DUNLAP INSTITUTE *for* ASTRONOMY & ASTROPHYSICS

2023
A YEAR IN REVIEW

Dunlap Institute for
Astronomy & Astrophysics
UNIVERSITY OF TORONTO

WHO WE ARE

The Dunlap Institute for Astronomy & Astrophysics at the University of Toronto is an endowed research institute with over 80 faculty, students, postdocs, and staff.

WHAT WE DO

At Dunlap, we design and build innovative technology like telescopes, spectrographs, and supercomputers to pursue ground-breaking astronomical research.

We also provide world-class training to students, and we run science and astronomy outreach events to engage the public across the Greater Toronto Area and beyond.

WHAT WE STUDY

Our team studies optical, infrared and radio instrumentation, dark energy, large-scale structure, cosmic magnetism, time-domain science, galaxy evolution, the early Universe, and more.

OUR COMMITMENT

The Dunlap Institute is committed to making science, training, and outreach productive and enjoyable for everyone.

Background Photo: Parrish Freeman on Unsplash.

Prof. Suresh Sivanandam

DIRECTOR'S MESSAGE

This year was one of reflection, change, and sadness. Dunlap celebrated its 15th year anniversary, which was a joyous occasion where multiple alumni returned for a two-day event. Through short talks, they presented their career paths and how much of an impact the Institute made on them. There were common stories about how the Institute provided them a safe space to grow and try new things, which ended up being central to their careers even after they left. These stories reminded me of what makes the Institute special: its core focus on innovation and impact on its people. Most importantly, there was a sense of family.

At the 15th anniversary reception, our benefactors, J. Moffat Dunlap and David Dunlap, and their families had the opportunity to meet our many dozens of current students, postdocs, faculty, and alumni. I remembered that the Institute had rather humble beginnings with only two Dunlap fellows arriving as its first members in 2009. I came a year later as its third fellow along with the first Dunlap director, Prof. James Graham. I was thankful that J. Moffat Dunlap was able to attend and see the success that emerged from his generous gift. He regretfully passed away later in the year. At his memorial service, his family members highlighted how the creation and continued successes of the Dunlap Institute were a great sense of pride for him.

Lastly, our long-time director, Prof. Bryan Gaensler, bid farewell at this same celebration after a more than eight-year stint shepherding the Institute through its formative years. It was a moving moment as we had all grown close over the years. While his departure has been sad, Bryan had laid down a strong foundation for the Institute that will allow it to continue its upward trajectory over the next 15 years.

Photos from left to right:

J. Moffat Dunlap at the 15th Anniversary Celebration.

David M. Dunlap at the 15th Anniversary Celebration.

Prof. Keith Vanderlinde and Alice Chow.

Prof. Bryan Gaensler speaks at the 15th Anniversary Celebration.

Credit: Alicia Richardson.

OUR RESEARCH

Although it is our home in the universe, much of the Milky Way is hard to understand from our view inside it. In 2023, Dunlap Institute PhD candidate Amanda Cook turned to another one of astronomy's great mysteries for a new way to measure our galaxy's outer edges.

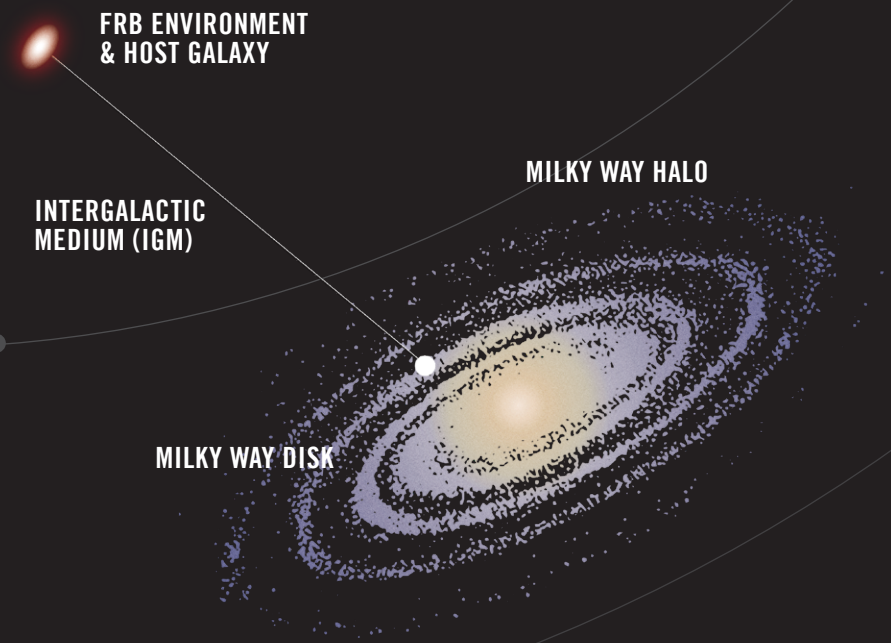
Cook used a large sample of fast radio bursts (FRBs) collected by the Canadian Hydrogen Intensity Mapping Experiment (CHIME) radio telescope to study the amount of gas in the Milky Way "halo," which stretches outwards into space by around half a million light-years in all directions.

FRBs are brief, powerful blasts of radiation emitted by distant, still unknown sources. They generate both high frequency and low frequency radio waves. As these waves pass through gases on their journey towards us, they slow down—especially at higher frequencies. The delay between high and low frequencies as they hit our telescopes effectively smears the radio burst's signal. The more gas these signals pass through on their journeys, the greater the smearing.

"Using smearing to study the universe is like using your home heating bill to work out what the weather must have been like over the winter," says Cook.

By studying FRBs at different distances from Earth, Cook and her team found much less gas in the Milky Way halo than previous models predicted. They hope to create a 3D map of the Milky Way halo as even more signals are discovered.

"Improving our knowledge of the Milky Way halo helps us learn about the formation of our Galaxy as a whole."



Left: An illustration of a radio signal from a fast radio burst, moving toward telescopes on Earth. Credit: J. Josephides/Swinburne, University of Technology, with minor edits from the Dunlap Institute.

Right: PhD student Amanda Cook.

OUR TECHNOLOGY

CHIME / CHORD

In 2023, the Canadian Hydrogen Intensity Mapping Experiment (CHIME) team reported the detection of cosmic hydrogen at redshift 2.3 in cross-correlation with Lyman-alpha forest catalogs, marking the highest-redshift hydrogen intensity mapping measurement to date. In the field of fast radio burst (FRB) science, CHIME/FRB has also made notable strides this year, including the reported discovery of 25 new repeating FRB sources. The CHIME/FRB Outriggers program for FRB localization is advancing rapidly: the first outrigger telescope has commenced full science operations, the second outrigger is concluding its commissioning stage, and the construction of the third and final outrigger is set to begin shortly. Simultaneously, the Canadian Hydrogen Observatory and Radio-transient Detector (CHORD) is in the final stages of designing and validating enabling technologies, with the construction of CHORD foundations initiated this fall.

OPTICAL INFRARED

The Gemini Multi-Object Infrared Spectrograph (GIRMOS) project is moving towards the completion of its overall design early next year. Soon after our final design review, we will begin construction of the instrument, which is expected to last two years. Another major milestone this year involved developing closer ties with the Gemini Observatory, which included a site visit by our project staff this summer and the signing of a memorandum of understanding this fall. Thanks to Gemini's support, GIRMOS is gearing up to be the next big facility instrument for Gemini North.

Dunlap has also been contributing to the development of an updated adaptive optics system for the 6.5-meter MMT telescope in Arizona, called the MAPS project. In collaboration with the University of Arizona, Dunlap graduate students Jacob Taylor and Robin Swanson have been working on commissioning a new wavefront sensor and developing the calibration algorithms for the MMT adaptive optics system this past year. The system has seen first light and is in the process of being refined for scientific observations.

CIRADA

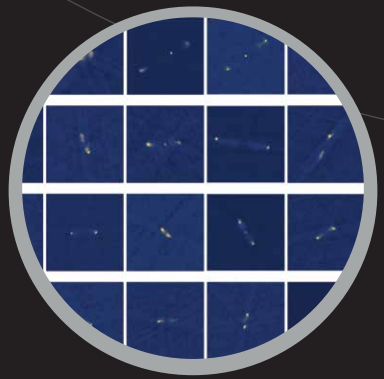
The Canadian Initiative for Radio Astronomy Data Analysis (CIRADA) is a $10M program intended to create sophisticated new software products and catalogues for studying the sky at radio wavelengths. In 2023, CIRADA released a new catalogue from the Very Large Array Sky Survey (VLASS) of 17,000 double radio galaxies with associated machine-learning classifications, along with a value-added list of more than 500,000 single-component radio sources. CIRADA has now also generated self-organizing maps of sources detected in VLASS; these maps classify sources into 100 different classes based on their distinct morphologies, allowing researchers to create samples of galaxies based solely on morphology.

Photos from left to right:

CHIME/FRB outrigger currently being commissioned at the Green Bank Observatory in West Virginia. Credit: Kevin Bandura.

The GIRMOS and Gemini Observatory team stand in front of the Gemini Observatory atop Hawai'i's Maunakea. Credit: Scott Christie.

Examples of double radio galaxies identified by CIRADA. Credit: Gordon et al. (2023).



SuperBIT

The SuperBIT balloon-borne telescope completed its science flight in the spring of 2023. The payload was launched by NASA and the Columbia Scientific Balloon Facility from Wanaka, New Zealand on April 15, 2023, and circled the southern hemisphere 5 ½ times at an altitude of 33km before flight termination over Patagonia, Argentina on May 25, 2023. SuperBIT imaged dozens of astronomical targets, including a collection of galaxy clusters. SuperBIT's resolution of 0.3 arc seconds over a 0.11 square degree field of view—better than any ground-based telescope—will permit the determination of the distribution of dark matter around these galaxy clusters using weak lensing. Analysis has begun in parallel with the design and construction of GigaBIT—a next generation balloon borne telescope with three times better resolution, twice the field of view, and ten times the collecting area of SuperBIT.

Left: The Dragonfly Telephoto Array pointed up at a dazzling night sky. Credit: Imad Pasha.

Right: Members of the SuperBIT team prepare for a flight test. Credit: SuperBIT.

Dragonfly

The Dragonfly Telephoto Array is a mosaic design telescope, consisting of 48 Canon commercial lenses, specialized to observe the low surface brightness universe. During 2023, the Dragonfly team completed 80% of its ultrawide survey, which will map the full footprint of the Sloan Digital Sky Survey. The narrowband imaging expansion to the array called the Dragonfly Spectral Line Mapper, is also now complete. Consisting of an additional 120 lenses with ultra-narrow bandpass filters, the Dragonfly Spectral Line mapper is optimized to observe diffuse gas in emission, with the goal of directly imaging the Circumgalactic Medium in emission. Currently, half of the Dragonfly Spectral Line Mapper array is on sky taking data with the other half in the calibration phase.

LUVCam

Internally funded, the Little UltraViolet Camera (LUVCam), which will be flying in two missions, is Dunlap's first foray into space instrumentation. The first LUVCam design and build is nearly complete, and environmental and performance testing of critical components has begun in Dunlap's newly built space simulation chamber. LUVCam is being prepared for an orbital Technology Demonstration flight on the GRBBeta CubeSat in 2024. After that it will do breakthrough science, serving as the focal plane cameras for the Quick UltraViolet Imager for Kilonovae (QUVIK) mission, a 33 cm two-channel UV telescope, with launch circa 2027. Work continues to push the LUVCam qualified performance into the far UV regime, to support more partners interested in using LUVCam, and to develop our own novel space telescopes leveraging this new capability.

OUR OUTREACH

The Dunlap Institute has returned to in-person outreach in a big way! In 2022-23, we hosted Astronomy on Tap T.O. three times, most recently on November 10 with an audience of over 450 people—our largest in-person event since the pandemic. This past summer, Dunlap continued its partnership with Visions of Science to offer research opportunities to low-income and marginalized youth. The youth completed projects on the habitability of extra-solar planets and galaxy classification and presented their results at the STEM Expo.

16 new episodes of Cosmos From Your Couch were published in 2023, including three special episodes for Pride month. The latest release in our Astronomy in Focus series, featuring the SuperBIT Telescope, is now our most viewed video!

The past year has also been all about preparing for the upcoming solar eclipse on April 8, 2024. Our partners at Discover the Universe have been hosting eclipse training for teachers in Ontario, Quebec, and the Atlantic provinces while also preparing over 200,000 eclipse glasses to be sent to schools in these provinces! The Dunlap Institute has procured an additional 50,000 eclipse glasses to be distributed in the Toronto area.

Right: Margaret Ikape presents at Astronomy on Tap T.O. Credit: Alicia Richardson.

OUR TRAINING

In 2023, the Dunlap Institute held the 10th installment of its widely recognized Introduction to Astronomical Instrumentation Summer School, drawing dozens of top students from both undergraduate and graduate levels and around the world. Globally recognized expert instructors led students through foundational material in lectures each morning, while the afternoon lab experiences gave students their first taste of instrument development, from radio interferometry to optical wavefront sensing. Professional development activities and a night visit to the David Dunlap Observatory capped off the program.

We also co-hosted the DADDAA-Dunlap Summer Undergraduate Research Program (SURP), pairing 28 undergraduate students with astronomers at the University of Toronto. SURP students got first-hand experience contributing to ongoing research projects, from designing a receiver chain for a 46-meter radio telescope to analyzing the distribution of ultra-light axions.

Left: Students, staff, and faculty of the Dunlap Institute Summer School. Credit: Michael Pereira.

Cover Photo: A false-colour image taken by the SuperBIT telescope soon after launch in visible and ultra-violet light of the "Tarantula Nebula" — a neighbourhood of the Large Magellanic Cloud where new stars are being born. Credit: SuperBIT.

Smaller Cover Photo: Dunlap Institute faculty and Dunlap Fellow alumni gather at the 15th Anniversary Homecoming Celebration. Credit: Michael Pereira.

Back Cover Photo: Messier 83, also know as the The Southern Pinwheel spiral galaxy, taken by the SuperBIT telescope. Credit: NASA/SuperBIT.

Smaller Back Cover Photo: Prof. Laurie Rousseau-Nepton as featured in the NFB's North Star.

JOIN US!

Please visit our website or check us out on social media to find out more about what's going on at Dunlap!

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