

**A DECADE OF THE
DUNLAP INSTITUTE**
2017-2018 ANNUAL REPORT



Prof. Bryan Gaensler

Cover

Two neutron stars merge, generating gravitational waves detected on Earth.

Credit: Robin Dienel; Carnegie Institution for Science

U of T astronomy graduate student Matt Young at the South Pole.

Credit: Matt Young

Prof. Bryan Gaensler

Prof. Bryan Gaensler and faculty, postdocs, students and staff at 2017 Dunlap Retreat for three days of science, training and team building.



Director's Message

This year marks ten years since the establishment of the Dunlap Institute. This special edition of our annual report celebrates this milestone, and looks back through the many highlights of the past decade.

The Dunlap Institute's mandates are to develop and apply innovative astronomical instrumentation and technology, to prepare the leaders of the future, and to bring the excitement of the Universe to the public. In all three of these areas, we have made colossal progress over the last ten years, culminating in some extraordinary achievements in the past 12 months.

Two frontier projects in which we have invested enormously over many years are the Wide Integral-Field Infrared Spectrograph (WIFIS) and the Canadian Hydrogen Intensity Mapping Experiment (CHIME). In the past year, both WIFIS and CHIME achieved "first light", and are now beginning to produce scientific data.

WIFIS is the work of Dae-Sik Moon, Suresh Sivanandam and many others, and has the largest field-of-view ever developed for an infrared integral-field

spectrograph. It is now taking data at the Bok Telescope in Arizona, and will revolutionise our understanding of supernova remnants, young stellar objects and galaxies. CHIME is a unique radio telescope in British Columbia, with Keith Vanderlinde and Ue-Li Pen playing key roles. It will survey the largest volume of the Universe ever mapped, and aims to solve the mysteries of dark energy and of fast radio bursts. After years of hard work on these projects, our teams are extremely excited to now see the resulting data streams come to life. Get ready for the many scientific discoveries that will soon follow.

Two big new projects also got underway this year, thanks to \$23M in funding from the Canadian Foundation for Innovation (CFI). Suresh Sivanandam will lead the development and construction of the Gemini InfraRed Multi-Object Spectrograph (GIRMOS), which will produce spectacularly detailed, new 3D images of star clusters and high-redshift galaxies, and which will serve as a prototype for even more powerful instruments to be developed for the Thirty Meter Telescope. I will

“The Dunlap Institute’s mandates are to develop and apply innovative astronomical instrumentation and technology, to prepare the leaders of the future, and to bring the excitement of the Universe to the public.”

use CFI funding to establish the Canadian Initiative for Radio Astronomy Data Analysis (CIRADA), which aims to convert the enormous raw data streams from CHIME and other new radio telescopes into digital databases that all astronomers can use to make new discoveries. We’re now beginning to hire new staff and develop new technologies within both these projects. Expect to hear quite a lot more about GIRMOS and CIRADA in future annual reports.

The past year was also one of several major scientific results. Most notable was the discovery of the merging neutron star system GW170817, a result that *Science* magazine designated its 2017 Breakthrough of the Year. Dunlap Fellow Maria Drout was part of the team that discovered the first-ever electromagnetic counterpart to a gravitational wave event. Her detailed follow-up of the fading ultraviolet, optical and infrared afterglow proved that neutron star mergers produce many of the heavy elements in the Universe. Meanwhile, Bob Abraham and the Dragonfly team continue to redefine our understanding of how galaxies form and evolve, with the discovery of a galaxy that seems to contain almost no dark matter. Within the standard accepted model of galaxy formation, such objects should not exist; the wider community is now furiously debating these measurements and what they imply.

Our commitment to training students and young researchers continued to strengthen this year, in the form of a structured five-year training plan. We now offer formal mentoring to all students and postdocs, and have run focused training sessions on data analysis, job applications, imposter syndrome, and proposal assessment.

We also had some fantastic career outcomes, with Jeff Chilcote, Rachel Friesen and Maria Drout all landing faculty positions, and Tessa Vernstrom, Nolan Denman and Jeilai Zhang accepting prestigious prize fellowships. Congratulations to all these young scientists on being recognised for their outstanding research and hard work.

It has been a big year for our outreach and education programs. The centrepiece was the solar eclipse of August 2017. Even though Toronto was not under the path of totality, we were able to generate enormous interest from the public and from the media, centred on the eclipse session that we ran at the Canadian National Exhibition (CNE). We distributed around 30,000 pairs of eclipse glasses, and many of our faculty, postdocs and students were interviewed for TV, radio and newspapers across the country. Mark down April 8, 2024 in your calendars, because that will be the date of an even bigger solar eclipse: this time Hamilton will be under the path

of totality, and you can be assured the Dunlap Institute will be at the centre of the action.

Meanwhile, Astronomy on Tap T.O. continues to grow in popularity, with our new bigger venue at the Great Hall having to put up the full-house sign every time. Our *Discover the Universe / À la découverte de l’univers (DU)* program also continues to expand; this year Mike Reid and Julie Bolduc-Duval were awarded an NSERC PromoScience grant that will allow DU to continue its core program of teacher training, to build a national network of DU Ambassadors, and to develop expertise in Indigenous astronomy (in collaboration with Indigenous Knowledge Holders).

Spectacular progress is made by spectacular people, and the Dunlap Institute is extremely fortunate to have employed so many talented and dedicated individuals over the last ten years. Across all our programs, our signature has been scientific rigour and uncompromising quality. I particularly highlight the work of our superb administrative team, led by Alice Chow, which makes everything we do possible.

As we look to the next decade and beyond, there is much to celebrate and even more to look forward to. Please join us on our journey of discovery as we continue to push back the frontiers of understanding and to share them with the wider community.

A Decade of the Dunlap Institute 2008 - 2018



MAY 2008

The Dunlap Institute is established
at the University of Toronto.

SEPTEMBER 2010

Prof. James Graham is appointed
as the Dunlap's first director.

Credit: Rita Leistner



2012

Dunlap scientists, led by Dunlap Fellows
Dr. Nick Law, Dr. Jérôme Maire and Dr.
Suresh Sivanandam, study the feasibility
of an astronomical observatory at
the Polar Environment Atmospheric
Research Laboratory on Ellesmere Island
in the Canadian High Arctic.

Credit: Jérôme Maire; Dunlap Institute





JUNE 5 2012

Over 5000 people fill U of T's Varsity Stadium to witness the last transit of Venus of the century using transit-viewing glasses and telescopes. Organization of the event is led by the Dunlap's Outreach Coordinator, Prof. Michael Reid.



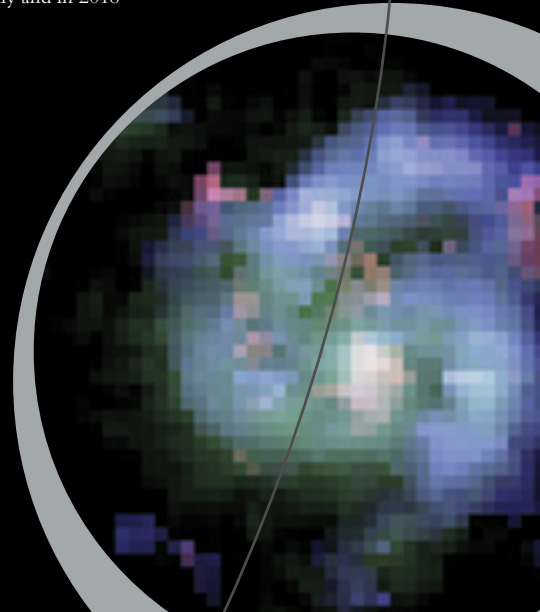
JULY 2012

Students from around the world attend the inaugural Dunlap Institute Introduction to Astronomical Instrumentation Summer School, to learn the fundamentals of telescopes, as well as optical, infrared, x-ray and long-wavelength instrumentation. The school attracts some 40 students annually and in 2018 is in its seventh year.

JULY 2012

In a paper published in the journal *Nature*, Dunlap Fellow Dr. David Law and colleagues announce the discovery of a galaxy 10.5 billion light-years from Earth, one of the most distant to exhibit "grand design" spiral arms.

Credit: Dr. David Law; Dunlap Institute



21 MARCH 2014

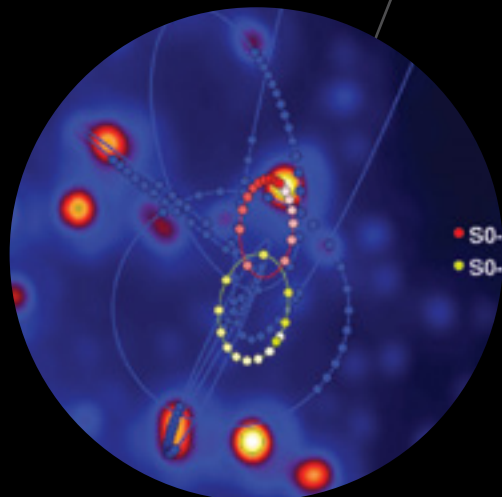
The Dunlap Prize is awarded to Neil deGrasse Tyson for sparking a love of astronomy in millions around the world. Tyson delivers the Dunlap Prize Lecture to a capacity crowd of 1500 in U of T's Convocation Hall.



OCTOBER 2012

In a paper published in the journal *Science*, Dunlap Fellow Dr. Tuan Do and his colleagues at the UCLA Galactic Center Group announce the discovery of a star that orbits the supermassive black hole at the centre of the Milky Way Galaxy every 11.5 years, the shortest such orbital period known.

Credit: Keck/UCLA; Galactic Center Group





JANUARY 2015

Prof. Bryan Gaensler is appointed director of the Dunlap.

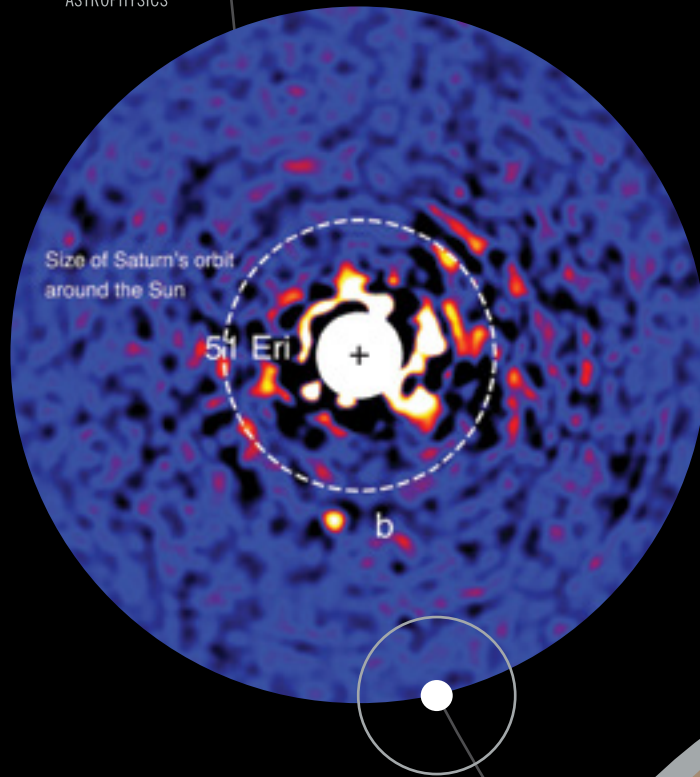
SEPTEMBER 2014

Astronomy on Tap, which originated in New York City, comes to Toronto, organized by U of T astronomy students and postdocs. The Toronto event is eventually organized and sponsored by the Dunlap, and grows into one of the largest "Taps" in the world, routinely attracting 500 people, four times a year, for a lively night of talks, games and conversation.

MARCH 2015

After years of development at the Dunlap, a new instrument joins the search for extraterrestrial intelligence (SETI): Prof. Shelley Wright and colleagues' NIROSETI, or Near Infrared Optical SETI detector.





AUGUST 2015

The Gemini Planet Imager (GPI) collaboration announces its first discovery: 51 Eri b, an exoplanet orbiting a star 96 light-years from Earth. Astronomers at the Dunlap, including Prof. James Graham, played a key role in developing GPI, a ground-breaking instrument designed to directly image planets orbiting stars other than the Sun.

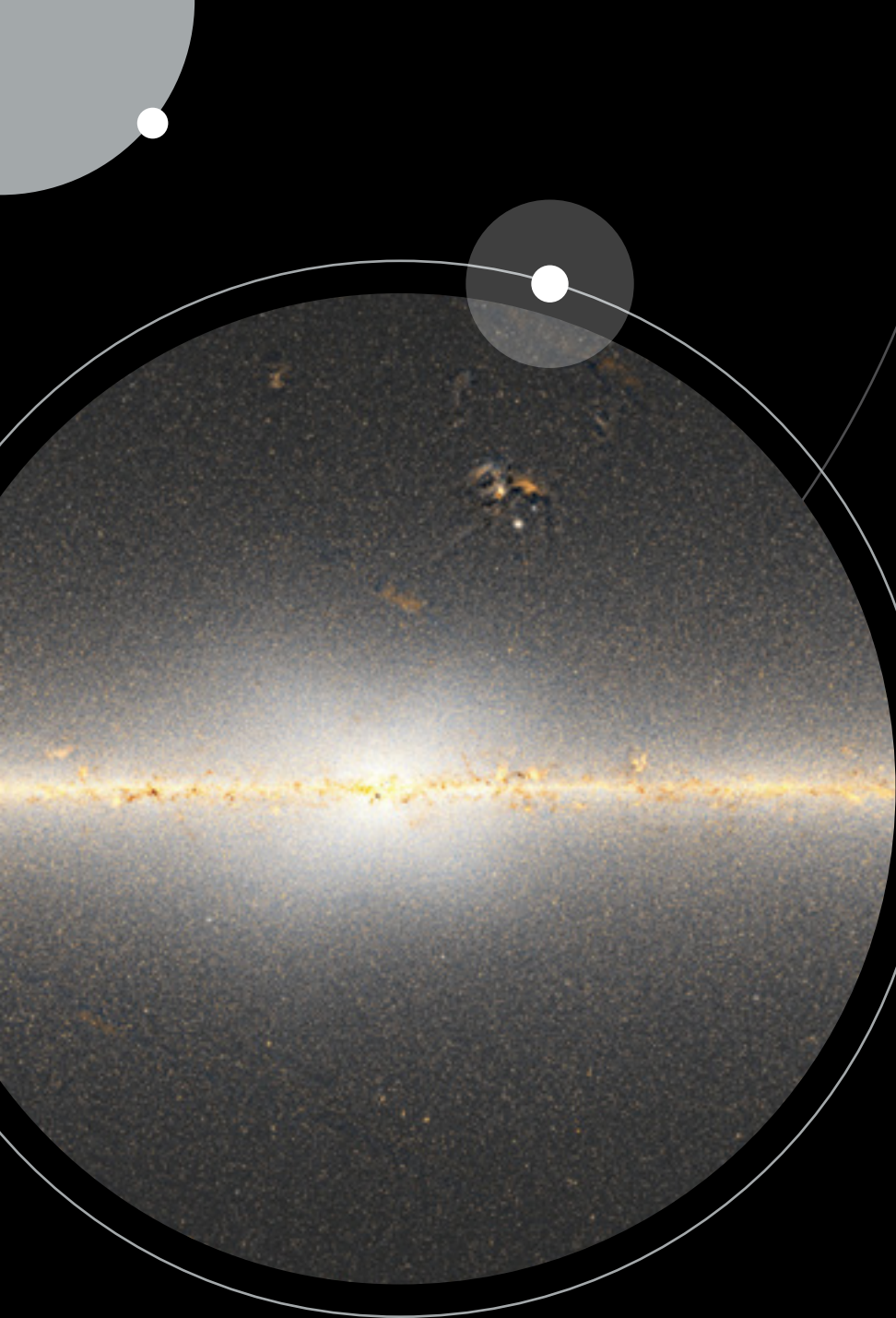
Credit: J. Rameau (UdeM) and C. Marois (NRC Herzberg)



SEPTEMBER 2015

Thousands pack U of T's King's College Circle at the Dunlap's Supermoon Total Lunar Eclipse Viewing Party. Clouds diminish the visibility of the eclipse, but not the crowd's enthusiasm.

Credit: Lorne Bridgman



2016

The Dunlap partners with Julie Bolduc-Duval and Discover the Universe to provide English and French resources, workshops and webinars to help teachers across the country provide astronomy instruction to their students.

Credit: Julie Bolduc-Duval



JULY 2016

Dr. Dustin Lang and his colleague uncover the strongest evidence yet that an enormous X-shaped structure made of stars lies within the central bulge of the Milky Way Galaxy.

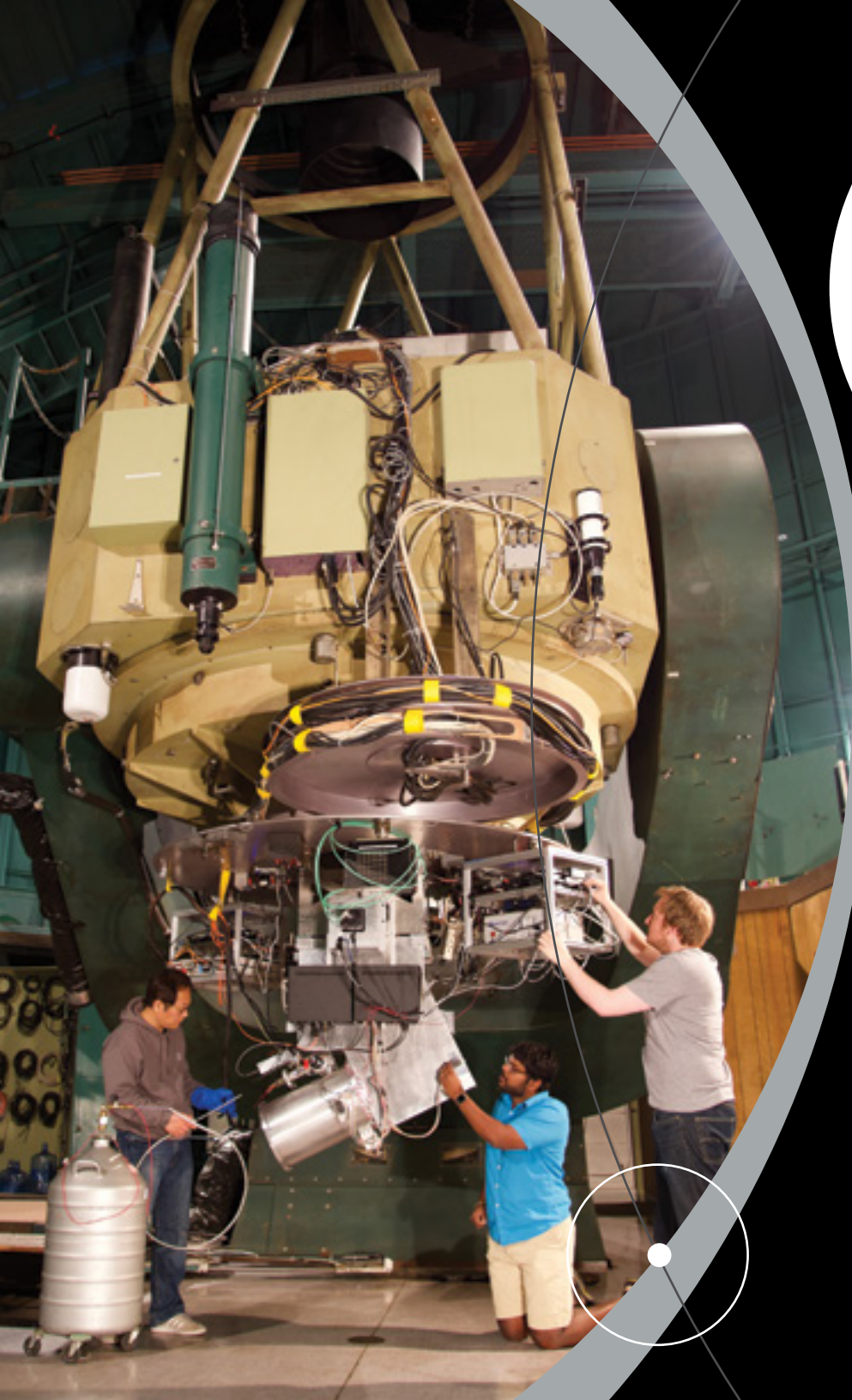
Credit: Dr. Dustin Lang; Dunlap Institute



FEBRUARY 2017

Using data from the Gaia mission to map the positions of stars in the Milky Way Galaxy, Dunlap Fellow Dr. Jason Hunt and his colleagues discover evidence that our Galaxy's spiral arms will eventually disappear.

*Credit: NASA/JPL-Caltech/R. Hurt
SSC/Caltech*

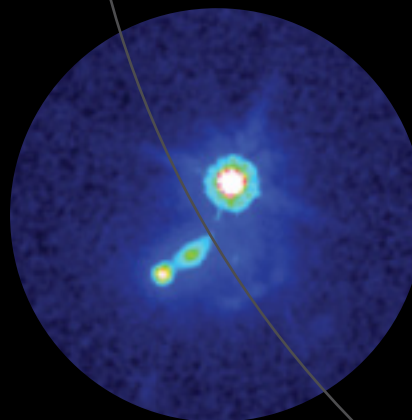


JUNE 2017

The Greenbank Ammonia Survey, co-led by Dunlap Fellow Dr. Rachel Friesen, releases an image of a 50-light-year long filament of ammonia molecules in the Orion Nebula. The survey will map major, nearby star-forming regions.

JULY 2017

After years of development by the Dunlap and an international collaboration, the Wide Integral-Field Infrared Spectrograph achieves “first light.” It is designed to study colliding galaxies, stellar nurseries and the remnants of exploded stars.



AUGUST 2017

Dunlap Director, Prof. Bryan Gaensler and colleagues measure the magnetic field of a galaxy five-billion light-years from Earth, evidence that cosmic magnetism appeared early in the life of the Universe.

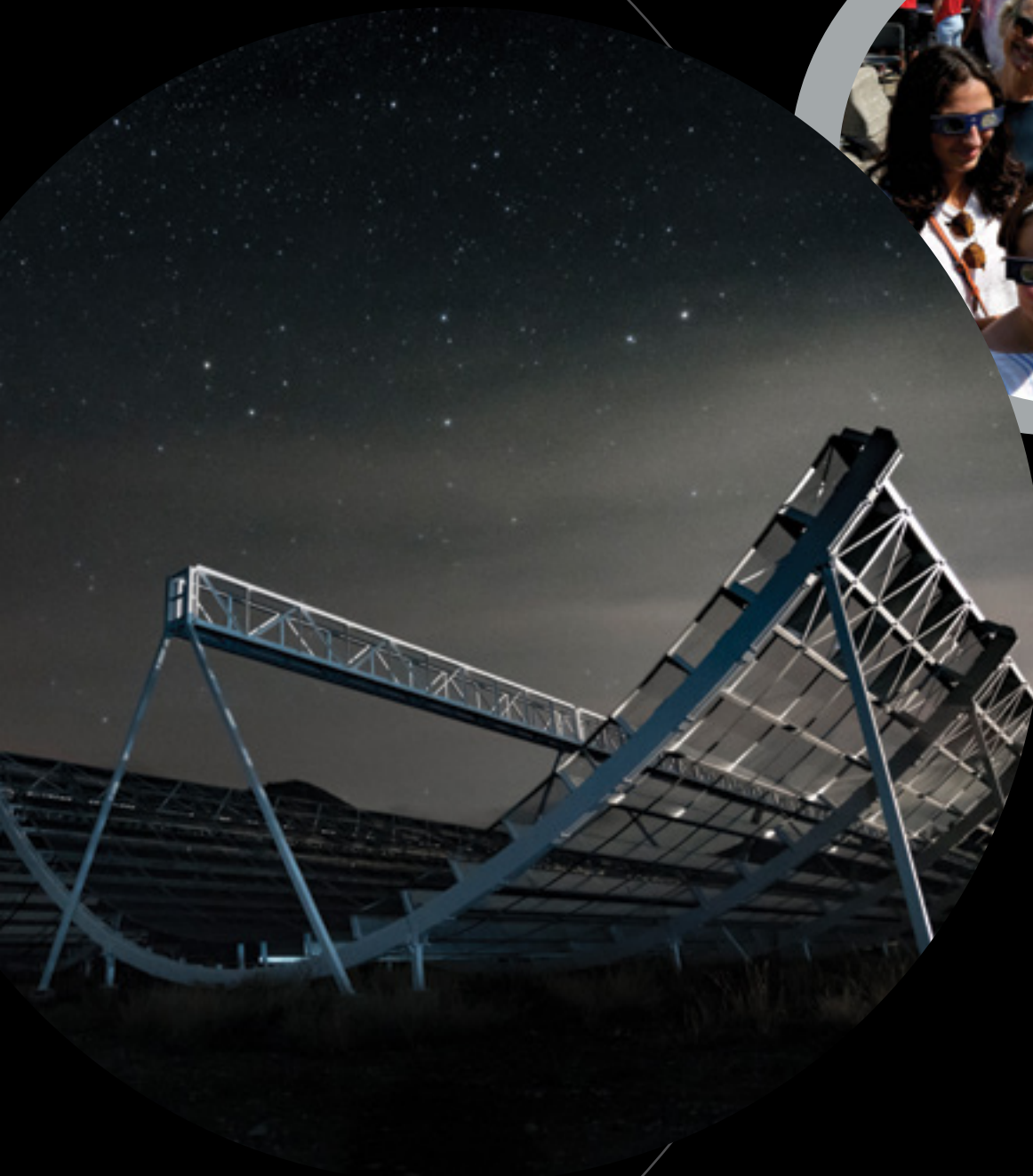
21 AUGUST 2017

Thousands view a partial eclipse of the Sun at the Dunlap's eclipse viewing event at the Canadian National Exhibition.



SEPTEMBER 2017

CHIME, the Canadian Hydrogen Intensity Mapping Experiment, begins its mission to create the largest three-dimensional map of the Universe after years of development and construction at the Dominion Radio Astrophysical Observatory in B.C. At the Dunlap, Prof. Keith Vanderlinde leads the team of students and postdocs working on CHIME.



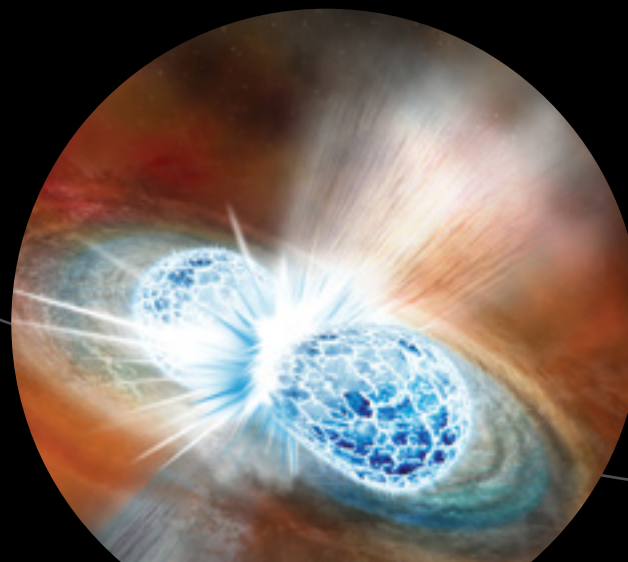
Dunlap Institute Starfinder



OCTOBER 2017

Projects led by Prof. Bryan Gaensler and Prof. Suresh Sivanandam receive a combined \$23 million in funding for the development of a radio astronomy data centre called CIRADA and a multi-target, infrared spectrograph for Gemini Observatory called GIRMOS.

Credit: Image: Gemini Observatory; AURA



OCTOBER 2017

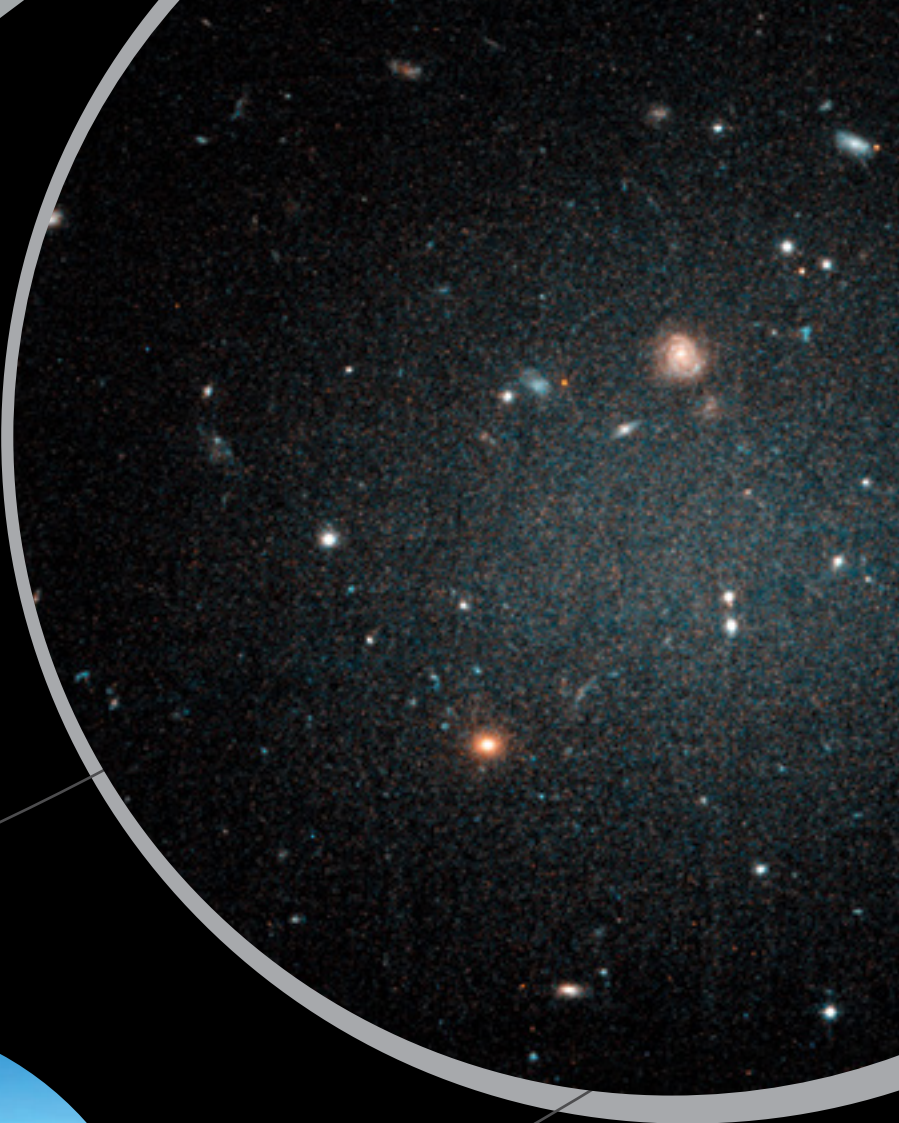
Hubble Fellow and Carnegie-Dunlap Fellow Dr. Maria Drout is a member of the team that is the first in history to detect the visible counterpart of an event that generates gravitational waves detected on Earth—the merger of two neutron stars.

Credit: Robin Dienel; Carnegie Institution for Science

MARCH 2018

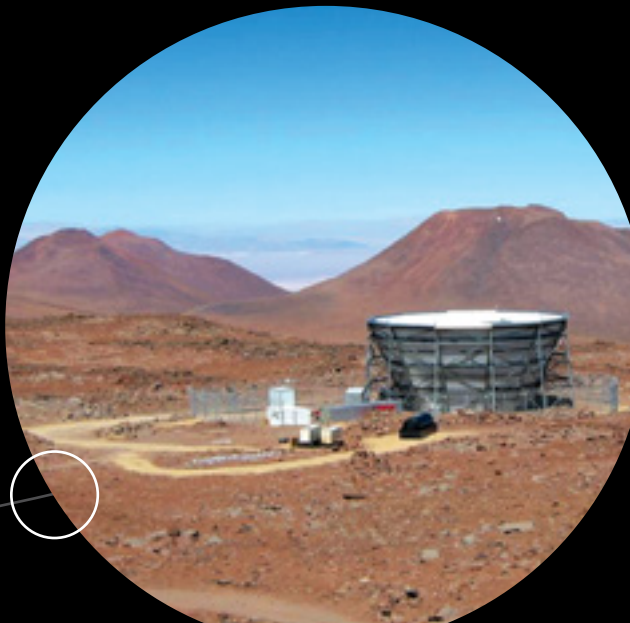
Prof. Roberto Abraham and colleagues announce the discovery of a one-of-a-kind galaxy, one that appears to contain virtually no dark matter, using the Dragonfly Telescope Array.

Credit: NASA; ESA; P. van Dokkum



WINTER 2018

U of T astronomy grad student Matt Young (cover) spends two months in Antarctica helping to install a new camera on the South Pole Telescope, the camera he and Dunlap Fellow Dr. Tyler Natoli (l.) helped build.



FEBRUARY 2018

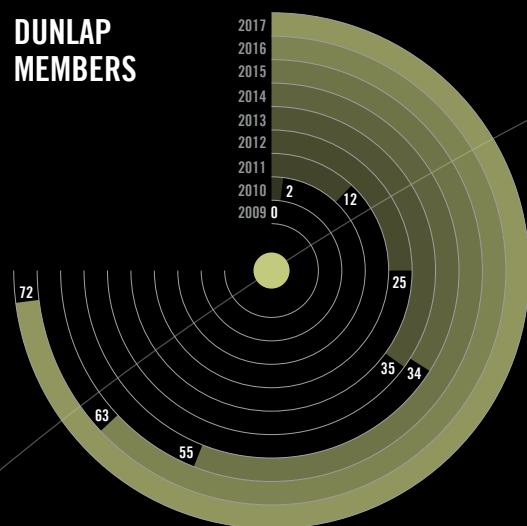
Prof. Renée Hlořek becomes chair of the Collaboration Council of the Simons Observatory to be built in the high Atacama in Northern Chile on the current site of the Atacama Cosmology Telescope (pictured). The Observatory will provide a powerful means to study the Cosmic Microwave Background and the early, inflationary Universe.

Credit: Atacama Cosmology Telescope

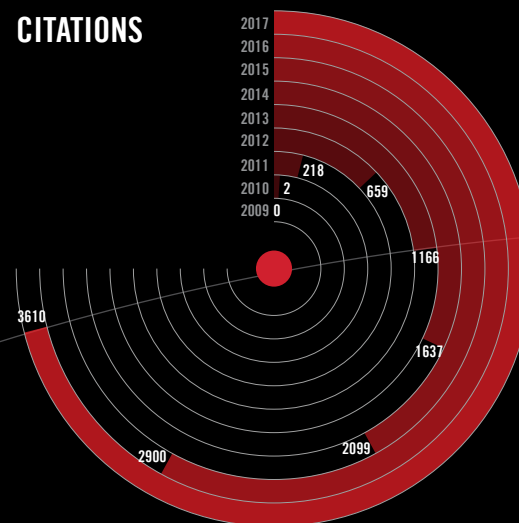
Dunlap by the Numbers 2008 - 2018

All figures unofficial. All figures are per year; i.e. not cumulative. For clarity, fiscal years are shown as the latter year; for example, 2010-2011 is shown as 2011.

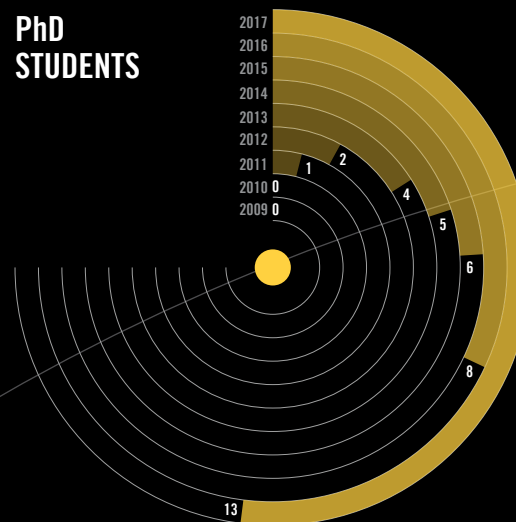
DUNLAP MEMBERS



CITATIONS

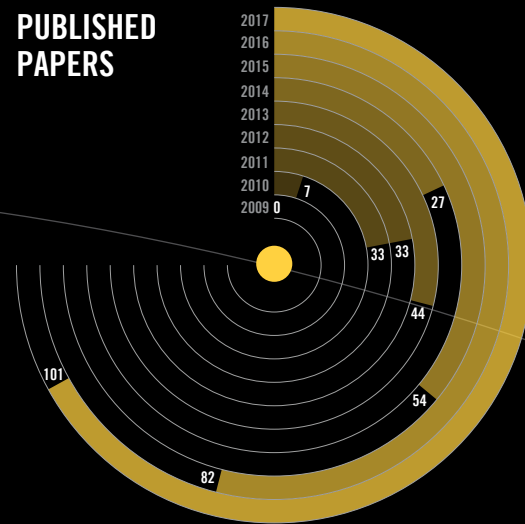


PhD STUDENTS

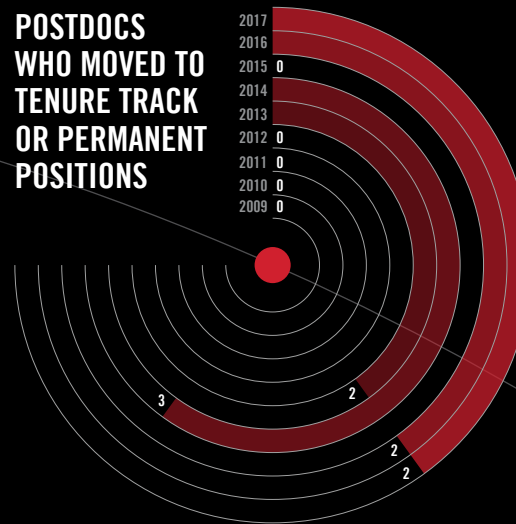




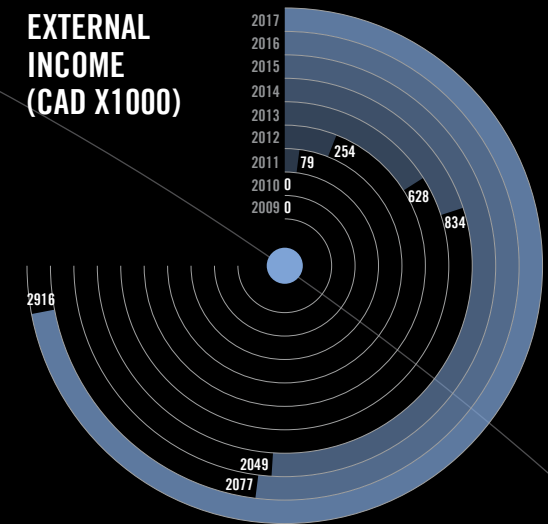
PUBLISHED PAPERS



POSTDOCS WHO MOVED TO TENURE TRACK OR PERMANENT POSITIONS

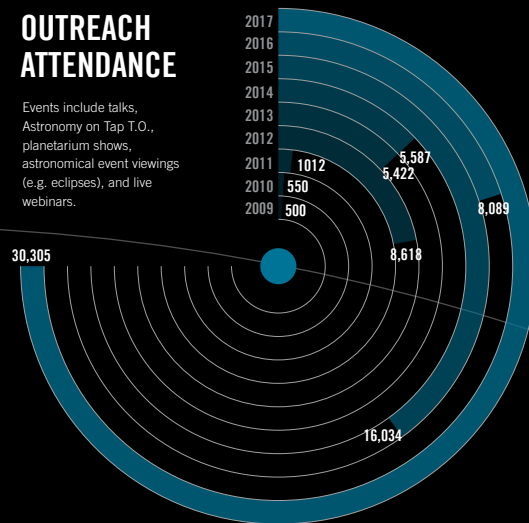


EXTERNAL INCOME (CAD X1000)



OUTREACH ATTENDANCE

Events include talks, Astronomy on Tap T.O., planetarium shows, astronomical event viewings (e.g. eclipses), and live webinars.



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UNLESS OTHERWISE NOTED, ALL PHOTOGRAPHS:
DUNLAP INSTITUTE FOR ASTRONOMY &
ASTROPHYSICS



David Dunlap (l.) views the August 21st partial solar eclipse at the Canadian National Exhibition with the help U of T astronomy graduate students.

Eclipse image:
Dr. Charles Zhu

www.dunlap.utoronto.ca
www.universe.utoronto.ca
www.discovertheuniverse.ca

