University of Victoria

ARC 2018 NEWSLETTER

ASTRONOMY RESEARCH CENTRE

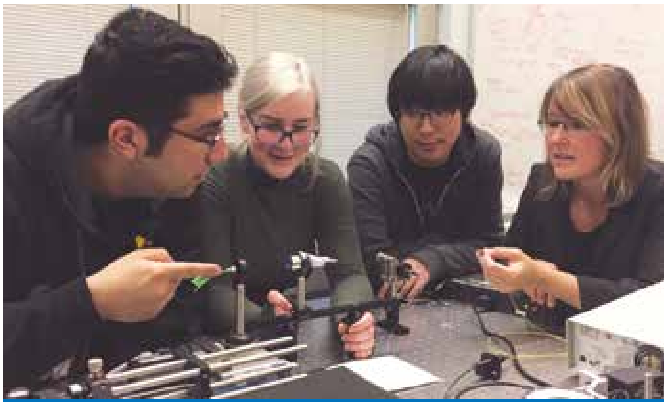
UVic Astrophotography Club

UVic Astrophotography Club executive Nic Annau embraces the Milky Way during an astrophotography session at French Beach Provincial Park, near Sooke BC. *(See article on page 12).*

In this issue:

Director's message

The Astronomy Research Centre was founded at UVic in 2015 to help build and connect the astronomy community in Victoria, and across Canada. At UVic, this includes faculty, staff, and students in the Departments of Physics and Astronomy, Mechanical Engineering, Electrical Engineering, and Computer Science, and the Centre for Earth and Ocean Science. We also partner with other research institutes in British Columbia, including the National Research Council's Herzberg Institute of Astronomy and Astrophysics, the Dominion Radio Astrophysical Observatory, and TRIUMF. The ARC provides members with new opportunities for team building, innovation, and leadership in the coming era of large telescopes, large surveys, and big data. We aim to communicate the wide variety of expertise and experience of our members to one another, to the Canadian astronomical community, to Canadian industrial partners, and to government and UVic leaders and decision makers.



ARC Director Prof. Kim Venn (right side) works with the FiTS (Fibre Transmission System) team, which is a collaboration at UVic between Astrophysics and Mechanical Engineering. The FiTS team is part of Prof. Colin Bradley's lab, and includes (from left) Farbod Jahandar, Stephanie Monty, and Eddie Jooyoung Lee, as well as Darren Erickson and Dr. David Crampton at the NRC Herzberg. *Credit: Henry Coll*

In 2017, ARC was awarded funding to develop an NSERC CREATE training program in *New Technologies for Canadian Observatories* (see page 11). In its first year, 15 astronomy and engineering students (graduate and undergraduate) participated in the program, and we are looking forward to expanding those numbers over the next five years. Members of the ARC were also involved in several large and multi-institutional grant proposals to the Canada Foundation for Innovation, including the successful grant for the Gemini Infra Red Multi Object Spectrograph (see page 11). Many of our members were involved in substantial new scientific discoveries, ranging from new ways to detect planets and then study their atmospheres (page 6), to new ways to identify dual active galactic nuclei (page 7). ARC also supported the 2017 TRIUMF Summer Institute in Nuclear Astrophysics (page 10). As in our previous newsletter, we highlight a few of the new scientific results, new research tools, and outreach activities of our ARC members over this past year. Together, these two newsletters showcase the many facets of the astronomical research carried out in our local area.

NTCO AGM 2017

The kick-off for NTCO and its first annual general meeting (AGM) were held at the University of Victoria from December 14-15, 2017. This event was well attended by over 50 people, including NTCO members and students and many members of ARC. NTCO participants and industry partners travelled from across Canada to attend. The program featured both scientific and industrial research talks, on topics including optics & photonics, manufacturing precision & technologies, and software & machine learning. NTCO students presented posters on their research and internship experiences, and had many opportunities to network with Canadian industry representatives.

During the week leading up to the AGM, professional skills training workshops were organized for students. ARC sponsored a Skills for Employment at Observatories workshop, which featured representatives from the Gemini Observatory, the Dunlap Institute for Astronomy & Astrophysics, and NRC Herzberg and DRAO. A MITACS workshop on Project Management I was also offered through UVic's Research Partnerships and Knowledge Mobilization office.

The next NTCO AGM is being planned for November 2018 to be held at Laval University.

Written by: Jeremy Riishede, NTCO Program Coordinator, and Prof. Kim Venn, NTCO Program Director

NTCO industrial partners Amir Hosseinabadi and Lisa Crofoot from Dynamic Structures Ltd., in Port Coquitlam, BC, discussing their innovative new robot polisher.

Credit: Jeremey Riishide

ARC member list

FACULTY

Name	Research Area
Justin Albert	Physics
Arif Babul	Astronomy
Jens Bornemann	Engineering
Colin Bradley	Engineering
Sara Ellison	Astronomy
Colin Goldblatt	Planetary
Falk Herwig	Astronomy
Julio Navarro	Astronomy
Poman So	Engineering
Geoff Steeves	Physics
Kim Venn	Astronomy
Jon Willis	Astronomy

EMERITUS FACULTY

Name	Research Area
Tony Burke	Astronomy
Ann Gower	Astronomy
David Hartwick	Astronomy
Chris Pritchet	Astronomy
Colin Scarfe	Astronomy
Jeremy Tatum	Astronomy
Don VandenBerg	Astronomy

ADJUNCT FACULTY

Name	Research Area
David Andersen	Astronomy, Engineering, NRC-Herzberg
John Blakeslee	Astronomy, NRC-Herzberg
Patrick Cote	Astronomy, NRC-Herzberg
David Crampton	Astronomy, Engineering, NRC-Herzberg
James Di Francesco	Astronomy, NRC-Herzberg
Iris Dillmann	Nuclear Physics, TRIUMF
Greg Fahlman	Astronomy, NRC-Herzberg
Laura Ferrarese	Astronomy, NRC-Herzberg
John Hutchings	Astronomy, Engineering, NRC-Herzberg
Doug Johnstone	Astronomy, NRC-Herzberg
JJ Kavelaars	Astronomy, NRC-Herzberg
Helen Kirk	Astronomy, NRC-Herzberg
Christian Marois	Astronomy, Engineering, NRC-Herzberg
Brenda Matthews	Astronomy, NRC-Herzberg
Alan McConnachie	Astronomy, NRC-Herzberg
Chris Ruiz	Nuclear Physics, TRIUMF
David Schade	Astronomy, NRC-Herzberg
Luc Simard	Astronomy, NRC-Herzberg
Peter Stetson	Astronomy, NRC-Herzberg
Jean-Pierre Veran	Astronomy, Engineering, NRC-Herzberg
Gordon Walker	Astronomy, Engineering

STAFF

Name	
Margaret Gwyn	Communications
Jeremy Riishede	NTCO Program Coordinator
Stephenson Yang	Communications

ASSOCIATES

Name	Research Area
David Bohlender	Astronomy, NRC-Herzberg
Stephanie Côté	Astronomy, NRC-Herzberg
Timothy Davidge	Astronomy, NRC-Herzberg
Barry Davids	Nuclear Physics, TRIUMF
Pavel Denisenkov	Astronomy
Darren Erickson	Astronomy, Engineering, NRC-Herzberg
Sebastien Fabbro	Astronomy, NRC-Herzberg
Séverin Gaudet	Astronomy, NRC-Herzberg
Stephen Gwyn	Astronomy, NRC-Herzberg
Glen Herriot	Astronomy, Engineering, NRC-Herzberg
Jim Hesser	Astronomy, NRC-Herzberg
Frank Jiang	Astronomy, Engineering, NRC-Herzberg
Lewis Knee	Astronomy, Engineering, NRC-Herzberg
Olivier Lardiere	Astronomy, Engineering, NRC-Herzberg
Lisa Locke	Astronomy, Engineering, NRC-Herzberg
Andrew MacRae	Physics
John Ouellette	Astronomy, NRC-Herzberg
John Pazder	Astronomy, Engineering, NRC-Herzberg
Tim Robishaw	Astronomy, Engineering, NRC-DRAO
Joel Roediger	Astronomy, NRC-Herzberg
Michael Rupen	Astronomy, Engineering, NRC-DRAO
Gerald Schieven	Astronomy, NRC-Herzberg
Eric Steinbring	Astronomy, NRC-Herzberg
Karun Thanjavur	Astronomy
Bruce Veidt	Astronomy, Engineering, NRC-DRAO
Chris Willott	Astronomy, NRC-Herzberg

POSTDOCTORAL RESEARCHERS

Name	Research Group
Robert Andrassy	Stars
Celia Blain	Engineering, NRC-Herzberg
Vincent Henault Brunet	Dynamics, NRC-Herzberg
Chervin Laporte	Dynamics
Samantha Lawler	Planetary, NRC-Herzberg
Henry Ngo	Planetary, NRC-Herzberg
Nienke van der Marel	Planetary, NRC-Herzberg
Joanna Woo	Galaxies

STUDENTS

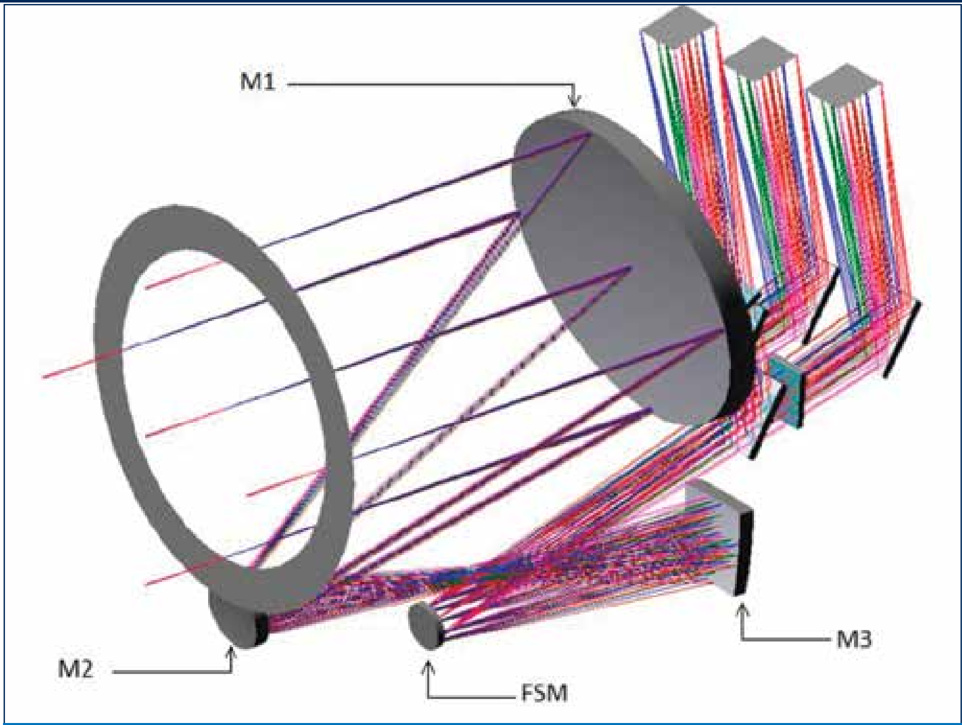
Name	Research Group
Ivar Arroway	Planetary
Trystyn Berg	Galaxies
Spencer Bialek	Spectroscopy, Machine learning
Connor Bottrell	Galaxies
Michael Chen	Star formation
Ondrea Clarkson	Stars
Austin Davis	Stars
Ruth Digby	Cosmological simulations
Zachary Draper	Planetary, Debris disks
Nick Fantin	Stars
Logan Francis	Star Formation
Benjamin Gerard	Planetary, Adaptive optics
Maan Hani	Galaxies
Clare Higgs	Stellar populations, Galaxies
Julia Horne	Planetary atmospheres
Brittany Howard	Astronomical data analysis
Farbod Jahandar	Stars, Stellar populations
Jared Keown	Star formation
Collin Kielty	Stars, Stellar populations
Nic Loewen	Cosmological simulations
Douglas Rennehan	Cosmological simulations
Chelsea Spengler	Galaxies
David Stephens	Stars
Mojtaba Taheri	Stellar populations, Adaptive optics
Mallory Thorp	Galaxies
Thorold Tronrud	Cosmological simulations

CASTOR: The Cosmological Advanced Survey Telescope for Optical and UV Research

CASTOR is a proposed Canadian-led space telescope that has been in detailed study since 2011. It is a 1-metre telescope with a wide-field imager that will deliver resolution comparable to the Hubble Space Telescope (HST) at ultraviolet/blue-optical wavelengths, but with a field of view that is 100 times larger than HST. This wide view makes CASTOR's capabilities unique and of wide international interest.

The current CASTOR concept is a three-bandpass imager covering a 0.5 x 0.5 degree field simultaneously. The primary aperture, image quality, optical throughput, and detector efficiency combine to make CASTOR a powerful vehicle for deep surveys that will complement other major facilities such as the Large Synoptic Survey Telescope, the NASA-led future space telescope WFIRST, and the European-led space telescope Euclid. The current study also incorporates ultraviolet spectroscopy and innovative approaches to exoplanet research.

The project is now entering an important next step, an extended Science Maturation Study that will refine the science goals, technical performance, and costing of the mission, funded by the Canadian Space Agency in Ottawa, ON. The study also involves major international partners, currently the Jet Propulsion Laboratory and the Indian Space Research Organization, who have strong interests and related access to funding.



Design for the CASTOR space telescope, showing the three mirror design that will disperse light into three detectors sensitive to slightly different wavelength regions: UV 150-250 nm; u 300-450 nm; and g 450-650 nm.

Credit: Dr. Patrick Côté

We have a strong science team, comprised of eight Science Working Groups that cover different astronomical interests. The team is lead by ARC member Dr. Patrick Côté, and includes contributions from ARC members Drs. John Hutchings, JJ Kavelaars, Christian Marois, Doug Johnstone, Prof. Kim Venn, John Pazder, and Tim Hardy. Industrial partners include Honeywell in Cambridge, ON, ABB Engineering in Quebec City, QC, and Magellan Aerospace in Toronto, ON.

The Science Maturation Study will run through March 2019, and should produce a fully-defined concept for a Canadian-led space telescope that would be the next flagship mission for the Canadian Space Agency and for the Canadian astronomy community.

Written by: Drs. Patrick Côté and John Hutchings
National Research Council Herzberg Astronomy & Astrophysics
ARC Adjunct Members

CASTOR team leader Dr. Patrick Côté, and ARC student member Chelsea Spengler working together at NRC Herzberg

Credit: UVic Communications & Marketing

Rendering of the CASTOR space telescope (right side) compared with the Hubble Space Telescope (left side).

Credit: Dr. Patrick Côté

MSE: The Maunakea Spectroscopic Explorer

The Maunakea Spectroscopic Explorer (MSE) is an ambitious project to transform the 3.6-metre Canada-France-Hawaii telescope (CFHT) into an 11.25-metre facility dedicated to wide field multi-object spectroscopy. This project has been discussed in the Canadian astronomical community for a decade, and its recommendation in the Canadian Long Range Plan 2010 for Astronomy led to a feasibility study in 2011–2012 investigating science drivers, technical challenges, and international interest, and the opening of the Project Office in Waimea, Hawaii in 2014.

The project involves several members of ARC, including the Project Scientist Dr. Alan McConnachie, and Science Advisory Group delegate Prof. Kim Venn. Several ARC members have also contributed to the science cases (Prof. Julio Navarro, Prof. Sara Ellison, Prof. Jon Willis, Prof., Falk Herwig, Dr. Patrick Côté, Dr. Karun Thanjavur, and grad student Trystyn Berg) and to the technical developments (Prof. Colin Bradley, Dr. David Crampton, Darren Erickson, John Pazder, and grad students Farbod Jahandar, Collin Kielty, Jooyoung Lee, and Stephanie Monty). Currently, the entire MSE science consortium consists of over 100 members from Canada, France, Hawaii, Australia, China, India, the USA, and elsewhere.

MSE is designed to measure up to 4000 objects simultaneously, with a spectral resolution ranging from 2000 to 20 000. The science cases for MSE are dominated by two top priority projects: constraining the properties of dark matter through precision measurements of the properties of both intact and disrupted dwarf galaxies in the halo of the Milky Way; and exploring the distributions, kinematics, and chemistries of stars in the Milky Way to build a detailed picture of our home galaxy. Moreover, all fields of astronomical sciences will benefit from the MSE, ranging from studies of galaxy formation and evolution, to the nature of dark energy, AGN physics, stellar physics, characteristics of exoplanets, and constraints on the physics in the early Universe.

MSE is being developed through close collaboration between scientists and engineers in academia, government, and industry, and provides cutting edge opportunities for all those sectors. The project completed a very successful Systems Conceptual Design Review in January 2018. The external review panel, chaired by Prof. Michael Strauss from Princeton University, stated: "this project is in very good shape, and at an appropriate level of maturity for the end of the Conceptual Design phase. We have been very impressed by the level of sophistication that the MSE project team has brought to this project, and the tremendous amount of hard work that has been carried out thus far."

As a flagship facility for the 21st century, the MSE has an impressive and compact design. It is a much larger telescope than the current CFHT, yet its dome will span the same footprint at the current observatory and will be only 10% taller. One reason those involved in MSE are dedicated to this project is because of the excellence of Maunakea as a site for exploring the universe. All of us in the MSE project recognize and acknowledge the very significant cultural role and reverence that the summit of Maunakea has always had within the indigenous Hawaiian community. We are most fortunate to have the opportunity to conduct observations from this mountain. Maunakea is known worldwide as the site of amazing discoveries about our universe, and MSE is poised to continue that legacy.

For further information on MSE, see **mse.cfht.hawaii.edu**

Written by: Prof. Patrick Hall, York University

Prof. Hall is a professional astronomer and visiting professor from York University, on sabbatical at UVic during the 2017 – 2018 academic year. He is also the MSE Management Group Chair and member of the MSE Science Team.

The conceptual design model of the MSE telescope. The hexagons that make up the primary mirror can be glimpsed just below the centre of the image.

A rendering of MSE in the current location of the CFHT on Maunakea. The MSE dome is only 10% taller than the current CFHT dome, despite the telescope being nearly three times larger in diameter.

A group photo of the MSE Project Office staff and the Conceptual Design Review Panel members in Waimea, Hawaii, in January 2018.

Credit: Prof. Patrick Hall

Characterizing planetary atmospheres

Prof. Goldblatt speaks at a TEDx Victoria event.

Credit: Gwen Ewart Photography

Professor Colin Goldblatt is an ARC member in the UVic School of Earth and Ocean Sciences. His expertise is in the characterization of planetary atmospheres, a field particularly important to the search for life on other planets.

One way to determine if planets have life is to examine the chemistry of their atmospheres. Consider the Earth: "There would be two to three times more nitrogen in our atmosphere if not for life, and there would be no oxygen. If you looked at the atmosphere today, you would say it must have been created by life", says Prof. Goldblatt.

For most of Earth's history, life has existed on the planet, over a huge range in atmospheric conditions. Therefore, researchers who want to detect life on other planets must consider many potential atmospheres. Models of planetary atmospheres are developed using radiative transfer codes, which model the emission and absorption processes in a beam of light as it travels through parcels of gas. By varying the conditions in the model, such as temperature, density, and composition, scientists can simulate the spectrum that emerges from a planetary atmosphere at various stages in its evolution, and that could be detected and examined for signs of life.

The timing for this work is ideal, as NASA examines new space mission concepts in preparation for the US 2020 Astrophysics Decadal Survey. Two of these space satellite concepts, HabEx and LUVOIR, both aim to examine planetary atmospheres for signs of life. Scientists and engineers are "working on the design of these missions now, making this the critical time to talk about the range of things we can observe", says Prof. Goldblatt. The ultimate goal is not only to find life, but to characterize the environment of enough planets to find out if life is common or uncommon. "On the only habitable planet we know, life is a dominating planetary phenomenon. Is that the norm or not?"

Written by: Margaret Gwyn, ARC staff member

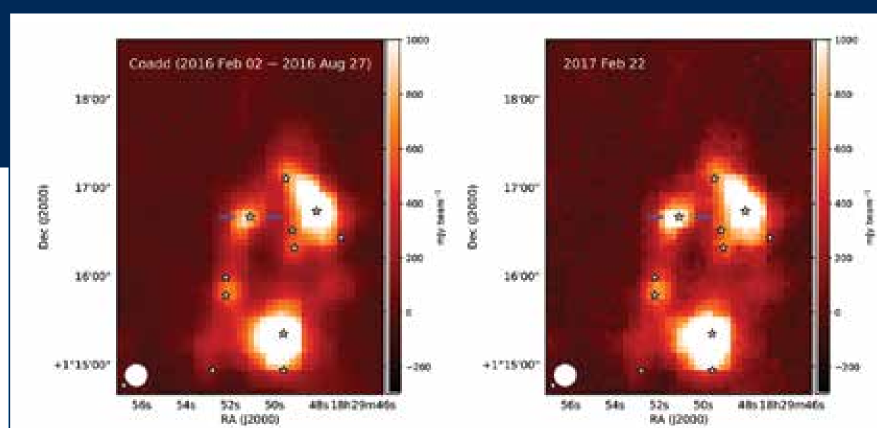
Searching for exoplanets

There's more than one way to detect a planet. Dr. Doug Johnstone, an ARC member from NRC-Herzberg, is co-leading an international team that may have developed a new technique: catching the planet in its very earliest stages of formation by the way it disrupts the co-formation of the parent star.

The results, published in the Astrophysical Journal in 2017, came from a forming star known as EC53. Over 18 months, Dr. Johnstone and his team watched EC53 brighten and dim again in the sub-millimetre wavelengths. For forming stars like EC53, brightness is directly related to accreditation of mass. The fact that the changes recurred every 18 months suggested something in orbit around the forming star, such as a hidden forming planet, was disrupting the accretion.

Although the potential planet itself is not visible, its existence would have implications for theories of planet formation. If there is a planet forming around a star as young as EC53, this suggests that planetary formation can occur much earlier than previously thought.

The EC53 data was collected as part of the James Clerk Maxwell Telescope Transient Survey. The primary aim of the survey is to learn how stars form. If mass accretion is episodic, as recent work suggests, then repeated observations over time should show this.



SCUBA-2 850 µm images. On the left is a coadded map from 2016 February 23 to August 27. On the right is a map obtained on 2017 February 22. The white stars mark the positions of protostars. The blue horizontal lines mark the position of EC53. The white filled circle in the bottom left corner in each image represents the JCMT beam at 850 µm.

Credit: Yoo et al. 2017, ApJ 849, 69

At sub-millimetre wavelengths, brightness calibration uncertainties make comparing repeated observations difficult. New data reduction techniques to make this work possible were developed by Dr. Steve Mairs, a former ARC member, as part of his PhD thesis while a student at UVic.

The JCMT Transient Survey will continue til early 2019. The team will continue to regularly monitor EC53 and its star formation region, along with seven other similar regions, in hopes of identifying more episodic variable forming stars.

Written by: Margaret Gwyn, ARC staff member

The search for active galactic nuclei pairs

Astronomers are taught early in their education that most large galaxies will have supermassive black holes at their centres. When gas and dust fall into these black holes, they become the incredibly luminous regions we call active galactic nuclei (AGN). Galaxy mergers can trigger this accretion of material and they are expected to play a key role in the growth of large galaxies. Putting these facts together suggests that there should be lots of pairs of AGN out there, brought together into close proximity when their host galaxies collide. So where are they? Only a handful of dual AGN have been found, almost all serendipitously.

UVic ARC faculty member Prof. Sara Ellison recently led a project that developed two new techniques for detecting dual AGN. Both involved archival data from the Wide-Field Infrared Survey Explorer (WISE), a NASA mission to image the entire sky at mid-infrared wavelengths, ideal for finding AGN that may be optically obscured. The hot dust surrounding AGN is very bright in the mid-infrared, and has a different spectral energy distribution than that of inactive galaxies. In one technique, candidate AGN pairs also had to look like a merger at optical wavelengths, as determined by the citizen scientists of the Galaxy Zoo project. In the second, the pair had to have spatially-resolved optical spectroscopy from the Sloan Digital Sky Survey's MaNGA (Mapping Nearby Galaxies at Apache Point Observatory) program that were consistent with those of AGN.

Together, the two techniques identified seven potential dual AGN. Prof. Ellison and her team used the Chandra X-Ray Observatory to find that five of the seven pairs showed the signature X-ray luminosities of AGN. These five new dual AGN increase the previously known sample by 50%, which is a "significant new haul" according to Prof. Ellison. "Supermassive black hole mergers take place over hundreds of millions of years. The more pairs that are found, the better we can understand how these formative interactions happen."

Two pairs of active galactic nuclei discovered by Prof. Ellison and her team. The main panel shows optical data from the Sloan Digital Sky Survey that was combined with infrared data from WISE to identify potential dual AGN. The inserts show X-ray data from Chandra that confirmed the dual AGN.

Credit: X-ray: NASA/CXC/Univ. of Victoria/S.Ellison et al.; Optical: SDSS

This work is particularly timely and exciting in the new era of gravitational wave detections. Only last year, the Laser Interferometer Gravitational-Wave Observatory (LIGO) made the first gravitational wave measurements from the merger of two stellar mass black holes (see below). The measurement is of the tiny disturbances in space and time made by the gravitational wave as it passes through the Earth. Currently, LIGO cannot measure the disturbances created by the gravitational waves from the merger of binary AGN, however the proposed Laser Interferometer Space Antenna (LISA) project should have that capability. LISA is a European Space Agency mission designed to detect and accurately measure gravitational waves throughout the universe, and planned for a 2034 launch. Knowing how common dual AGN are will help to plan the gravitational wave observatories and experiments in the next decade.

Written by: Margaret Gwyn, ARC staff member

Right place at the right time

ARC student member Clare Higgs unexpectedly found herself involved in LIGO's ground-breaking gravitational wave detection last year. She was at Las Campanas Observatory in Chile preparing to take observations for her research when word came from LIGO about a "target of opportunity". Clare ended up assisting with observations of the neutron star collision, and is listed as an author on two related Science papers.

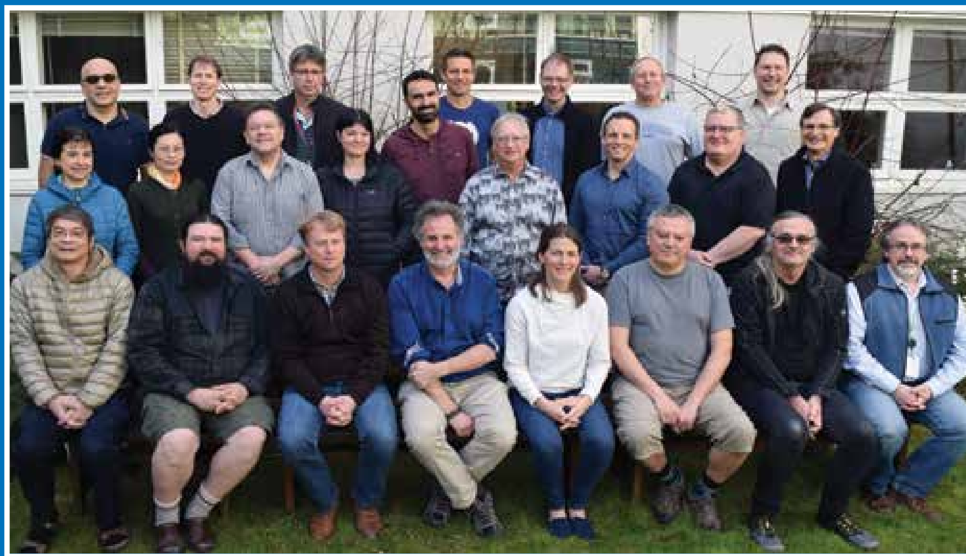
"Astronomers will be studying these observations for years," says Clare. "It was a thrilling and fortuitous opportunity to observe something that has never been seen by humankind before. I feel incredibly lucky to have been present and to have played a very small role in this unique and groundbreaking detection."

Written by: Margaret Gwyn, ARC staff member

Clare Higgs at the Las Campanas Observatory in Chile.

Credit: Clare Higgs

Machine learning at the **CADC**



The astronomers, engineers and staff of the Canadian Astronomy Data Centre, located at NRC-Herzberg.

Credit: Margaret Gwyn

The Canadian Astronomy Data Centre (CADC) is located at NRC Herzberg and is home to several ARC members and associates. Since its beginnings in 1986, the CADC has grown its tools and services based on the needs of the Canadian astronomical community. Right now, one of those needs relates to the field of machine learning: a subset of artificial intelligence, where computer systems can "learn"—improve performance through experience—without being explicitly programmed.

The idea of machine learning has been around since 1959, but the field is currently booming. Increased processing power makes machine learning techniques more feasible, and the vast quantities of data now available means lots of material with which to train the systems. All that data also provides the motivation. "We need new algorithms to tackle things that we used to do manually", explains Dr. Sébastien Fabbro, an ARC adjunct member at the CADC.

The CADC is exploring machine learning techniques in a few different projects. One is a collaboration with ARC members at UVic. The group used a convolutional neural network called StarNet on stellar spectra from the SDSS APOGEE survey to automate the determination of parameters like temperature, gravity and metallicity. The results were promising, with StarNet showing similar precision and accuracy as more traditional pipelines.

Spectroscopic surveys much larger than APOGEE are now being planned, and other upcoming projects like the Canadian-led Maunakea Spectroscopic Explorer will also generate huge amounts of data. New techniques like machine learning need to be developed to manage these future data sets. This focus on the long term is integral to the CADC's philosophy. The CADC Director and ARC member Dr. JJ Kavelaars says "researchers in labs need to be focused on the short term, but we like to ask, where do we need to be in 7 – 8 years, so that we can provide the critical data tools and products?"

Written by: Margaret Gwyn, ARC staff member

Crew of the StarNet enterprise. Its continuing mission to explore new neural network techniques, to seek out new keras and new TensorFlow algorithms, and to boldly go where few astronomers have gone before. ARC members (from left) Teaghan O'Briain, Dr. Sebastien Fabbro, Farbod Jahandar, Spencer Bialek, and Collin Kielty.

Credit: Kim Venn

DRAO: The Dominion Radio Astrophysical Observatory

Dr. Tim Robishaw and the 26 m John Galt Telescope he and his team are refitting.
Credit: National Research Council of Canada

The Dominion Radio Astrophysical Observatory (DRAO) in Penticton, BC, is an internationally known facility for science and technology research and development related to radio astronomy. Home to NRC astronomers, astrophysicists, engineers, and technologists, as well as visiting researchers and students from universities and astronomical observatories around the world, these facilities support the design and development of leading-edge instrumentation for new and existing telescopes.

In 2017, ARC associate member Dr. Tim Robishaw was the project leader for upgrades to the 26-metre John Galt Telescope. Built in 1959, this single dish telescope is undergoing a major refit so that the telescope will have the sensitivity to map the magnetic field of the Milky Way galaxy. The upgrades to the telescope will allow Dr. Robishaw and his team to measure the Zeeman effect, when spectral lines split in the presence of a magnetic field, at three different frequencie ranges simultaneously.

At 1420 MHz, the Zeeman effect on hydrogen will allow them to map the magnetic field in the cold diffuse regions between stars. From 900 - 1800 MHz and from 1612 - 1720 MHz, they will also be able to probe the magnetic fields of hot diffuse interstellar regions and dense star formation regions through the Zeeman effect on recombination lines of hydroxyl. Ultimately, this survey will see the DRAO mapping along every line of site to map the magnetic field throughout the Milky Way that is visible in the Northern Hemisphere.

Also in 2017, Dr. Michael Rupen joined the DRAO as the new Director. Dr. Rupen has been heavily involved in the development of the Square Kilometre Array (SKA) and brings more than 20 years of experience in radio astronomy, astronomical transient sources, and observations of the interstellar medium in the Milky Way and other galaxies to Canada. His team's work on the correlator and beam former for SKA1_MID, a portion of the SKA that will be located in South Africa, recently passed the critical design review in early 2018. Dr. Rupen says, "This was a huge milestone. It puts us in a very strong position to say we're the ones who should build this. I hope Canada will get to build the instrument we've designed."

As the new Director, he will oversee the DRAO's involvement in the Canadian Hydrogen Intensity Mapping Experiment (CHIME). This is an interferometric radio telescope at the DRAO, which consists of four 100 x 20 metre semi-cylinders (roughly the size and shape of snowboarding half-pipes) populated with 1024 dual-polarization radio receivers sensitive at 400–800 MHz. The telescope's low-noise amplifiers are built with components adapted from the cellphone industry. The telescope has no moving parts and observes half of the sky each day as the Earth turns, and saw first light in September 2017. CHIME will map the 21 cm line of neutral hydrogen over the cosmological redshift range of 0.8 to 2.5 to measure baryon acoustic oscillations, giving a length scale that can be used to measure the expansion history of the universe. CHIME was constructed at the DRAO because the site is well protected from radio frequency interference.

Dr. Rupen is talking with universities for ideas for future directions for DRAO. "There is a great interaction between the academic community and DRAO. When they have that bright idea, DRAO is where they can find the support they need to carry it out."

Written by: Margaret Gwyn, ARC staff member, and Prof. Kim Venn, ARC director

ALMA data processing made easy

Dr. Kirk visits ALMA in the Chajnantor Plateau of the Atacama Desert of Chile. *Credit: Dr. Kirk*

The Atacama Large Millimeter / submillimeter Array (ALMA) is the most sensitive millimeter interferometer in the world. Its location and design allow for the exquisite image resolution needed to study high redshift galaxies and local star and planet forming systems.

Dr. Helen Kirk, an ARC member and Research Officer at NRC-Herzberg, is leading a project to develop services that will allow astronomers to process ALMA data on CANFAR, the Canadian Advanced Network for Astronomy Research. She works closely with other researchers from NRC-Herzberg's Millimeter Astronomy Group, many of whom are also ARC members. The project will greatly increase the number of Canadian astronomers who can use ALMA data in their research.

The plan is to develop two different streams. The first is for expert users, who are familiar with ALMA data, but need more computational power and storage to process and analyse it. The other stream is for researchers with less experience. Users will be able to request observations from the ALMA archive, and simplified data reduction scripts will automatically provide them with basic images and spectral cubes. These data products will allow the users to see the noise level and amount of detail available in the observations.

The Canadian Astronomy Data Centre (CADC) will be working closely with the team. Dr. JJ Kavelaars, Director of the CADC and ARC member, says that this project is similar to one "we did with the Hubble Space Telescope (in 1986), where people would come to Victoria to learn how to process this new and rare HST data." The data tools being developed for ALMA will also be transferrable to the next generation of large ground-based interferometers, such as the Square Kilometer Array.

Written by: Margaret Gwyn, ARC staff member

BRIKEN:
The Beta-Delayed Neutrons at RIKEN Project

Dr. Iris Dillmann, an ARC adjunct member from TRIUMF, her postdoc Dr. Roger Caballero-Folch, and their international collaborators have an ambitious goal: by 2020, they hope to measure almost all of the 621 presently known beta-delayed neutron emitters with higher precision and accuracy than ever before. For more than 100 of these emitters, these will be the first such measurements ever made.

Beta-delayed neutron emission is a decay process that occurs for very neutron-rich isotopes. As these isotopes approach the neutron dripline, the neutron separation energy decreases. When the neutron separation energy gets lower than the beta-decay energy window, a neutron can be emitted after the beta-decay, leading to a daughter nucleus with one mass unit less.

These beta-delayed neutrons influence how many neutrons are available in the late phases of the rapid-neutron capture process, which is responsible for the creation of about half of the stable isotopes beyond iron. An accurate knowledge of the neutron-branching ratios and half-lives of beta-delayed neutron emitters is thus crucial for understanding the nucleosynthesis of heavy elements.

To measure these key input parameters, Dr. Dillmann and her collaborators started the Beta-Delayed Neutrons at RIKEN (BRIKEN) project. An international effort, it aimed to create the world's most efficient neutron detector by merging neutron counters from several smaller neutron detection experiments in Europe, the USA, Russia, and Japan. The detector was set up in 2016 at the current world-leading in-flight fragmentation facility at the RIKEN Nishina Research Center in Wako, northwest of Tokyo, Japan. It consists of a neutron detector, a state-of-the-art implantation detector, and an optional gamma-ray detection system that consists of two high purity Germanium clover detectors.

Members of the collaboration around the BRIKEN setup at RIKEN Nishina Center in Wako, Japan

Credit: Shunji Nishimura

In 2017, the first 6 weeks of beam time were successfully carried out and data analysis of these experiments is ongoing. Also included in this program is the hunt for new isotopes by the local RIKEN team to extend the chart of nuclides on the neutron-rich side. The BRIKEN collaboration hopes to make the first ever measurement of half-lives and neutron-branching ratios for these isotopes.

Written by: Dr. Iris Dillmann, TRIUMF, ARC Adjunct Member

TRIUMF Summer Institute

The 26th TRIUMF Summer Institute (TSI2017) took place from 24 July–4 August 2017 in Vancouver, BC. TSI2017 was devoted to astrophysics, and ARC was heavily involved: director Prof. Kim Venn and TRIUMF members Dr. Iris Dillmann, Dr. Barry Davids and Dr. Chris Ruiz all served on the organizing committee, and student member Ondrea Clarkson was one of the attendees. ARC also provided travel support for students, as did the Joint Institute for Nuclear Astrophysics – Center for the Evolution of the Elements and the Canadian Institute for Nuclear Physics.

TSI2017 was organized around the theme of "Modern Tools for Nuclear Astrophysics" and included 26 graduate students and postdocs participating in 2 weeks of lectures and hands-on problem-solving activities. Topics ranged from experimental nuclear astrophysics and nucleosynthesis, to modern techniques to investigate metal poor stars, to stellar modeling and modeling nuclear astrophysics events. The invited lecturers in 2017 included researchers from Canada and the US, as well as Spain, Australia and the United Kingdom.

Of course, time for rest and relaxation was also included in the schedule. A highlight was a hike to the Second Peak of Siám' Smánit (Stawamus Chief), a 700 m high granite cliff with amazing views. Participants also had the chance to take a bike trip around Stanley Park, and attend the closing banquet at the Pacific Institute of Culinary Arts.

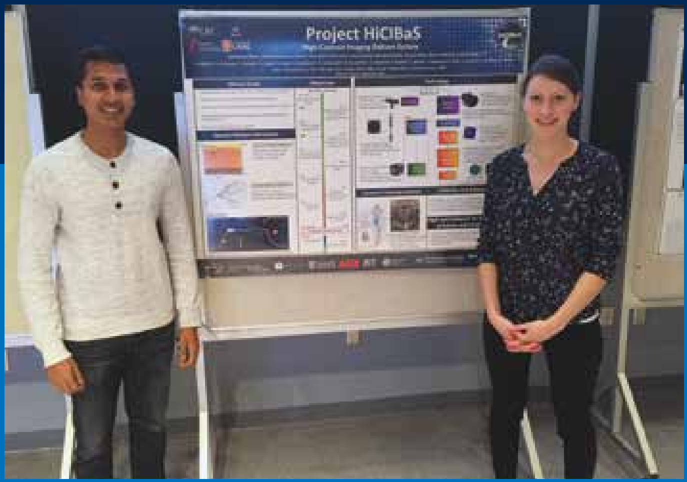
The summer school was a full success. At the end the participants elected the winner for the best new mnemonic for the Harvard spectral classification (OBAFGKMLTY): "Orange Businessman, Awful For Government. Keeps Making Laughable Tweets, Yes?"

Written by: Dr. Iris Dillman, TRIUMF, ARC Adjunct Member

TSI2017 participants enjoy the views from the Second Peak of Siám' Smánit during a weekend hike.

Credit: Dr. Iris Dillman

New Technologies for Canadian Observatories: **NTCO**



NTCO students Mirelle Ouelette and Deven Patel from Laval University presenting their research on the High-Contrast Imaging Balloon System, supervised by NTCO team members Prof. Simon Thibault (Laval) and Prof. Colin Bradley (UVic), and in collaboration with NTCO industrial partners at ABB Engineering (Quebec, QC) and NuVu Camera (Quebec, QC), as well as researchers in several government labs.

Credit: Jeremey Riishide

New Technologies for Canadian Observatories (NTCO) is a national, NSERC CREATE-funded program designed to foster innovation in astronomical instrumentation and to train students in new scientific and engineering technologies. The NTCO team includes researchers from four universities, four observatories, two government labs, two astronomy institutes, and several Canadian industries. Since the summer of 2017 it has been recruiting students in astronomy, physics, and engineering to work with or within Canada's high-tech industry. Through industrially relevant, hands-on training, as well as professional skills training workshops and annual networking events, NTCO students are well positioned to make significant and innovative contributions to Canadian academic and industrial research initiatives.

This program was motivated by the recognition that scientific progress and breakthrough research are often enabled through new technologies (e.g., gravitational wave detectors), and that innovation in astronomical instrumentation will be necessary in the coming decade of large new astronomical facilities (e.g., the Thirty Metre Telescope and the Square Kilometre Array). Such innovation is ideal for collaboration between research labs in academia, government, and industry, and new developments can often lead to broader applications. NTCO students provide an excellent means of sharing knowledge between universities, government labs, and industry, while companies benefit from student involvement in research and technological developments, which accelerate the path to technology commercialization.

All NTCO students must be supervised or co-supervised by a NTCO team member, and must also meet the key NSERC-mandated requirement of spending 20% of their time in an industrial internship with one of the program's NSERC-approved industrial partners. These research collaborations are central to the success of the program and the value-added experience for our students. While the NTCO program is targeted at graduate students in astronomy, engineering, and physics, undergraduates are also welcome to apply. For more information about the NTCO program and application procedure, visit the NTCO website:
uvic.ca/research/centres/arc/create

Written by: Jeremy Riishede, NTCO Program Coordinator, and Prof. Kim Venn, NTCO Program Director

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GIRMOS

The 2017 CFI Innovation Fund awards included over $5M towards a $15M spectrograph unlike any in the world. The Gemini InfraRed Multi-Object Spectrograph (GIRMOS) will be built for the 8-meter Gemini South telescope in Chile, and key components will be developed and tested by ARC members.

To create clear, sharp pictures, GIRMOS will combine spectroscopy with an adaptive optics system. ARC astronomers and engineers are world-class experts in adaptive optics, having already built the highly successful RAVEN instrument, tested on the Subaru Telescope from 2014-2016. The GIRMOS project is led by Prof. Suresh Sivanandam, at the University of Toronto's Dunlap Institute for Astronomy & Astrophysics, and includes former ARC member and UVic PhD graduate Dr. Masen Lamb in leadership roles related to both instrumentation and science applications. Several ARC members are currently involved in both the technology and science developments, such as Prof. Colin Bradley in the Department of Mechanical Engineering, and Drs. Olivier Lardiere, Celia Blaine, and Darren Erickson, all ARC associates at NRC Herzberg. Other major partners include the University of British Columbia, Laval University, Dalhousie University, and Saint Mary's University.

GIRMOS should be available to the Gemini science community by 2024. In addition to providing a unique opportunity for studying clusters of galaxies at intermediate redshifts, it will also provide important technological answers for the development of similar instruments for the Thirty Metre Telescope project. GIRMOS will also support projects carried out by the James Webb Space Telescope by providing important follow-up spectroscopy to further explore new discoveries.

Written by: Margaret Gwyn, ARC staff member

UToronto and Dunlap Institute astronomer Prof. Suresh Sivanandam, and former UVic graduate student and ARC member Dr. Masen Lamb (now postdoctoral researcher at the Dunlap Institute, Toronto) study the light path on an optical bench in preparation for the Gemini InfraRed Multi Object Spectrograph design and development.

Credit: Prof. Suresh Sivanandam

The 2017 Solar Eclipse

One of the biggest astronomy events of 2017 was "the Great American Eclipse". On August 21st, a total solar eclipse was visible in a band that stretched coast to coast across the United States. Canada and many other parts of the world were treated to a partial eclipse. In all, millions of people watched the eclipse, in person or online.

As a science and engineering research centre, ARC was not directly involved in the outreach events related to the eclipse. ARC members, however, are often involved with public outreach as part of their jobs, or just as something they love to do, and the 2017 eclipse is a prime example.

Dr. Karun Thanjavur, an ARC associate member at UVic, was in charge of UVic's eclipse event. The organizers expected a few hundred people, but by the time the eclipse started, well over a thousand people had arrived. Several UVic staff and students helped with crowd control and sharing information about the eclipse. Over the hours of the eclipse, a real sense of community developed as people talked to their neighbours and shared eclipse glasses.

Dr. John Blakeslee, an ARC associate member from NRC-Herzberg, was one of many ARC members who got involved out of a passion for public outreach. After answering a call from NASA looking for "subject matter experts" to attend eclipse events, he was paired up with a small private campground in Oregon that was directly in the path of the total eclipse. He described the experience as "really quite amazing. You can imagine how ancient people were terrified by an event like that."

Written by: Margaret Gwyn, ARC staff member

An image of the mostly-eclipsed sun is projected for viewing by crowds on the roof of UVic's Bob Wright Building.

Even more visitors watch the eclipse from the grounds of UVic.
Credit: UVic Communications & Marketing

UVic Astrophotography Club

The picture seen on the front cover is just one of the hundreds of stunning images produced by UVic's Astrophotography Club. ARC student member Mojtaba Taheri Nieh helped found the Club in 2016, and currently serves on its executive. The Club received funding from ARC in 2017 to upgrade its equipment, including the hardware necessary for the group to do astrophotography sessions at remote locations. The key purchase was the Sky-Watcher EQ6 SynScan GPS equatorial mount, designed for precision sky tracking, with built in autoguider ports, hand controller, and object database from several sky catalogues. The Club used the new equipment throughout the summer and produced a 2018 calendar of their images, which was a popular gift over the holiday season.

The Club also holds astrophotography sessions in more accessible locations, which attract a wide range of people. "They immediately get interested in astronomy", says Mojtaba. "For some of them, I think it could be a life changing experience." To see more of the Astrophotography Club's work, or to get involved, check out the UVic Astrophotography Club on Facebook, follow them on Instagram at #irrelevantbedtime, or visit the website at **uvicastrophoto.ca**.

Written by: Margaret Gwyn, ARC staff member

UVic undergraduate students Levente (Levy) Buzas and Nic Annau exploring the heavens with the new Sky-Watcher EQ6 SynScan GPS equatorial mount. *Credit: UVic Astrophotography Club*