging the workshops' benefits for their academic and career goals. The workshops also fostered a strong sense of community and interactions between students and instructors. The workshop series not only facilitated skill development but also increased awareness of departmental resources and strengthened connections within the academic community. Building on this success, MGAPS and TSI are excited to refine and expand the series for future cohorts.

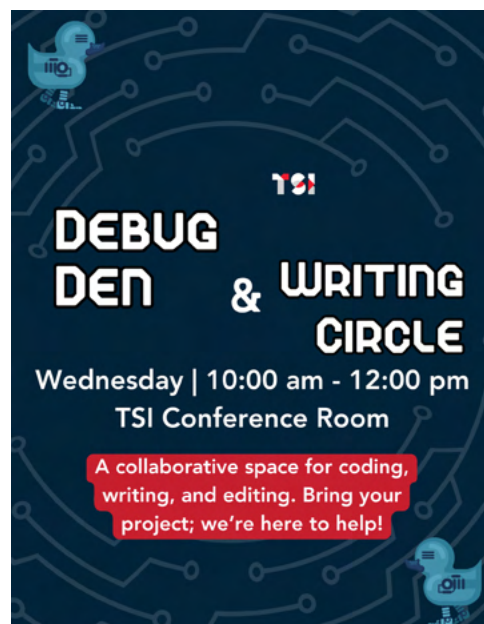
Research Computing Workshops

Recognizing that high-performance computing plays a crucial role in modern astronomical research and in advancing our understanding of the universe, TSI hired a Research Computing Fellow in 2023. The Research Computing Fellow's multi-faceted role includes:

- Engaging in computational research projects with research groups within TSI
- Providing in-house expertise and resources to aid computational research.
- Delivering workshops on programming languages, existing technologies, and services available to astronomers.
- Encouraging best practices by developing guides and testing new technologies.

This year we ran a number of workshops to aid and assist our researchers with their computational needs. Topics such as containerization with Docker and Apptainer, programming (such as introduction and intermediate Python, scientific programming) and website development. In addition to this, the weekly "Debug Den and Writing Circle" continues to grow in popularity, with the main success being evident from the number of repeat visits. The Debug Den and Writing Circle is a weekly informal get together, where folks come to work in a social setting, seek help for issues with code or writing or attend a dedicated session-- such as website development, research proposals, info sessions or preparation sessions for future workshops.

To encourage the visibility of our researchers, a workshop on research websites was held. This workshop had two parts. The first part covered what makes a good research website. Using examples of well-designed websites, an image of a research website was built. We discussed how to highlight research interests, previous work and how to also come across as a well-rounded human by showcasing personal interests and hobbies. The second part of the workshop covered how to actually create a website. This was a practical example, showing how to use MkDocs to produce a website which can be hosted via GitHub pages or any hosting service. This was then followed up with a Debug Den and Writing circle session dedicated to website development.



EQUITY, DIVERSITY & INCLUSION

TSI is committed to equity, diversity, and inclusion (EDI) within the community. Fostering and sustaining an equitable and inclusive environment — one which recognizes the diversity of backgrounds, identities, and expectations— strengthens our community and our research. We aim to build EDI into our activities as we develop them, taking advantage of the fact that we are still a young research institute. So far, we have focused on creating space for discussion of EDI and workplace climate issues, identifying and addressing areas of underrepresentation in the immediate TSI community, and embedding equity into our inreach and outreach activities.

EDI Discussion Group: APIERY Discussion

APIERY Discussion (Astronomy/Physics Inclusion, Engagement, Reimagining pedagogy) is a weekly discussion group run by the TSI Program Admin that focuses on science engagement, education, and pedagogy, in order to make our astronomy and physics spaces and practise more inclusive. APIERY is open to everybody at TSI and any of our member departments, regardless of position within the university or level of knowledge. APIERY runs primarily like a journal club; the discussion is based on an academic paper (though other sources like blogs, podcasts, and YouTube videos may also be used.), but the paper is mainly a jumping-off point to discuss a broader topic. While Astronomy and Physics are in the title, discussions also draw upon and are relevant to other areas of science education. Topic selection is a collective effort; at the beginning of each term, we run a brainstorming session where everyone is encouraged to suggest topics. TSI members are encouraged to suggest topics and lead the discussion if they so choose!

Identifying and Addressing Areas of Underrepresentation

We have made a particular effort to address under-representation at the post-doctoral level, implementing best practices during the application and evaluation process. The changes we implemented yielded results; for the past two years, over 50% of our incoming TSI postdoctoral fellows have been women. For the 2025 cycle, we are looking at how to do the same for racial diversity, particularly to address the lack of Black and Indigenous postdocs. To identify areas where we can do better, TSI teams up the Physics department to develop and deploy a bi-annual climate survey. The climate survey provides insight into the experiences of TSI & Physics to inform the changes needed to create a more inclusive environment. The results of the most recent climate survey are expected in 2025.

Building and Maintaining Relationships

Fostering equity requires building relationships with equity-oriented organisations within and outside McGill , particularly with those that serve marginalised groups in STEM. TSI has collaborated with McGill's Branches program, which works with communities and partners to create sustainable programming for Black and Indigenous youth. This year, we hosted 3 astronomy workshops for Indigenous youth on the McGill campus. Through Branches, we connected with the West Island Black Community Association's STEM program, where we then ran a series of three astronomy workshops in December 2024. The youth in the program used what they learned about astronomy to inform their entries for a robotics competition they participated in in 2025. TSI also collaborates with Dell Technologies's Girls Who Game program and the Physics Department on Science in Space: How to Telescope, which creates inclusive spaces for girls and nonbinary students within STEM. Students in grades 5 and 6 build their astronomy knowledge and scientific thinking skills through designing and building telescopes in Minecraft, with the aid of TSI and Physics graduate student mentors. TSI collaborates on EDI related issues with similar groups both within and outside McGill. TSI works closely with the EDI Committee in the Physics Department and the EDI Committee in Earth & Planetary Sciences, as well as the EDI Committee of the Center for research in astrophysics of Quebec (CRAQ), and the Faculty of Science's Equity and Climate Committee (SECC).

Embedding EDI into TSI Activities

One of the pillars of TSI's approach to EDI is to build it into our activities as we develop them. On the Outreach side, we employ the principles of Inclusive Science Communication to make our programming more inclusive. To that end, we are intentional about the audience we are trying to reach, collaborate with participants on assessing and adapting programs to fit their needs. On the Inreach side, we foreground inclusion in the evaluation process for TSI's Summer Undergraduate Research Awards and in curating the list of speakers for TSI Seminars.

05

PEOPLE

AWARDS

Faculty Members

Adrian Liu

2024 President's Prize for Excellence in Teaching (Assistant Professor) (McGill University)

Daryl Haggard

2024 Arthur B. McDonald Fellowship (NSERC)

Katelin Schutz

2024 CIFAR Azrieli Global Scholar (CIFAR)

Katelin Schutz

2024 Scialog Fellow (Research Corporation for Science Advancement)

Natalya Gomez

2024 Arthur B. McDonald Fellowship (NSERC)

Staff

Carolina Cruz-Vinaccia

2024 President's Awards for Administrative and Support Staff (McGill University)

Postdoctoral Researchers

Richard LaBrie

2024 Raymond L. Lindeman Award (Association for the Sciences of Limnology and Oceanography)

Graduate Students

Aditya Krishna Karigiri Madhusudhan

2024 Murata Family Fellowship (McGill Faculty of Science)

Laurie Amen

FRONT Master's Research Scholarship

Dhvani Doshi

FRONT Master's Research Scholarship

Guillaume Payeur

2024 Dr & Mrs Milton Leong Fellowship (McGill Faculty of Science)

Ian Hendricksen

2024 Mitacs Accelerate Fellowship (Mitacs)

Jennifer Glover

NSERC Canada Graduate Scholarship - Masters (CGS-M)

Kim Morel

Richard H. Tomlinson Fellowship (McGill GPS)

Kit Gerodias

Chalk Rowles Fellowship (McGill Faculty of Science)

Mahesh Herath

FRONT Doctoral Research Scholarship

Mohan Agrawal

Vanier Canada Graduate Scholarship (NSERC)

Shu Zhang

Max Stern Recruitment Fellowships (McGill)

Zarif Kader

NSERC Postgraduate Scholarship – Doctoral

TSI DIRECTORY

Faculty Members

Robert Brandenberger (Phys)
Cynthia Chiang (Phys)
Jim Cline (Phys)
Nicolas Cowan (Phys/EPS)
Andrew Cumming (Phys)
Matt Dobbs (Phys)
Natalya Gomez (EPS)
Daryl Haggard (Phys)
David Hanna (Phys)
Jason Hessels (Phys)

Yi Huang (AOS)
Vicky Kaspi (Phys)
Eve J. Lee (Phys)
Adrian Liu (Phys)
Nagissa Mahmoudi (EPS)
Ken Ragan (Phys)
Katelin Schutz (Phys)
Jonathan Sievers (Phys)
Tracy Webb (Phys)
Lyle Whyte (NRS)

Associate Members Staff

René Doyon (UdeM)
Oscar Hernandez (Phys)
Yasher Hezaveh (UdeM)
Richard Léveillé (EPS)
Laurence Perrault-Levasseur (UdeM)

Carolina Cruz-Vinaccia
Maxime Mutombo
Stephan O'Brien

Postdoctoral Researchers

Lindsay Berkhout (Phys)
Arnab Chakraborty (Phys)
Amanda Cook (Phys)
Christina Davis (NRS)
Cherie Day (Physics)
Wellington De Oliveira Avelino (Phys)

Hannah Dykaar
Saniya Heeba (Phys)
Vigneshwaran Krishnamurthy (Phys)
Richard Labrie (EPS)
Robert Main (Phys)
Ryan Mckinven (Phys)

Joshua Montgomery (Phys)
Thomas Navarro (EPS)
Mason Ng (Phys)
Giang Nguyen (Phys)
Aaron Pearlman (Phys)
Lauren Rhodes (Phys)

Mawson Sammons (Phys)
Debanjan Sarkar (Phys)
Yitian Sun (Phys)
William Tyndall (Phys)
Sophia Waddell (Phys)
Mike Wilensky (Phys)

Graduate Students

Thomas Abbott (Phys)
Michel Adamic (Phys)
Mohan Agrawal (Phys)
Roman Akhmetshyn (Phys)
Avery Albert (NRS)
Laurie Anna Thi-Tâm Amen (Phys)
Daniel Amouyal (Phys)
Bridget Andersen (Phys)
Srobona Basak (Phys)
Vadim Bidula (Phys)
Matteo Blamart (Phys)
Olivia Blenner-Hasset (NRS)
Louis-Jacques Bourdages (NRS)
Nirmalya Brahma (Phys)
Christina Capanelli (Phys)
Matias Castro Tapia (Phys)
Rebecca Cepas de Castro (Phys)
Hoi-Man Kelvin Chan (Phys)
Paul Chouha (Phys)
Vincent Comeau (Phys)
Alice Curtin (Phys)
Rachel Darlinger
Evan Davies-Velie (Phys)
Natnael Debru (Phys)
Caitlin Mackenzie Dewar (Phys)

Taylor Dibblee-Barkman (Phys)
Dhvani Doshi (Phys)
Aline Favero (Phys)
Stephen Fay (Phys)
Nicole Ford (Phys)
Hannah Fronenberg (Phys)
Kit Gerodias (Phys)
Erin Gibbons (EPS)
Jennifer Glover (Phys)
Joshua Goodeve (Phys)
Simon Guichandut (Phys)
Berkin Gurbuz (Phys)
Aryana Haghighi (Phys)
Timothy Hallatt (Phys)
Rebecca Hamel (Phys)
Raphael Hardy (Phys)
Ian Hendrickson (Phys)
Mahesh Herath (EPS)
Lawrence Herman (Phys)
Steven Hsueh (Phys)
Jeff Huang (Phys)
Michael Jafs (Phys)
Naman Jain (Phys)
Patrick Janulewicz (Phys)
Hao Jiao (Phys)

Zarif Kader (Phys)
Aditya Karigiri Madhusudhan (Phys)
Numa Karolinski (Phys)
Melisa Kozey (NRS)
Magnus L'Argent (Phys)
Samuel Laliberte (Phys)
Benoit Laurent (Phys)
Han Lei (Phys)
Anan Lu (Phys)
Matthew Lundy (Phys)
Keza (Kevi) Marimbu (Phys)
Lisa McBride (Phys)
Francis McGee (Phys)
Kyle McGregor (Phys)
Samuel McNichol (EPS)
Marcus Merryfield (Phys)
Kyle Miller (Phys)
Keavin Moore (EPS)
Kim Morel (Phys)
Georgia Mraz (Phys)
Nicole Mulyk (Phys)
Varun Muralidharan (Phys)
Lisa Nasu-Yu (Phys)
Brady O'Connor (NRS)
Robert Pascua (Phys)

Julia Pasiecznik (Phys)
Guillaume Payeur (Phys)
Syed Nayyer Raza (Phys)
Marlon Rivera Valladares (Phys)
Leandro Rizk (Phys)
Maclean Rouble (Phys)
Jean-Samuel Roux (Phys)
Sophia Rubens (Phys)
Ketan Sand (Phys)
Vincent Savignac (Phys)
Hugo Scherer (Phys)
Vishawangi Shah (Phys)
Sarah Silverman (Phys)
Jared Splinter (Phys)
Zach Sumners (Phys)
Maya Tartarelli (Phys)
Afura Taylor (Phys)
Shronim Tiwari (Phys)
Nicolas Vieira (Phys)
Samantha Wong (Phys)
Wenke Xia (Phys)
Qing Hao Xu (Phys)
Shu Zhang (Phys)

Undergraduate Students

Donovan Allen (NRS)
Christopher Barbarie (Phys)
Maria Bayder (Phys)
Audrey Bernier (Phys)
Brandon Bhattacharya (Phys)
Mathis Bouffard (Phys)
Samy Boutros (Phys)

Luca Camarra (Phys)
Ben Coull-Neveu (Phys)
Jamie Cox (Phys)
Lina D'Aoust (Phys)
Evan Davies-Velie (Phys)
Abigail Denney (Phys)
Maya Goss (Phys)

Benjamin Herfray (Phys)
Michael Hetu (Phys)
Dinah Ibrahim (Phys)
Ella Iles (Phys)
Chaitanya Khamar (Phys)
Olivia Locke (Phys)
Justin Mainville (Phys)

Natalia Martorella (Phys)
Natalie Oosterman (Phys)
Antoine Parise (Phys)
William Paty (Phys)
Laura Reumont (EPS)
Sofia Savchyn (Phys)
Félix St-Amour (Phys)

TSI FELLOWSHIPS

Trottier Space Institute Fellowships are made possible by a generous donation from the Trottier Family Foundation to support TSI postdoctoral researchers, graduate students, and undergraduate summer researchers.

TSI Postdoctoral Fellows

TSI Postdoctoral Fellowships recognize excellence in research and are awarded by a committee of faculty members across different fields of TSI.



Libby Berkhout

Physics • Prof. Matt Dobbs' & Prof. Cynthia Chiang's Group

Dr. Berkhout joined TSI in Fall 2024. She designs and tests instruments that focus on understanding the history and evolution of the universe. Using a technique called intensity mapping, these telescopes study the distribution of matter throughout cosmic history. Dr. Berkhout specifically works on the unique engineering challenges these telescopes face as they observe some of the oldest and farthest away light in the universe.



Arnab Chakraborty

Physics • Prof. Matt Dobbs' Group

Dr. Chakraborty joined TSI in Fall 2021. His research focuses on understanding and mitigating instrumental systematics and foregrounds to extract the faint cosmological 21-cm signal. He works on auto-correlation measurements with the Canadian Hydrogen Mapping Experiment (CHIME) and also contributed to developing the calibration algorithm for the upcoming Canadian Hydrogen Observatory and Radio-transient Detector (CHORD).



Saniya Heeba

Physics • Prof. Katelin Schutz's Group

Dr. Saniya Heeba has been a TSI Postdoctoral Fellow since Fall 2021. She studies dark matter phenomenology at the intersection of particle physics and cosmology. Her recent work explores how interactions with an ambient particle environment can alter dark matter properties, potentially revealing new ways to detect it.



Richard LaBrie

EPS • Prof. Nagissa Mahmoudi's Group

Dr. Labrie joined TSI in June 2023. Using the deep ocean as a model for Ocean Worlds, his research explores how microbes survive in extreme environments. Although life is harsh in the deep ocean, microbes fail to use most of the organic carbon (their food source). Using laboratory experiments, he studies how microbes utilize different organic molecules and how they impact the ocean's carbon cycle.



Aaron Pearlman

Physics • Prof. Vicky Kaspi's Group

Dr. Pearlman has been a TSI postdoctoral fellow since Fall 2020. He studies fast radio bursts (FRBs), extragalactic radio flashes of unknown origin. He has been playing a leadership role in building three new Outrigger radio telescopes across North America, which are being used with the CHIME/FRB telescope to localize large numbers of FRBs with sub-arcsecond precision.



Lauren Rhodes

Physics • Prof. Daryl Haggard's Group

Dr. Rhodes has been a TSI postdoctoral fellow since Fall 2024. Her research focuses on using radio telescopes to study transient events associated with the formation and growth of compact objects, which helps to improve our understanding into some of the most extreme environments in the Universe.



Mawson Sammons

Physics • Prof. Vicky Kaspi's Group

Dr. Sammons joined TSI in October 2023. His research focuses on understanding how Fast Radio Bursts (FRBs) propagate through our Universe and how they can be used to explore it. Specifically, he's been investigating how clusters of galaxies gravitationally lens FRBs, a phenomena which could help unveil the origins of FRBs as well as the nature of dark matter itself.



Debanjan Sarkar

Physics • Prof. Adrian Liu's Group

Dr Sarkar joined TSI in August 2023. He uses galaxy surveys and line intensity mapping to study cosmology and astrophysics, focusing primarily on modeling and inference. His current work includes developing a simulation pipeline for the 21-cm signal expected from the CHORD telescope and an inference pipeline for the observations with the HERA telescope. Additionally, he is estimating various summary statistics from LIM observations.



Emilie Storer

Physics • Prof. Jonathan Siever's Group

Dr. Storer joined TSI in Fall 2023. She is working on analyzing the data collected from different telescopes. These telescopes are used to peer back in time to when the universe was much younger and in some ways simpler, to get information about the properties of the universe as a whole and to understand the formation of the first stars and galaxies.



Bailey Tetarenko

Physics • Prof. Daryl Haggard's Group

Dr. Tetarenko has been a TSI Postdoctoral Fellow since Summer 2022. She uses advanced machine learning techniques to construct maps of gas orbiting black holes in some of the most extreme, highly energetic environments within our Galaxy.



Yitian Sun

Physics • Prof. Katelin Schutz's Group

Dr. Sun has been a TSI postdoctoral fellow since Fall 2024. He searches for interactions between dark matter and the visible Universe. Using simulations and Machine Learning, he looks for signals in astrophysical data that may reveal dark matter's particle nature. He is focused on looking for any energy-injecting dark matter, the promising axion model, and the mysterious gamma-ray glow in the Galactic Center that may be of dark matter origin.



Willian Tyndall

Physics • Prof. Cynthia Chiang's Group

Dr. Tyndall joined TSI in Fall 2024. He is interested in developing and testing radio instrumentation for 21cm intensity mapping experiments. He is also developing and improving drone-based calibration techniques for radio telescopes and interferometers.



Sophia Waddell

Physics • Prof. Daryl Haggard's Group

Dr. Waddell has been a TSI postdoctoral fellow December 2024. She studies active galactic nuclei, supermassive black holes with masses millions to billions of times greater than our sun, that lie at the centre of most galaxies. The AGN she studies are special in that they are actively accreting material. To study them, she uses X-ray telescopes, which allow us to probe the hottest material closest to the black hole.



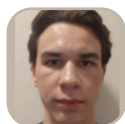
Michael Wilensky

Physics • Prof. Adrian Liu's Group

Dr. Wilensky joined TSI in Fall 2024. He uses measurements from radio interferometers to look for ancient, yet-to-be-detected, signals from the early universe that will tell us about different processes that took place. He specialises in developing formal statistically motivated methods for extracting information from data, such as identifying corrupted data or describing the instrument's behavior.

TSI Graduate Fellows (incoming)

Recognizing the high calibre of our graduate students; every new MSc or PhD student supervised by a TSI faculty member receives a fellowship and the title of TSI Graduate Fellow. As a result, all TSI graduate students receive a portion of their funding from the Trottier Family Foundation's gift. Our incoming 2024 TSI Graduate Fellows are featured below.



Roman Akhmetshyn

Supervisor: Nicolas Cowan
Department: Physics



Rachel Darlinger

Supervisor: Jason Hessels
Department: Physics



Evan Davier-Velie

Supervisor: Matt Dobbs
Department: Physics



Natnael Debru

Supervisor: Katelin Schutz
Department: Physics



Joshua Goodeve

Supervisor: Adrian Liu & Daryl Haggard
Department: Physics



Berkin Gurbuz

Supervisor: Katelin Schutz
Department: Physics



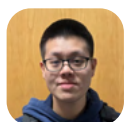
Rebecca Hamel

Supervisor: Daryl Haggard & John Ruan
Department: Physics



Steven Hsueh

Supervisor: Tracy Webb
Department: Physics



Jeff Huang

Supervisor: Jason Hessels
Department: Physics



Numa Karolinski

Supervisor: Andrew Cumming
Department: Physics



Han Lei

Supervisor: Tracy Webb
Department: Physics



Kyle McGregor

Supervisor: Vicky Kaspi & Jason Hessels
Department: Physics



Kim Morel

Supervisor: Adrian Liu
Department: Physics



Nicole Mulyk

Supervisor: Vicky Kaspi & Jason Hessels
Department: Physics



Sachin Pradeep Etakkepravan Thulicheri

Supervisor: Katelin Schutz
Department: Physics



Marlon Josue Rivera Valladares

Supervisor: Katelin Schutz
Department: Physics



Sophia D'Agostino Rubens

Supervisor: Cynthia Chiang & Adrian Liu
Department: Physics



Sarah Silverman

Supervisor: Nicolas Cowan & Natalya Gomez
Department: Earth & Planetary Sciences



Zach Summers

Supervisor: Daryl Haggard
Department: Physics



Wenke Xia

Supervisor: Vicky Kaspi & Jason Hessels
Department: Physics



Shu Zhang

Supervisor: Andrew Cumming
Department: Physics

Not Pictured:

- Daniel Amouyal (Vicky Kaspi • Physics)
- Afura Taylor (Katelin Schutz • Physics)
- Tianyi Xie (Jim Cline • Physics)

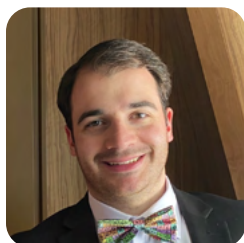
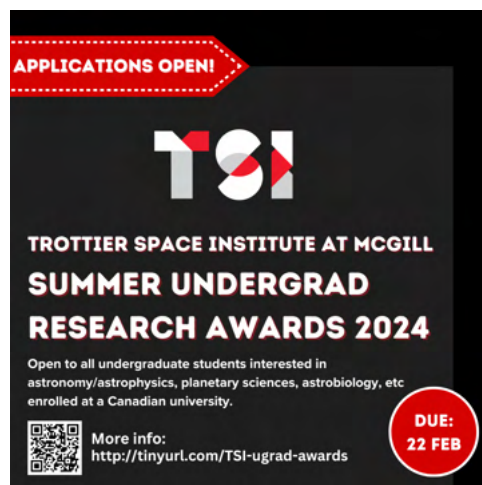
TSI SUMMER UNDERGRADUATE RESEARCH AWARDS

TSI Summer Undergraduate Research Awards (TSI SURAs), established in 2021, fund excellent undergraduate students interested in pursuing research with TSI faculty members. The program's acts as a financial complement to our existing Summer Undergraduate Research Program and aims to make more opportunities for summer research accessible, existing alongside other McGill summer undergraduate fellowship programs (NSERC USRA & McGill SURA). Applications are open to students pursuing an undergraduate degree in relevant fields at any Canadian university, at any point in their programs. In recognition of the growing importance of having access to research opportunities, we actively encourage applications from students in the early stages of their program.

The evaluation process was designed with TSI's commitment to equity, diversity, and inclusion in mind. Applications are evaluated by the TSI Summer Undergraduate Award Committee, which is composed of postdoctoral researchers and the TSI Program Admin (see page 47). The TSI Program Administrator runs in-person and online information sessions for applicants, to ensure that they understand the process regardless of their degree stage or level of previous research experience. Applications are evaluated on four criteria: 1) motivation for pursuing research, 2) preparedness for research, 3) capacity for engagement, and 4) academic excellence. This more expansive definition of success allows applicants to showcase their achievements inside and outside their academic programs. During the deliberation process, the committee also takes care to ensure that a diversity of interests, research fields, and background are represented on the short list of candidates.

In this fourth year of the program, we received over 120 applications from students enrolled in universities across Canada. We successfully expanded our geographical reach; we received applications from students at 17 different Canadian institutions, with over 40% of applicants coming from outside Quebec. We awarded 8 TSI SURAs, all of which were accepted. The 2024 cohort of awardees spans the breadth of research areas at TSI, with students working on everything from black holes to building instrumentation to microbial assays.

You can learn more about the members of our fourth cohort and their experiences with the program, in their own words, below.



Donovan Allen • Thompson Rivers University • Prof. Lyle Whyte
Title: Identification and Characterization of Polar Glacial Ice Microbes

My project involved finding out the types of microbes that exist in glacial ice and determining their tolerance to various abiotic factors. Using this information, we can make inferences about the life's potential elsewhere in the universe, such as the icy moon Enceladus. I had a wonderful summer in Montreal. I got to experience the multitude of events the city has to offer, practice/improve my French, and explore Quebec & Eastern Canada, all while getting the chance to do space-related research and make connections in the unique field of astrobiology!



Samy Boutros • McGill University • Prof. Jon Sievers
Title: Characterizing Earth's Ionosphere to Improve Fast Radio Burst Localizations.

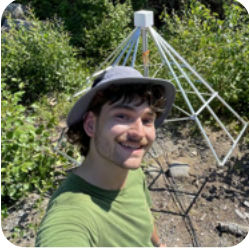
My project aimed to determine the delay radio signals experience within different regions of the Earth's ionosphere using satellite data. This signal delay can provide useful information regarding the location and time dependent total electron content of the ionosphere which is essential to improve the localization accuracy of FRBs. Through this project, I gained an appreciation for data analysis by parsing online data archives for satellite information and worked extensively on creating various Python scripts to analyze satellite trajectories and determine ionospheric total electron content.



Ben Coull-Neveu • McGill University • Prof. Nicolas Cowan

Title: ExoEcho: A Simplistic Noise Estimator for Exoplanetary Observations

I implemented noise calculations in Python to estimate the SNR expected from current and future space-telescope mission, with the goal of improving the target selection for the future exoplanetary survey mission, Ariel. Most of the work consisted of implementing plotting functionality and developing flexible code that can be used for other mission. I really enjoyed the various events throughout the summer and to talk with fellow undergraduate researchers. The sense of community made the struggles a lot more bearable, and talking through problems often made them easier to solve. Also, the weekly presentations about everything, from discussing imposter syndrome in academia to improving coding & debugging skills, proved invaluable, and were another way to improve the sense of community.



Michael Hetu • McGill University • Prof. Cynthia Chiang

Title: Developing an interactive radio-astronomy outreach toy for Indigenous youth across Québec

Funded by a FRQ Dialogue grant, we developed an outreach tool to introduce Indigenous youth across Québec to radio-astronomy and physics at large. The kit we constructed involves a user-assembled acrylic sculpture of our main radio antenna model illuminated by sound-reactive LEDs. I also developed a calibrated noise-source for the front-end electronics of the ALBATROS antenna system, and tested it at our engineering testbed at Station Uapishka near the Manicouagan Reservoir. I not only got to solidify my love and appreciation for outreach, but also discovered a surprising passion for fieldwork; getting the chance to install and test our equipment in remote locations was a highlight. These experiences will inform the style of research I hope to conduct during my PhD.



Chaitanya Khamar • University of Toronto • Prof. Daryl Haggard

Cross Correlations of Multiwavelength Light from Supermassive Black Holes

The goal of my project was to apply statistical machine learning techniques to electromagnetic data in order to cross-correlate the light curves of M87 and Sagittarius A*. Through this, I aimed to uncover the dominant physical processes driving activity around these black holes. One of the most rewarding aspects of the experience was being part of a strong, collaborative research community. The close-knit nature of the team and the way different projects connected gave me a clear sense of how my work contributes to broader scientific efforts.



Justin Mainville • McGill University • Prof. Daryl Haggard

Title: Phase field crystal modelling of nuclear pasta

At the heart of neutron stars lies nuclear pasta, non-spherical clusters of nucleons that may influence many aspects of these astrophysical objects, from the emission of gravitational waves due to their rotation to pulsar glitches. To investigate this intriguing form of matter, we developed a model based on the Phase Field Crystal (PFC) method, a technique commonly used in condensed matter physics to study defect evolution. Using this novel model, we performed large-scale simulations with the open-source software OpenPFC, to explore how defects in nuclear pasta could influence observable phenomena.



Natalie Oosterman • McGill University • Prof. Tracy Webb

Title: Characterizing the mass of IR galaxy clusters detected by the Spitzer Space Telescope at 3.6 μ

My project entailed assigning a large set of galaxies to their respective clusters and carrying out background reductions. This enabled me to convert the flux of each galaxy cluster to a mass using the mass-to-light ratio. I feel that what I got out of participating in summer research at TSI was a warm community of students who learned the research process alongside me and motivated each other. Also, the astrophysics knowledge and programming skills that stemmed from my project will serve me in the future.



Sabrina Wong • McGill University • Prof. Natalya Gomez

Title: Changing Tides in the Arctic Ocean to 2300

My project investigated how tidal amplitudes will change around Greenland and in the Arctic Ocean in the coming decades and centuries. Using projected ice sheet changes to 2300, we computed sea level changes from glacial isostatic adjustment, Greenland Ice Sheet melt, and Antarctic Ice Sheet melt, which were then used to model changes in tidal amplitude. I really enjoyed working in the Gomez Geodynamics Group and learned a lot from my supervisors and other members of the lab. I also appreciated all of the TSI lunches and programming over the summer, as they were always enjoyable, informative, and allowed me to meet other summer researchers in physics or at the TSI.

TSI GOVERNANCE

TSI Board 2024

External Members

Lorne Trottier • Co-founder • Matrox

Marc Guilbert • Chief Financial Officer • Kelvin Zero Inc.

Juna Kollmeier • Staff Scientist • Carnegie Observatories

Internal McGill Members

Chris Manfredi • Provost

Martha Crago • Vice Principal - Research & Innovation

Bruce Lennox • Dean, Faculty of Science

Fellowships Committee

Adrian Liu [Chair] • Assistant Professor, Physics

Daryl Haggard • Associate Professor, Physics

David Hanna • Professor, Physics

Nagissa Mahmoudi • Assist. Professor, Earth & Planetary Sciences

Jonathan Sievers • Associate Professor, Physics

TSI Seminar Committee

Jason Hessels [Co-Chair] • Professor, Physics

Tracy Webb [Co-Chair] • Associate Professor, Physics

Matt Dobbs • Professor, Physics

Saniya Heeba • Postdoctoral Fellow, Physics

Vignesh Krishnamurthy • Postdoctoral Fellow, Physics

Erica Lucas • Postdoctoral Fellow, Earth & Planetary Sciences

Mawson Sammons • Postdoctoral Fellow, Physics

Carolina Cruz-Vinaccia • TSI Program Administrator

TSI Members

Vicky Kaspi • TSI Director; Professor, Physics

Jim Cline • Professor, Physics

Daryl Haggard • Professor, Physics

Nagissa Mahmoudi • Assist. Professor, Earth & Planetary Sciences

Aaron Pearlman • Postdoctoral Researcher, Physics

Leandro Rizk • MSc Student, Physics

Undergraduate Summer Awards Committee

Carolina Cruz-Vinaccia • TSI Program Administrator

Vignesh Krishnamurthy • Postdoctoral Fellow, Physics

Richard LaBrie • Postdoctoral Fellow, Earth & Planetary Sciences

Kimberly Metera • Undergraduate Advisor, Physics

Stephan O'Brien • Postdoctoral Fellow, Physics

Mawson Sammons • Postdoctoral Fellow, Physics

Emilie Storer • Postdoctoral Fellow, Physics

Outreach Committee

Thomas Brunner • Associate Professor, Physics

Carolina Cruz-Vinaccia • TSI Program Administrator

Catherine Boisvert • PhD Student, Physics

Alice Curtin • PhD Student, Physics

Valentina Mazzotti • PhD Student, Physics

Kimberly Metera • Undergraduate Advisor, Physics

Georgia Mraz • PhD Student, Physics

Samantha Wong • PhD Student, Physics

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IMPACT

FACILITIES USED BY TSI MEMBERS

Laboratory & Computing Facilities

Béluga Supercomputer

(Lee, Liu, Kaspi)

Owned and administered by Digital Research Alliance of Canada (formerly Compute Canada) and Calcul Quebec

Canadian Advanced Network for Astronomical Research (CANFAR)

(Dobbs, Hessels, Kaspi)

DRAC Computing and Storage Facilities

(Haggard, Lee, Liu)

Owned and administered by Digital Research Alliance of Canada (formerly Compute Canada).

Guillimin Supercomputer

(Brandenberger, Haggard, Huang, Kaspi, Gomez, Ragan, Hanna)

Owned and administered by Digital Research Alliance of Canada (formerly Compute Canada) and Calcul Quebec

Graham Supercomputer

(Lee, Brandenberger)

Owned and administered by Digital Research Alliance of Canada (formerly Compute Canada)

The Gamma-ray Astronomy Laboratory

(Hanna, Ragan)

Develops instrumentation for astroparticle and particle physics detectors.

The McGill Arctic Research Station (MARS)

(Whyte, Chiang)

Supports field research activities consisting of sample acquisition, some limited laboratory microbial and molecular analyses, and in situ analyses for microbial activity. Also used for low-frequency radio astronomy observations.

The McGill Cosmology Instrumentation Laboratory

(Dobbs)

Develops complex digital and ultra-low noise analog cryogenic electronics for astrophysics. Includes separate labs for radio instrumentation and mm-wave instrumentation.

McGill Radio Lab

(Chiang)

Develops radio instrumentation for observational cosmology experiments.

Narval Supercomputer

(Haggard)

Owned and administered by Digital Research Alliance of Canada (formerly Compute Canada) and Calcul Quebec

Prof. Whyte's Laboratory

One of the few laboratories worldwide with the facilities to perform fundamental studies at subzero temperatures for molecular biology/microbiology and astrobiology-related investigations.

Ground-based Telescopes

Anglo-Australian Telescope

(Webb)

Australian Telescope Compact Array
(Haggard)

Canada-France-Hawaii Telescope
(Cowan, Haggard, Webb)

CHIME - The Canadian Hydrogen Intensity Mapping Experiment
(Dobbs, Kaspi)

CHORD - The Canadian Hydrogen Observatory and Radio transient Detector
(Chiang, Dobbs, Kaspi, Liu, Sievers)

Event Horizon Telescope Array
(Haggard)

European Southern Observatory: La Silla 3.6 m Telescope
(Cowan)

Gemini Observatory
(Cowan, Haggard, Webb)

Green Bank Telescope, Radio wavelengths
(Kaspi)

The Hydrogen and Intensity Real-time Analysis eXperiment (HIRAX)
(Chiang, Dobbs, Sievers)

The Hydrogen Epoch of Reionization Array (HERA)
(Liu, Sievers)

James Clerk Maxwell Telescope
(Haggard)

Jansky Very Large Array, Radio wavelengths
(Haggard, Kaspi, Webb)

Large Binocular Telescope
(Webb)

Large Millimeter Telescope Alfonso Serrano
(Webb)

Magellan Telescopes
(Webb)

Observatoire du Mont-Mégantic
(Cowan)

POLARBEAR & the Simon's Array, mm-wave, Cosmic Microwave Background
(Dobbs)

Probing Radio Intensity at high-Z from Marion (PRIZM)
(Chiang, Sievers)

Pulsar backend recording and analysis system for CHIME
(Kaspi, Dobbs)

South Pole Telescope, mm-wave, Cosmic Microwave Background
(Dobbs)

W.M. Keck Observatory
(Haggard, Webb)

VERITAS Gamma-ray Observatory
(Hanna, Ragan)

Space-based Telescopes

NASA/James Webb Space Telescope
(Cowan, Haggard)

NASA/Hubble Space Telescope
(Cowan, Haggard, Lee, Webb)

NASA/Kepler Mission
(Cowan)

NASA/Swift X-ray Telescope
(Haggard, Kaspi)

NASA/Neutron Star Interior Composition Explorer, NICER
(Haggard, Kaspi)

NASA/NuSTAR X-ray Mission
(Haggard, Kaspi)

NASA/Chandra X-ray Observatory
(Haggard, Kaspi, Webb)

ESA/XMM-Newton X-ray Telescope
(Haggard, Kaspi, Webb)

NASA/Fermi mission
(Haggard, Ragan)

NASA/Transiting Exoplanet Survey Satellite
(Cowan, Lee)

FACULTY COLLABORATIONS

ATMOSPHERIX • *(Cowan)*

Ariel (European Space Agency's M4 mission) • *(Cowan, Lee)*

The Canadian Data Intensive Astrophysics Platform (CanDIAPL) • *(Haggard)*

CSA's CASTOR - Cosmological Advanced Survey Telescope for Optical and Ultraviolet Research • *(Haggard, Cowan)*

CHIME The Canadian Hydrogen Intensity Mapping Experiment • *Cosmology (Dobbs) and Fast Radio Burst (Kaspi, Dobbs)*

CHORD The Canadian Hydrogen Observatory and Radio transient Detector • *Chiang, Dobbs, Kaspi, Liu, Sievers*

D3A: Deep Dish Development Array • *(Chiang, Dobbs, Sievers)*

ESA's Transient High Energy Sources and Early Universe Surveyor (THESEUS) • *(Haggard)*

Event Horizon Telescope Collaboration • *(Haggard)*

Next Generation Event Horizon Telescope Collaboration • *(Haggard)*

GBNCC The Green Bank North Celestial Cap Pulsar Survey • *(Kaspi)*

Habitable Worlds Observatory • *(Cowan)*

HELIX - High Energy Light Ion eXperiment • *(Hanna)*

HERA - The Hydrogen Epoch of Reionization Array • *(Liu, Sievers)*

High-altitude Aerosols, Water vapour, and Clouds (HAWC satellite) • *(Huang)*

HIRAX • *(Chiang, Dobbs, Sievers)*

JINA/CEE Joint Institute for Nuclear Astrophysics - Centre for Evolution of the Elements • *(Cumming)*

Laser Interferometer Space Antenna (LISA) Consortium (European Space Agency's L3 mission) • *(Haggard)*

Massive Ancient Galaxies At $z > 3$ NEar-infrared Survey (MAGAZ3NE) • *(Webb)*

MIST - Mapper of the IGM Spin Temperature • *(Chiang, Sievers)*

NASA's Advanced X-ray Imaging Satellite (AXIS) • *(Haggard)*

NASA's Neutron Star Interior Composition Explorer (NICER) • *(Kaspi)*

NASA's PRobe Far-Infrared Mission for Astrophysics (PRIMA) • *(Haggard)*

NIRISS Near-InfraRed Imager and Slitless Spectrograph, James Webb Space Telescope • *(Cowan)*

NIRPS Near Infrared Planet Spectrograph • *(Cowan)*

POLARBEAR • *(Dobbs)*

PITCH BLACK - JCMT Large Program • *(Haggard)*

PLANETS • *(Cowan)*

PRIZM/ALBATROS • *(Chiang, Sievers)*

The Simons Observatory • *(Sievers)*

SpARCS the Spitzer Adaptation of the Red-Sequence Cluster Method • *(Webb)*

SPIRou Spectro-Polarimetre InfraRouge Science Legacy Survey • *(Cowan, Lee)*

SPT The South Pole Telescope • *(Dobbs)*

The Simons Array • *(Dobbs)*

Vera C. Rubin Observatory • *(Haggard)*

VERITAS • *(Hanna, Ragan)*

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