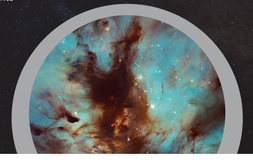
Prof. Suresh Sivanandam
Acting Director

DIRECTOR'S MESSAGE

This past year at the Dunlap Institute has been one of cautious optimism. With the successful rollout of COVID-19 vaccinations, we have been slowly returning to normalcy, with many of us only seeing each other in person after an 18-month hiatus. It has been a time of rejuvenation and reinvigoration.

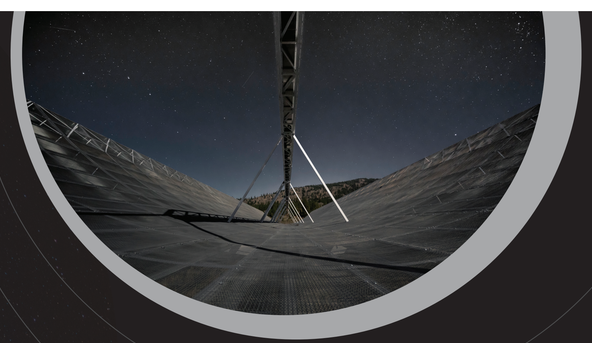
Over the past year, our faculty, staff, and students have remained highly productive even with significant challenges imposed by virtual collaborations and limited lab access. This year was also a first for an all-virtual Dunlap Instrumentation Summer School. Cancelled in 2020 due to COVID, we were motivated to maintain the momentum of the Summer School. The new virtual format was very successful, with more than 100 students across the world able to attend the program and interact with world experts in instrumentation.

CHIME has also been a tremendous success, with the CHIME / fast radio bursts (FRBs) team being awarded the 2022 Berkeley Prize by the American Astronomical Society. In another major development, Professor Keith Vanderlinde and his team secured Canada Foundation for Innovation (CFI) funding for the follow-on of CHIME: the CHORD telescope array. One of the largest investments in university developed instrumentation, CHORD will be a game changer in radio astronomy.



Background Photo: Ivana Cajina on Unsplash.

Bottom Right: The Flame Nebula. NASA, ESA, and N. Da Rio (University of Virginia). Processing: Gladys Kober (NASA/ Catholic University of America).



The CHIME telescope in Penticton, BC. Credit: Andre Renard.

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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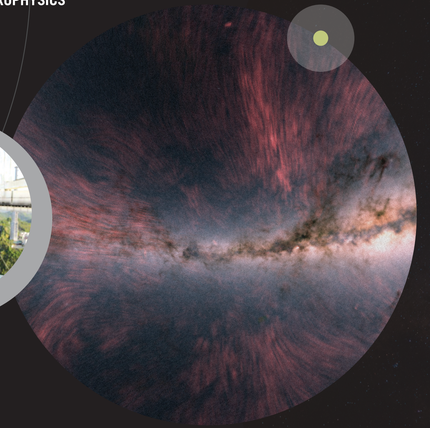
DUNLAP INSTITUTE *for* ASTRONOMY & ASTROPHYSICS



Dunlap Institute for Astronomy & Astrophysics
UNIVERSITY OF TORONTO

2021
A YEAR IN REVIEW

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. We pursue ground-breaking astronomical research using these facilities.

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.

Cover Picture: Research Associate Jennifer West (pictured) published a research paper in 2021 that proves our solar system may be surrounded by a giant magnetic tunnel.

Larger Cover Picture: The sky as it would appear in radio polarized waves with the orientation of the local magnetic field (red) shown superimposed on Gaia's all-sky view of our Milky Way Galaxy. Credit: Dominion Radio Astrophysical Observatory/Alla Eloaf Planck Collaboration/ESA/Gaia/DPAC.

DUNLAP INSTITUTE
for ASTRONOMY & ASTROPHYSICS

OUR RESEARCH

We are pleased with Dunlap's research achievements for 2021. One story comes from graduate student Ariel Amaral. Amaral has led a team of researchers who have helped define the strength of magnetism in the Universe. What they've discovered is that the largest magnetic fields in the Universe are about three billion times weaker than a fridge magnet.

Unlocking the mysteries of magnetism is necessary for our understanding of many astronomical processes, such as the formation of stars, planets, and galaxies.

Amaral and her colleagues applied a technique called Faraday rotation to study the effect magnetic fields have on light. The amount that this polarization of light rotates is directly related to the strength of the magnetism at play.

Her work was published in the spring of 2021.

Astronomers know very little about the Universe's magnetism, but this may be changing.

"We'll soon have millions of sources to perform the same technique that we used," explains Amaral. With these sources, astronomers will be able to more precisely measure the properties of magnetism – like scale, turbulence, and strength.

"This will tell us what was going on at earlier times in the Universe"

— **Ariel Amaral**

Top Background: Springel & others / Virgo Consortium.

Top Foreground: Graduate Student Ariel Amaral and her research team fix the feed in the Algonquin Radio Observatory dish. Credit: Ariel Amaral.

Bottom: Dunlap Fellows Kartheik Iyer, Josh Speagle, and Lamiya Mowla working outdoors with SURF students Rebecca Cepeas de Castro, Alicia Savelli, Daniella Monroe, Juan Pablo Alfonzo, and Jeff Shen on galaxy evolution in August 2021. Credit: Kartheik Iyer.

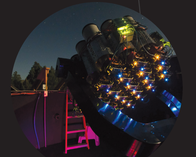
OUR TECHNOLOGY

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. In 2021, CIRADA released new tools to identify and classify complex sources in radio images, a mock cube generator for simulating observations of gas in galaxies, and an image cut-out service for the rotation measure sky. In 2022, we will release an all-sky transient marshal, an image cut-out server for the new Rapid ASKAP Continuum Survey (RACS), software to efficiently correct radio data for ionospheric Faraday rotation, and an updated and improved multi-epoch catalogue of sources found in the Very Large Array Sky Survey (VLASS).

Dragonfly

In 2021, the Dragonfly team completed another 30% of the ultrawide survey, which is mapping the full footprint of the Sloan Digital Sky Survey. A large expansion to the telescope is underway (what we are calling the Dragonfly Spectral Line Mapper, or DSLM), with plans for an additional 120 lenses with ultra-narrow bandpass filters. The team has written four papers on the dark matter content of Ultra Diffuse Galaxies, two reporting science results from the pathfinder DSLM, one on the stellar halos of edge-on galaxies, and one describing a new stellar point-spread function modelling technique.

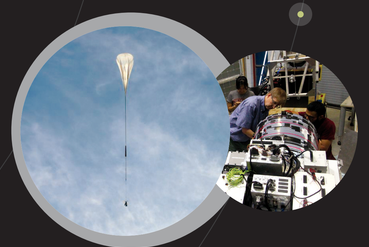


The Dragonfly telescope. Credit: Pieter van Dokkum.

SuperBIT

SuperBIT is a balloon-borne telescope that takes images of the sky. Flying above over 99% of the Earth's atmosphere, SuperBIT's images have a full-image resolution only otherwise achievable by space telescopes such as the Hubble Space Telescope, but with a much smaller budget. Despite the COVID-19 pandemic, SuperBIT's team of students have repaired damage from their 2019 test flight, and have upgraded several key features of the instrument, including the main science camera.

SuperBIT is scheduled to make its months-long science flight from New Zealand in the spring of 2023. SuperBIT will use gravitational lensing (the distortion of images of very distant galaxies caused by the bending of space by massive objects closer to us) to map out otherwise undetectable dark matter around giant clusters of galaxies. The long term goal is to help unlock the mysteries of dark matter and dark energy.



Balloon-borne telescope SuperBIT launches in 2019. Credit: SuperBIT research team.

Dunlap Associate Barth Netterfield and Graduate Student AJ Gill align the SuperBIT telescope in the Toronto High Bay. Credit: SuperBIT research team.

CHIME & CHORD

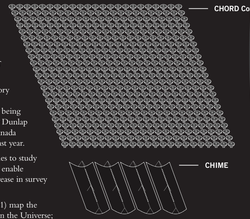
CHIME has managed to continue regular operations without any major disruptions of our observing or upgrade schedule throughout the pandemic. The CHIME/fast radio bursts (FRBs) team has published several scientific papers, including our first year catalog containing almost 500 new FRB sources. The CHIME/FRB Outrigger program was also fully funded by the Gordon and Betty Moore Foundation with the first of three eventual stations is nearing completion.

Building on the successes of CHIME, The Canadian Hydrogen Observatory and Radio-transient Detector (CHORD), one of the largest Canadian university led astronomical instrumentation projects ever commissioned, is being co-led by Professor Keith Vanderlinde. A high-profile success story for the Dunlap Institute, the $23M project was successful in securing funding from the Canada Foundation for Innovation (CFI) and provincial funding agencies in the past year.

CHORD will leverage advances in digital and radio-frequency technologies to study the transient and cosmic-radio sky in previously impossible ways. This will enable unprecedented observational capabilities, from an order-of-magnitude increase in survey speed, to unparalleled precision in the localization of FRBs.

This facility will address three of the most exciting areas in physics today: (1) map the distribution of matter on cosmic scales to trace the evolution of structure in the Universe; (2) elucidate the nature of fast radio bursts; and (3) probe fundamental physics parameters, such as testing General Relativity.

Dominion Radio Astrophysical Observatory



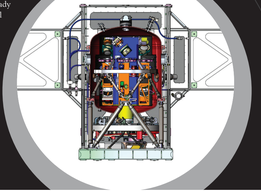
Credit: Vincent MacKay.

GIRMOS

The Gemini Infrared Multi-Object Spectrograph (GIRMOS) is a $20M CFI-funded program to develop a cutting-edge infrared spectroscopic instrument for the Gemini Observatory.

Despite the challenges over the past year, the GIRMOS team has been progressing well in developing the preliminary design for the instrument. GIRMOS has now become a major priority for the Gemini Observatory and has continued to generate significant interest within the Gemini user community. GIRMOS will be the key instrument that will utilize the Gemini's upcoming adaptive optics (GNAO) facility. Consequently, the GIRMOS and GNAO teams have been working in close collaboration over this period to develop both systems in an integrated fashion.

The GIRMOS team has also made steady progress in retiring significant technical risks in the project. The GIRMOS adaptive optics (AO) team has successfully implemented a testbed to prove the viability of the AO methods. Similarly, the optics team has been able to demonstrate the ability to manufacture the highly complex optical component at the heart of the instrument: the image slicer.



GIRMOS assembled view with cryostat internal components exposed (Credit: GIRMOS Team).

OUR TRAINING

In 2021, the Dunlap Training and Mentoring Committee became the broader DADDAA Training and Mentoring Committee. Faculty co-leads Suresh Sivanandam and Renée Hlozek were joined by Daven Cocroft, Sam Berek, Jennifer Chan, Mathew Dionyssiu, Joshua Speagle, Ayush Pandhi, and Rachel Friesen.

This now more diverse committee organized several training workshops and panels, including panel discussions on applying for jobs in a crisis, careers outside of academia, tips for writing job applications, and workshops on mentoring by Movement Consulting. This optional mentoring program consists of postdocs paired with faculty mentors, and graduate students paired with postdoctoral fellow mentors. We were pleased to have 11 faculty, 11 postdocs and 18 graduate students enrolled. We hope to have an even larger program next year.

After a hiatus for 2020 due to COVID-19, the Dunlap Summer School (DSS) returned in 2021 in an all-online version. While we look forward to running the in-person version of this school in the future, the remote access enabled us to have the largest DSS ever, with 125 students across 31 countries.

Community members in Mattagami, Quebec look through Dunlap Star Finders during the June 10, 2021 eclipse. Credit: Lyne Chevrefils.

Students join in via Zoom from across the world, for Dunlap Institute's first remote summer school.

OUR OUTREACH

In 2021, we explored new ways of connecting with our audience online and by mail. To celebrate the annual solar eclipse in June, we and our partners at Discover the Universe (DU) distributed 25,000 pairs of eclipse glasses to individuals and schools in every province and territory of Canada. DU worked with Indigenous outreach organizations and translators to deliver materials in six Indigenous languages commonly spoken throughout the path of the eclipse. This project lays the groundwork for even bigger things to come in the leadup to the total solar eclipse of 2024.

All summer long, Dunlap partnered with Visions of Science to offer virtual research experiences for low-income and marginalized youth. The youth explored everything from exoplanet dynamics to the way citizen scientists learn as they participate in research projects. In September, the online version of our annual Planet Party attracted thousands of people from across North America to stargaze with us, play trivia games, and win great prizes. While this pandemic year has been a challenging time to connect with the public, we have welcomed the opportunity to connect in new ways. We look forward to connecting in person again in 2022!