

Institute for Research on Exoplanets



ANNUAL REPORT

2019 - 2020

Université 
de Montréal



McGill



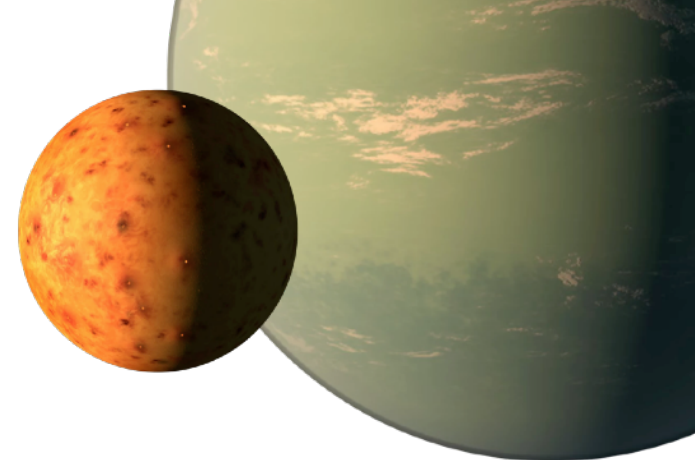
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About the Institute

Mission and Objectives

THE INSTITUTE FOR RESEARCH ON EXOPLANETS AIMS TO SEARCH FOR
NEW WORLDS BEYOND THE SOLAR SYSTEM AND TO ANSWER ONE
OF THE GREAT QUESTIONS FACING HUMANITY:
ARE WE ALONE IN THE UNIVERSE?

This question alone justifies multi-billion dollar investments in robotic exploration of our Solar System and the construction of powerful astronomical observatories, both on the ground and in space.

Since the discovery of the first planet orbiting a star other than the Sun in 1995, astronomers have confirmed the existence of **several thousands of exoplanets**. Thousands of other exoplanet candidates have also been identified, including rocky Earth-like planets and types of planets that have defied our theories of planetary formation. Over the next decade, a new generation of **telescopes** and **instruments** will make it possible to probe the **atmospheres of extrasolar Earth-like planets** for water vapour and, possibly, **signatures of biological activity** such as oxygen, ozone or methane for the first time.

The **Institute for Research on Exoplanets** - iREx - brings together the best researchers and the most promising students in order to take full advantage of the major observational projects underway or to come, and to share this research through our education and science communication efforts, with the ultimate goal of **finding life elsewhere in our Universe**.

A Word from our Director

At the risk of repeating ourselves, the least we can say is that this year was truly like no other. The unprecedented COVID-19 global pandemic put the iREx team to the test. We have had to deal with many unexpected setbacks and challenges. More than ever, this difficult year has highlighted the strength, resilience and determination of our team. We have all had to live through this difficult situation in a multitude of different contexts, and we all rose to the challenge.

The period covered by this annual report, **September 1 2019 to August 31 2020**, began with the same momentum and energy we have accumulated over the past several years. All our scientific and instrumentation projects have stayed on course. SPIRou's scientific results are being published at a steady pace, its sister NIRPS is nearing completion and will be delivered to La Silla in Chile in 2021, and the majestic Webb telescope is still on track for its historic launch in Fall 2021. And not to mention all our in-person public events that have been replaced by online activities with unprecedented reach and success!

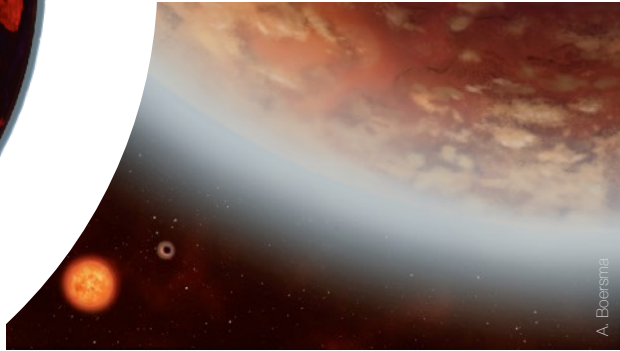
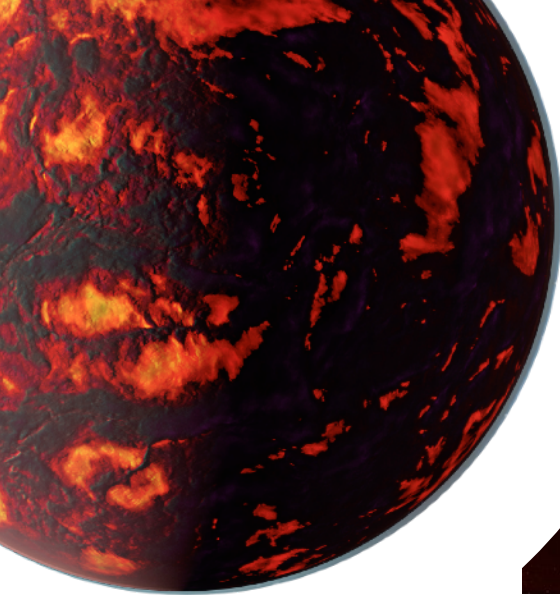
I wish us all, in the very near future, better times filled with happiness, health and scientific curiosity!



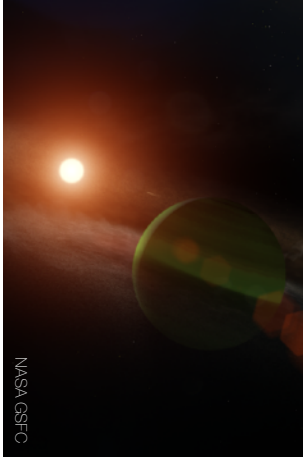
René Doyon
Director, iREx
Professor, Université de Montréal

The Year in Review

IN 2019-2020...



iREx members detected water vapour on an exoplanet, K2-18b, in the habitable zone for the first time: an important step towards the detection of extraterrestrial life!



An iREx researcher participated in a study that led to the detection of an exoplanet in the young star AU Mic's system, a difficult target given its debris disc and strong stellar activity.

Two brown dwarfs with surprising characteristics were discovered thanks to a citizen science project, *Backyard Worlds: Planet 9*, funded by NASA. An iREx researcher and six amateur astronomers participated in the study.



The SPIRou instrument spent 190 nights on the Canada-France-Hawaii Telescope. iREx researchers have been working on the development of algorithms that will eventually allow SPIRou to reach an accuracy of 1 m/s. The NIRPS instrument saw its first light in a laboratory at the Université Laval.

A new launch date of 31 October 2021 has been announced for the James Webb Space Telescope. Despite this slight delay due in part to the global pandemic, the mission has progressed well and several important tests have been completed.

[...] The Year in Review

IN 2019-2020...

iREx researchers were involved in 108 scientific papers published in peer-reviewed journals.

iREx members participated in 7 television interviews, 37 radio interviews and 25 print and online interviews.

The size of iREx's team remained stable with 61 members, despite recruitment being harder during the COVID-19 pandemic. Our team included a record number (29) of graduate students and 10 summer interns in 2020.

We reached thousands of people in Quebec and abroad, in person and virtually, through 30 talks given at schools from elementary to university levels, 50 public lectures and 7 public events.

Our members received four awards, including a scientific communication grant from the Fonds Recherche du Québec and a nomination to the Royal Society of Canada for René Doyon. 54% of our students currently hold at least one prize grant, including 6/14 of our master's students, 11/15 of our doctoral students and 4/10 of our summer students.





Scientific Overview

TO CARRY OUT THEIR MISSION, THE SCIENTISTS OF iREx FOCUS THEIR RESEARCH PROJECTS AROUND THREE MAIN THEMES: OBSERVATION, INSTRUMENTATION AND THEORY.



A variety of observational methods can be used to detect exoplanets, both directly and indirectly. The observations carried out by iREx researchers are oriented along several different axes: **direct high-contrast imaging**, **high-precision infrared velocimetry** and **transit spectroscopy**.

In addition to exoplanets, iREx researchers are interested in related celestial bodies such as **stars**, **brown dwarfs**, **white dwarfs**, **moons**, **comets** and **asteroids**. Several iREx members also specialise in the study of the **formation and evolution of planets** using theoretical models.

Through its collaborations with the **Laboratoire d'Astrophysique Expérimentale** (LAE) of the **Observatoire du Mont-Mégantic** (OMM), the iREx has one of the only teams with access to such a wide variety of high-performance scientific instruments dedicated to the observation of exoplanets. Our researchers study, develop and improve data analysis techniques and push the iREx to the forefront of exoplanet research. iREx instrumentation projects include the **FGS/NIRISS** instrument which is the Canadian contribution to the **James Webb Space Telescope**, the **SPIRou** and **NIRPS** high-precision infrared spectrographs in Hawai'i and Chile, the **GPI** imager at the Gemini-North Observatory and the **PESTO** optical camera at the OMM.

Administrative Overview

Organisational

ESO

Board of Directors

The iREx is managed by the Board of Directors, comprised of the **Dean of the Faculty of Arts and Science of the Université de Montréal** who chairs the Board, the **Director of the Department of Physics**, the **Director of iREx**, a **professor who is an iREx member**, a **member of the Board of Governors**, the **Coordinator of iREx**, and a **representative of the Université's Office of Development and Alumni Relations** as an observer. The duties of the Board of Directors include appointing the Director of iREx, appointing members upon the recommendation of the Scientific Committee, approving the iREx's scientific program as defined by the Scientific Committee, and approving financial reports and projected budgets.

2019-2020 Membership: Frédéric Bouchard (chair), Richard Leonelli, René Doyon, Patrick Dufour, Patrick Sureau, Nathalie Ouellette, Marie-Claude Giguère

Scientific Committee

The Scientific Committee advises the Director on the scientific development of the iREx and defines its programme of activities. It is composed of the **Director of iREx**, the **Vice-Dean for Research and Development of the Faculty of Arts and Science of the Université de Montréal**, **two iREx faculty members**, the **Coordinator of iREx** and a **professor of astronomy and astrophysics from an institution other than the Université de Montréal**.

2019-2020 Membership: René Doyon, Sébastien Sauvé, Björn Benneke, David Lafrenière, Nathalie Ouellette, Nicolas Cowan

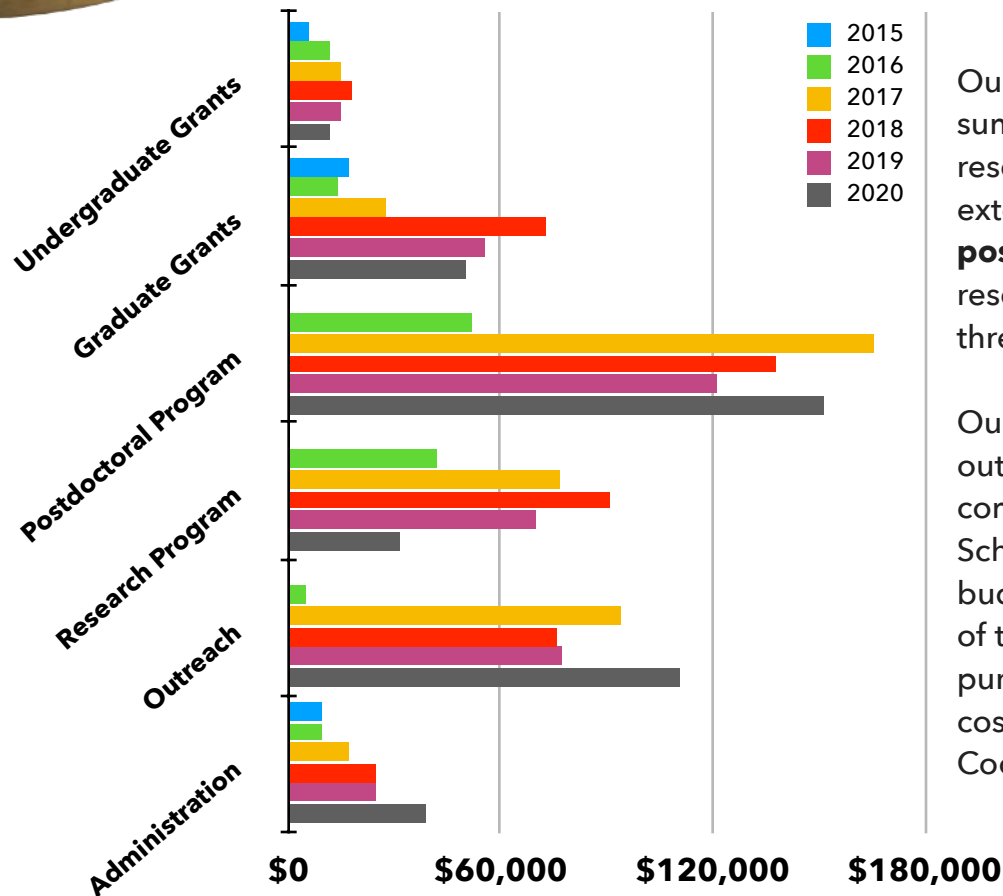
Governing Board

The Director of iREx is advised by the Board of Governors on all matters related to the proper functioning of the Institute, its outreach and funding. The Governing Board is made up of **external representatives from a variety of backgrounds with an interest in iREx's fields of research**.

Administrative Overview

Financial

THE iREx'S PRIORITY REMAINS ITS EXCELLENCE IN EXOPLANETARY RESEARCH. A CONSIDERABLE PORTION OF iREx FUNDS IS ALSO DEDICATED TO EDUCATION AND PUBLIC OUTREACH, AN IMPORTANT PILLAR OF THE INSTITUTE'S MISSION.



Our **student grants** include scholarships for our undergraduate summer interns as well as scholarships for our graduate student researchers. Many of our students are also recipients of scholarships external to iREx from NSERC, FRQNT and their home institutions. Our **postdoctoral and research programs** cover the salaries and research funds of all our post-Ph.D. researchers. On average, these three components account for **71%** of the total iREx budget.

Our **outreach programme** includes all of our educational and public outreach activities, including public talks and events, workshops, communications and marketing, online content and the Maunakea School. This portion of the budget, averaging **22%** of the iREx budget, also covers part of the salaries of our coordinators in charge of these activities. Finally, iREx **administration**, which includes the purchase of equipment and software, photocopying and telephone costs, other administrative expenses and a portion of our Coordinator's salary, averages only **7%** of our total budget.

Our Donors

THE iREx COULD NOT EXIST WITHOUT THE VALUED CONTRIBUTION OF ITS DONORS. WITHOUT THEIR SUPPORT AND VISION, OUR CONTINUED RESEARCH ENDEAVOURS TO EXPLORE AND BETTER UNDERSTAND THE UNIVERSE WOULD NOT BE POSSIBLE.



We would like to thank



Philippe Sureau

Jean-François Bertrand

Carole Kleingrib

Hortense Michaud-Lalanne

Isabelle Morin

Marie-Hélène Paquette

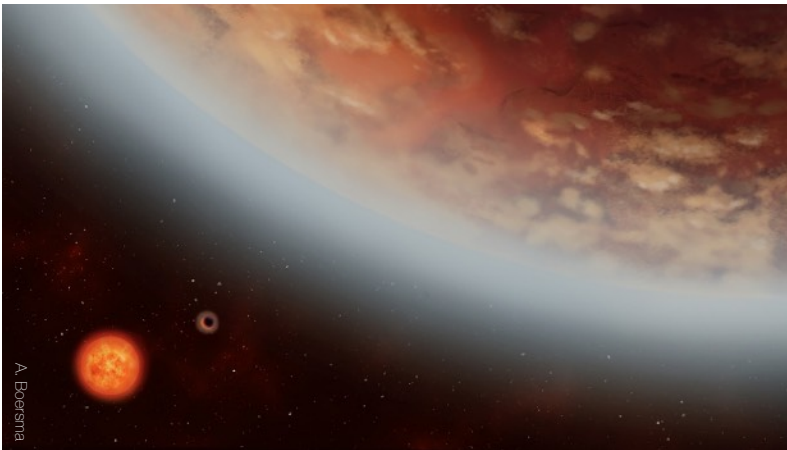
our other private donors

as well as our many supporters across solar systems near and far!

Research Highlights

Water in the Habitable Zone

AN INTERNATIONAL TEAM LED BY UDEM ASTRONOMER **BJÖRN BENNEKE** HAS DETECTED WATER VAPOUR ON THE EXOPLANET K2-18b. THIS IS A MAJOR DISCOVERY IN THE SEARCH FOR HABITABLE WORLDS AND EXTRATERRESTRIAL LIFE.



A team led by Björn Benneke and Caroline Piaulet, members of iREx at UdeM, has detected **water vapour** and possibly even **clouds of liquid water in the atmosphere of the exoplanet K2-18b**. This is an important step towards our ultimate goal of finding life on other planets.

The exoplanet K2-18b, which is about nine times more massive than Earth, lies in the **habitable zone** of the star around which it orbits. This M-type star is smaller and cooler than the Sun, but because of its closer proximity, K2-18b receives almost the **same total amount of energy from its star as the Earth receives from the Sun**.

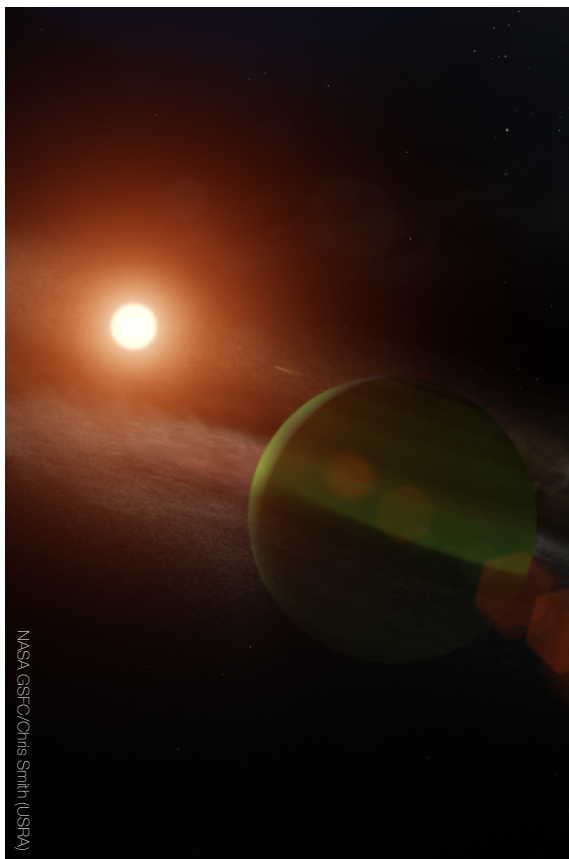
Similarities between the exoplanet K2-18b and Earth lead astronomers to believe that the exoplanet could potentially have a hydrological cycle that allows water to condense into clouds and fall as rain. The detection was made possible by combining observations from eight transits - when the exoplanet passes in front of its star - made by the Hubble Space Telescope.

Scientists currently believe that K2-18b's thick gaseous envelope would probably prevent the existence of life as we know it on the planet's surface. However, the study shows that even these relatively low-mass and therefore more difficult-to-study planets can be explored using astronomical instruments that have been developed in recent years. By analysing these planets which are located in the habitable zone of their star and on which the conditions for liquid water are present, astronomers are **one step closer to directly detecting signs of life beyond our Solar System**.

"Water vapour on the habitable-zone exoplanet K2-18b", Benneke *et al.*, *The Astronomical Journal*, 2019.

AU Mic, a Young System

JONATHAN GAGNÉ, SCIENTIFIC ADVISOR AT THE RIO TINTO ALCAN PLANETARIUM AND iREx MEMBER, PARTICIPATED IN THE DISCOVERY OF A NEPTUNE-SIZED EXOPLANET AROUND THE YOUNG STAR AU MICROSCOPII.



AU Microscopii (AU Mic), located about 32 lightyears from Earth, is a young star between 20 and 30 million years old. Since the discovery of its massive **debris disc** in 2000, astrophysicists have been actively searching for planets around this star, since it is within such discs of dust and gas that planets form.

Jonathan Gagné participated in the observations and data processing for this study, which took nearly 15 years to complete, given the star's **strong stellar activity and debris disc**, which both hinder the detection of planets.

In 2010, George Mason University Assistant Professor Peter Plavchan's team began observing the star from the ground with NASA's *Infrared Telescope Facility* (IRTF) in Hawai'i. This telescope operates in the infrared, a type of light where the star's activity is weaker.

Jonathan Gagné, who during his doctoral studies made numerous observing trips to the IRTF, joined the team in 2014. In 2016, team members noticed a possible periodic variation in the radial velocity of AU Mic, which could indicate the presence of a planet.

However, the accuracy of the ground-based data was not sufficient to confirm that the signal was due to an exoplanet. Instead, the team was able to confirm the presence of

the planet AU Mic b using the transit method. Astronomers observed two transits of the planet during the first of the *Transiting Exoplanet Survey Satellite* (TESS) missions in the Summer of 2018, followed by two more with NASA's *Spitzer Space Telescope* in 2019. These observations determined that **AU Mic b is about the size of Neptune and passes in front of its star every 8.5 days.**

[...] AU Mic, a Young System

By combining the IRTF observations with those from two other telescopes, the *European Southern Observatory* in Chile and the *W. M. Keck Observatory* in Hawai'i, the team deduced that the **mass of AU Mic b is less than about 3.4 times the mass of Neptune.**

AU Mic provides a unique laboratory for determining how planets and their atmospheres form, and how they interact with the disc of debris and gas that gives rise to them. Astrophysicists are delighted with this discovery, as few systems like AU Mic are known. Not only is it difficult to detect exoplanets in these systems, but they are also very rare because the period of planetary formation is relatively short compared to the lifetime of a star.

The system is close to us and thus appears bright, which makes it possible to observe it with a variety of instruments, such as the SPIRou spectrograph. This instrument, with its polarimetric capabilities, will make it possible to better distinguish the **effects of the star's activity**, which are often confused with signals from planets. This will allow the mass of AU Mic b to be determined accurately, and to know whether this planet resembles a large Earth or is rather a twin of Neptune.

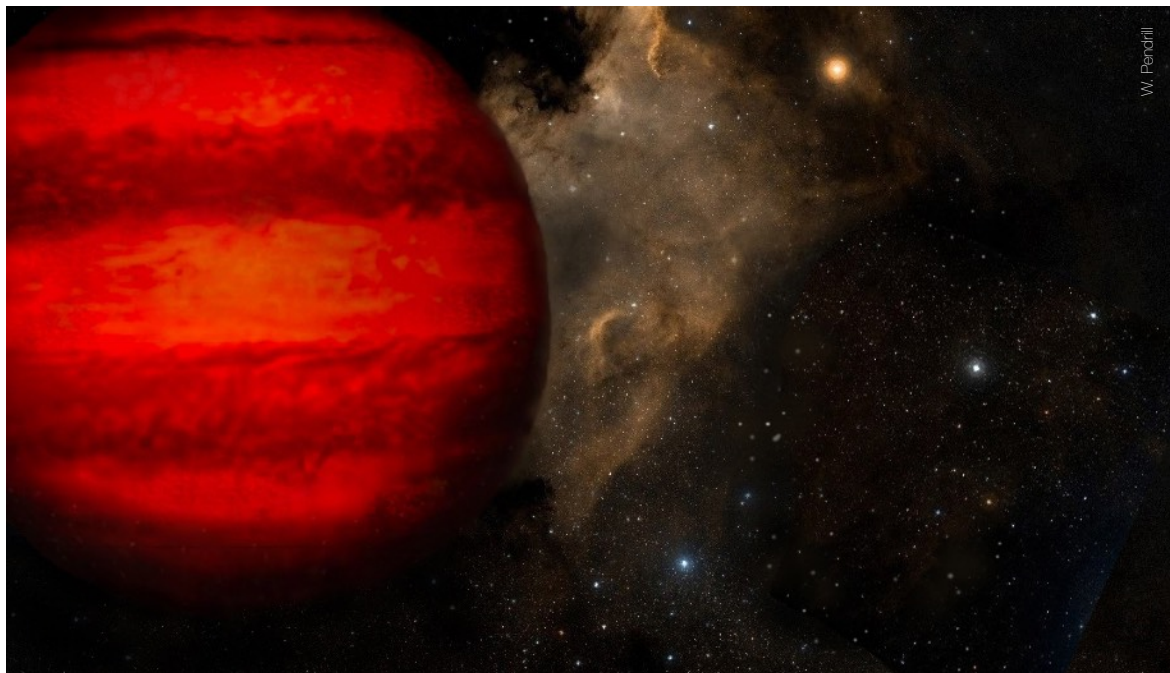
One of the interesting aspects of this discovery is that AU Mic is part of an association of young stars that formed at approximately the same time and place. Beta Pictoris, the star that gives its name to this association, also has a disc and has two known planets. However, the star and its planets are much more massive and do not seem to have evolved in the same way. The study of these two systems, which have many features in common, allows us to compare **two very different scenarios of planet formation.**



"A planet within the debris disk around the pre-main-sequence star AU Microscopii", Plavchan *et al.*, *Nature*, 2020.

Brown Dwarfs and Citizen Science

THROUGH A CITIZEN SCIENCE PROJECT, *BACKYARD WORLDS: PLANET 9*, AMATEUR AND PROFESSIONAL ASTRONOMERS INCLUDING iREx's **JONATHAN GAGNÉ** HAVE CONFIRMED THE EXISTENCE OF TWO BROWN DWARFS THAT LOOK NOTHING LIKE THOSE ALREADY KNOWN.

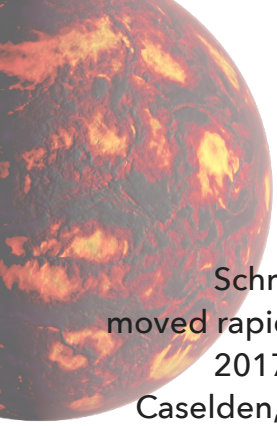


The two brown dwarfs discovered with the help of *Backyard Worlds: Planet 9* citizen scientists have luminous properties that are very different from those of other known brown dwarfs. According to researchers, these brown dwarfs could be among the **oldest ever observed**.

This is because the interstellar environment was different when they formed, and they have retained a particular chemical composition that the researchers are able to identify by studying their luminous properties.

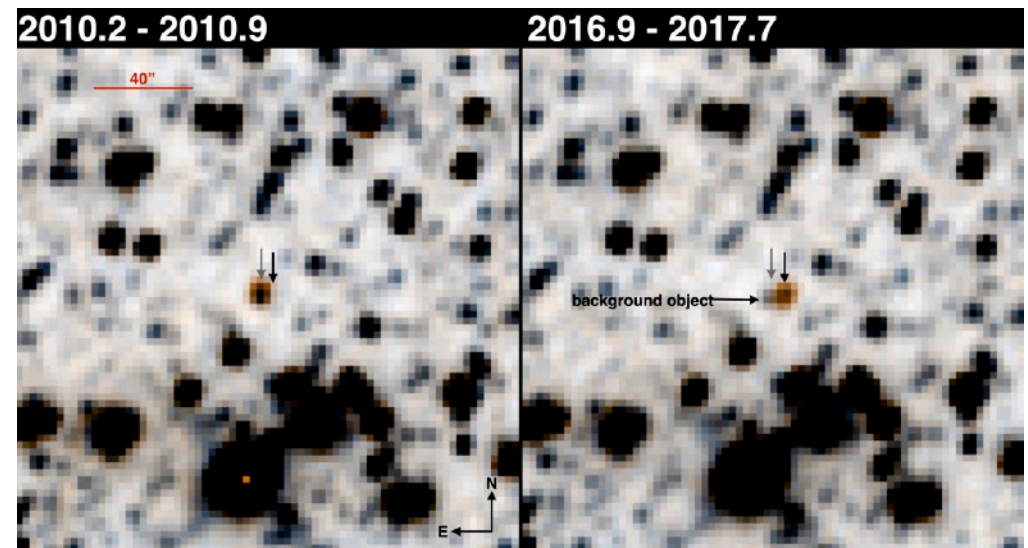
These two brown dwarfs are also so **massive** that they would have needed to accumulate only slightly more material at the time of their formation to initiate hydrogen nuclear fusion in their cores, and thus be born as stars.

Adam Schneider is the lead author of the paper, published in *The Astrophysical Journal*, which describes these findings and their potential impact. First identified a few years ago, one of these two brown dwarfs (WISE 1810) is located in a region of the sky with a high density of stars (in the plane of the Galaxy), making it difficult to study.



[...] Brown Dwarfs and Citizen Science

Schneider was able to confirm that WISE 1810 had moved rapidly across the sky between the years 2010 and 2017, using a tool called *WiseView* created by Dan Caselden, an avid amateur astronomer. This observation suggests that the brown dwarf is in the **solar neighbourhood**. Another amateur scientist, Arttu Sainio, also identified independently that this star was moving rapidly with *WiseView*. The second brown dwarf featured in the article was discovered independently by four other astronomy buffs: Paul Beaulieu, Sam Goodman, William Pendrill and Austin Rothermich.



The NASA-funded *Backyard Worlds* project **allows everyone to take part in the search for new stars** in the solar neighbourhood and beyond. The participants who discovered WISE 0414 combed through hundreds of images captured by NASA's *Wide-field Infrared Survey Explorer* (WISE) mission, looking for subtle shifts over time that can be easily detected by the human eye.

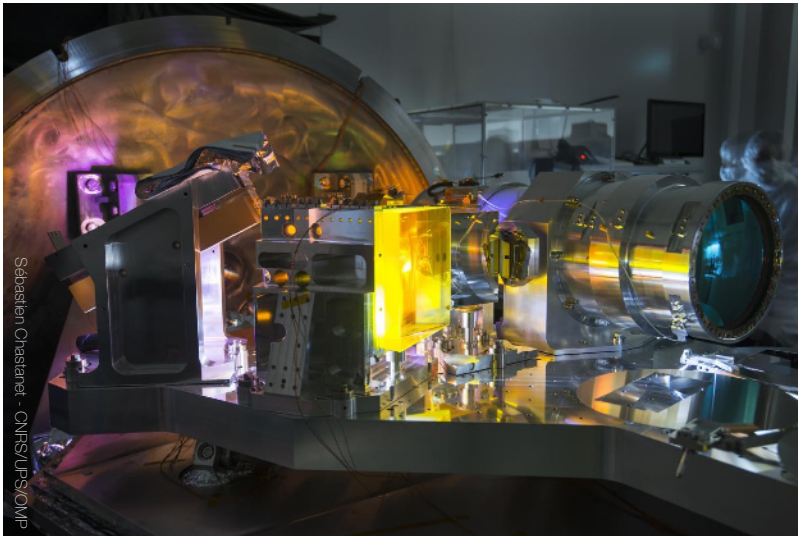
Jonathan Gagné is a member of the *Backyard Worlds* science team. He analysed the spectroscopic data of the second brown dwarf, obtained with the Magellan Baade telescope at the Las Campanas Observatory in Chile.

The discovery of these two unusual brown dwarfs, made possible by the successful collaboration between scientists and astronomy enthusiasts, gives specialists hope that other objects with surprising characteristics will be found in the future. The search for brown dwarfs based solely on the colours of those already known may omit brown dwarfs with unusual properties. Citizen science studies such as *Backyard Worlds* are helping to **define the parameters to watch for** in order to reveal other surprising brown dwarfs.

"WISEA J041451.67–585456.7 and WISEA J181006.18–101000.5: The First Extreme T-type Subdwarfs?", Schneider et al., *The Astrophysical Journal*, 2020.

SPIRou and NIRPS

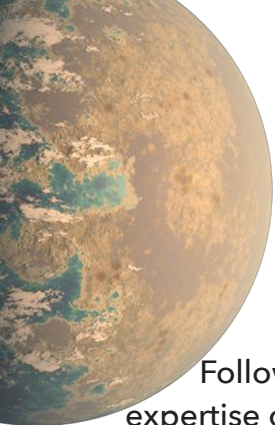
SPIRou CONTINUES ITS WORK AT THE CFHT. THE iREx TEAM ALSO CONTINUED THE DEVELOPMENT AND INTEGRATION OF THE **NIRPS** INSTRUMENT, WHICH WILL BE INSTALLED AT LA SILLA IN CHILE. IN 2020, NIRPS SAW ITS FIRST LIGHTS IN THE LABORATORY.



Installed at the **Canada-France-Hawai'i Telescope** on top of Maunakea since 2018, the **SpectroPolarimètre Infrarouge** (SPIRou) instrument was designed to study the magnetic fields of stellar systems and to detect Earth-like exoplanets. SPIRou measures the radial velocity of stars to detect minute variations that reveal the presence of planets around stars other than the Sun. Led by Jean-François Donati (Université de Toulouse, IRAP) and iREx director René Doyon, the SPIRou team is paying particular attention to **rocky, Earth-like exoplanets orbiting red dwarfs**, stars that are cooler, smaller and less massive than our Sun, which are very numerous in the solar neighbourhood.

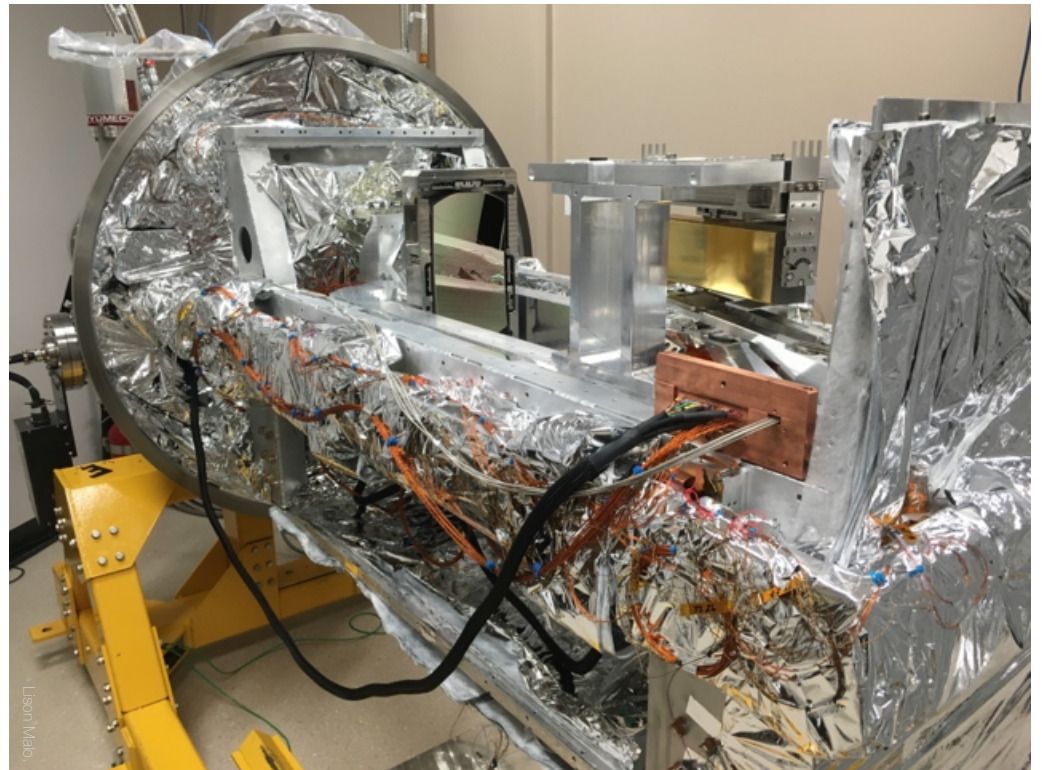
In 2019-2020, SPIRou spent **190 nights at the telescope to collect data for 40 observing programmes** designed by astronomers from institutions around the world. A special effort was made to improve SPIRou's data reduction algorithms. Étienne Artigau and Neil Cook, both iREx members, have been particularly critical in developing these algorithms and in making modifications to improve the quality of the calibrated spectra and the accuracy of the determined radial velocity measurements, such as consistent calculation of the spectrum trace shape, elimination of reference channel contamination in the science channel, and elimination of detector persistence effects.

The SPIRou team is confident that by improving the data reduction algorithms, the instrument will have the accuracy needed to detect Earth-like planets orbiting red dwarfs, which is the original goal of the project. This is no small feat: the instrument must be able to detect **variations in velocity of the order of 1 m/s** - the average speed of a person walking!



Following the success of SPIRou and the unrivalled expertise of its team, the iREx obtained a grant from the **Canada Foundation for Innovation** to build an infrared spectrograph called the **Near-Infrared Planet Searcher** (NIRPS). Its development is part of a large international collaboration, which includes the Geneva Observatory.

The Geneva team, which designed the HARPS spectrometer observing visible light, is among the world leaders in the detection of exoplanets using the **radial velocity method**. Their work with HARPS has revolutionised our understanding of planetary systems in the solar neighbourhood. HARPS was the first to obtain radial velocity measurements with a precision better than 1 m/s in visible light, a real achievement in this field.



The development of the NIRPS instrument progressed well during 2019-2020. NIRPS completed its **first thermal cycle** on July 31 2020. This step consists of gathering all the optical elements and aligning them with great precision in the cryostat, before cooling everything down to a temperature of about -200°C. The team was then able to take the **first images** with the instrument. As the instrument is not yet installed on a telescope, it was not starlight, but rather light from calibration lamps that was captured in these images.

NIRPS will soon be installed at the **3.6 m La Silla telescope** in Chile. This telescope is operated by the European Southern Observatory (ESO), an organisation that manages various observatories in Chile, including the four giant telescopes that make up the Very Large Telescope. NIRPS will be able to operate in parallel with the HARPS instrument, which has already been on this telescope for 10 years. By extending the capabilities of HARPS to the infrared, NIRPS will give the teams involved in the project unique **follow-up capabilities to characterise exoplanets**. Recognising the strategic importance of this pairing, ESO has awarded **740 nights of observing time** to the NIRPS team over five years.

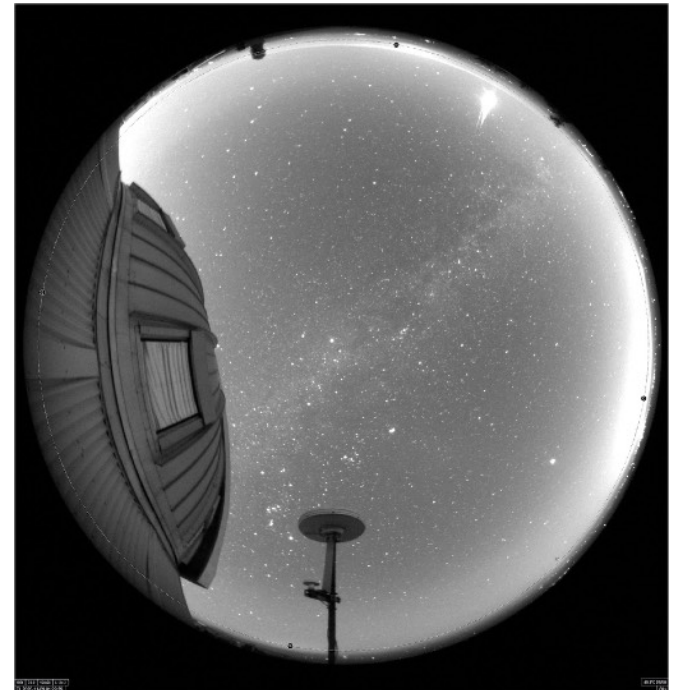
Observatoire du Mont-Mégantic

THE **OMM** IS A UNIQUE RESEARCH AND TRAINING FACILITY: IT IS THE ONLY PLACE IN CANADA WHERE FUTURE ASTRONOMERS ARE TRAINED IN THE USE OF A SCIENTIFIC TELESCOPE AND IS THE MOST PRODUCTIVE OBSERVATORY IN THE COUNTRY. IT IS ALSO A UNIQUE DEVELOPMENT FACILITY FOR ASTRONOMICAL INSTRUMENTS DEDICATED TO TELESCOPES ALL OVER THE WORLD.

iREx researchers and student investigators use the OMM as part of their research projects to **follow-up on potential exoplanets** identified by TESS, to study **ZZ Ceti white dwarfs** and to identify **new brown dwarfs** in the solar neighbourhood.

Researchers, many of whom are members of iREx, develop cutting-edge astronomical instruments at the **Laboratoire d'Astrophysique Expérimentale** (LAE). For example, one of the four scientific instruments on the James Webb Space Telescope was designed at the Observatory in collaboration with the Canadian Space Agency, Canadian industry and the National Research Council of Canada.

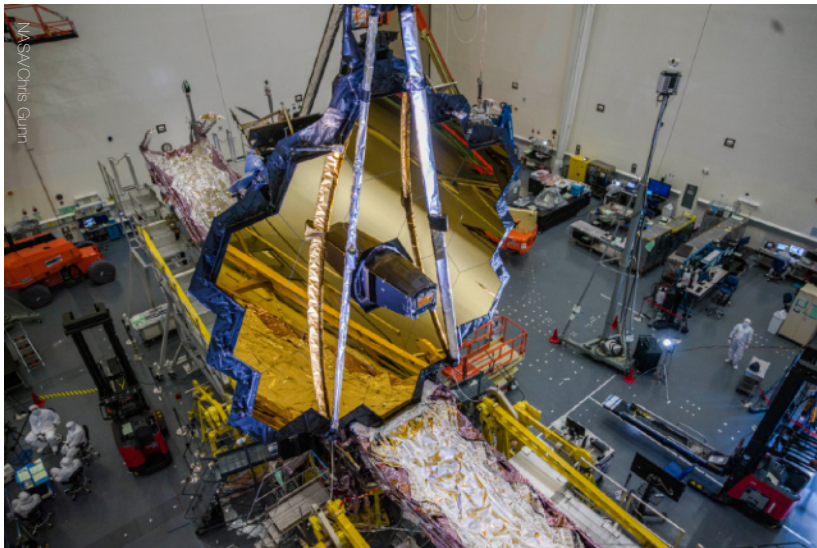
The OMM now has **two new outdoor cameras**. The first, the AllSky camera, is designed to **monitor weather** at the summit. This camera was installed as part of a partnership with the ASTROLab to study the evolution of light pollution in the **Mont-Mégantic International Dark Sky Reserve**. The second camera is part of the Canadian DOME (Detection and Observation of Meteors) camera network, which is itself part of FRIPON (Fireball Recovery and InterPlanetary Observation Network). The objective of this network of cameras installed around the world is to **detect fireballs and meteorites**. This project is managed from France, in collaboration with the **Rio Tinto Alcan Planetarium in Montreal**.



To learn more about the OMM: <http://omm.craq-astro.ca>.

James Webb Space Telescope

NASA AND ITS INTERNATIONAL PARTNERS ARE NOW AIMING FOR OCTOBER 31 2021 FOR THE LAUNCH OF THE **JAMES WEBB SPACE TELESCOPE**. THIS SEVEN-MONTH DELAY FROM THE PREVIOUSLY ANNOUNCED DATE OF MARCH 30 2021 IS DUE TO THE IMPACTS OF THE GLOBAL COVID-19 PANDEMIC AS WELL AS SOME TECHNICAL CHALLENGES RELATED TO THE MISSION.



The Webb team adapted to the COVID-19 pandemic by imposing heightened security measures. It also experienced a reduction in on-site staff and interruptions in work. To reflect the new launch date, the call to the scientific community for time requests for Cycle 1 was also modified. **Telescope time proposals for General Observing (GO) time must now be submitted by November 24 2020.**

Testing of the Webb telescope continued at Northrop Grumman, the mission's main industrial partner, in California, despite the challenges posed by the pandemic. Prior to the pandemic-related delays, the team had achieved important milestones to prepare for launch in 2021.

As the schedule margins tightened last autumn, NASA had planned an assessment of the project's status in April 2020. This assessment was postponed due to the pandemic and completed in mid-July. At that time, the **new launch date of October 31 2021** was chosen. Based on current projections, the mission team expects to complete the remaining work on the new schedule **without the need for any additional funding.**

The Webb team continues to perform a final round of extremely challenging environmental testing for the telescope, which is now fully assembled. In 2021, Webb will be folded like a piece of origami to be sent to the launch site in Kourou, French Guiana, and placed inside the Ariane 5 rocket that will then launch the telescope into space.

Team

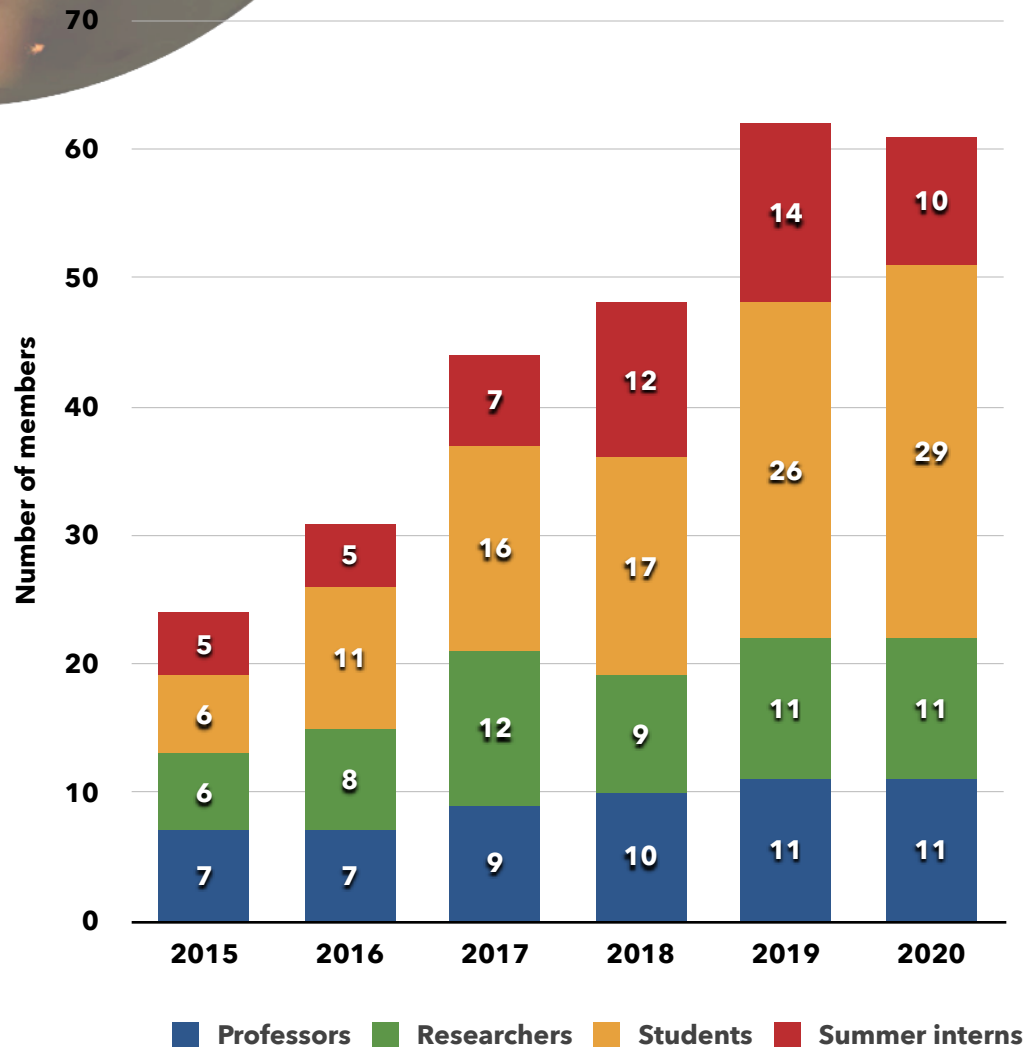
THE iREx TEAM CONSISTS OF UNDERGRADUATE AND GRADUATE STUDENTS, POSTDOCTORAL AND SENIOR RESEARCHERS, AND PROFESSORS. OUR MEMBERS ARE SPREAD ACROSS THE **UNIVERSITÉ DE MONTRÉAL**, **MCGILL UNIVERSITY**, **BISHOP'S UNIVERSITY**, **UNIVERSITÉ LAVAL** AND THE **RIO TINTO ALCAN PLANETARIUM** IN MONTRÉAL.

TOGETHER, WE FORM THE LARGEST EXOPLANET RESEARCH CENTRE IN CANADA AND ONE OF THE MOST COMPETITIVE IN THE WORLD.



Growth in our Team

SINCE ITS INCEPTION IN 2014 WITH BARELY A DOZEN MEMBERS, THE iREx TEAM HAS UNDERGONE **IMPRESSIVE GROWTH** THANKS TO THE RECRUITMENT OF NEW MEMBERS. DESPITE THE COVID-19 PANDEMIC, WHICH OBVIOUSLY MADE RECRUITMENT MORE DIFFICULT THIS YEAR, THE SIZE OF THE iREx TEAM HAS REMAINED STABLE.



A few new members joined our team in 2019-2020. This includes 10 summer interns who did their entire internship remotely, given the COVID-19 pandemic.

In the summer of 2020, the iREx had **61 members**. The size of the team thus remained stable compared to the previous year: quite a remarkable feat given the exceptional context!

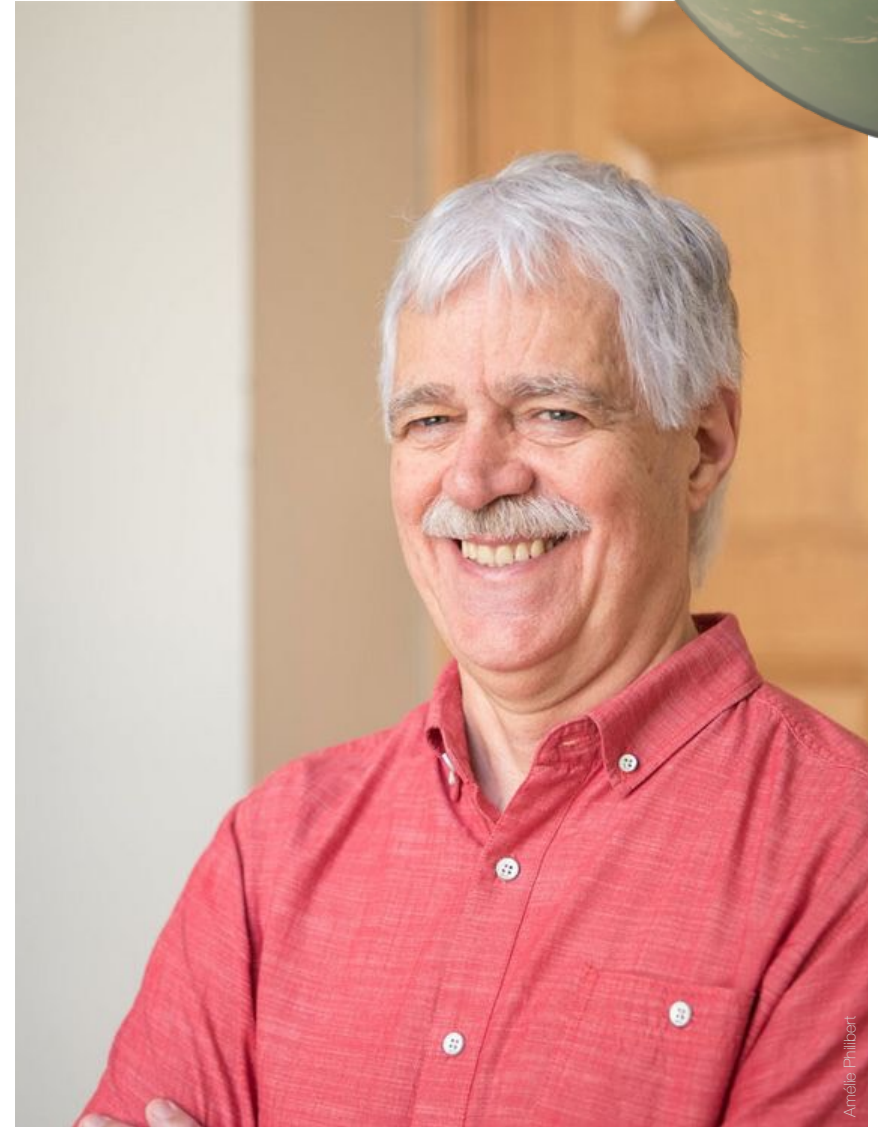
The total number of iREx members fluctuates each year as team members join and leave, but **our research network continues to grow** as we follow our students' and researchers' path after their stay with us.

In memoriam: Gilles Fontaine

On November 1st 2019, **Gilles Fontaine**, Professor of Astrophysics and iREx member, passed away. Gilles Fontaine was internationally recognised for his work on the last evolutionary stages of stars. He was a specialist in **white dwarfs**, and was particularly interested in pulsating white dwarfs, which he studied using **asteroseismology**.

At the turn of the 2010s, he became interested in the detection and characterisation of exoplanets around evolved stars, through the in-depth analysis of these stars. In 2011, he contributed to the **discovery and characterisation of two small planets around a late-stage star**, and to the analysis of **white dwarfs polluted by rocky debris**.

The entire team remembers the time spent with this great researcher, who was also an outstanding teacher and an exceptional colleague, fondly.



Changes in our Team

SEVERAL **NEW RESEARCHERS** JOINED THE TEAM IN 2019-2020. THE COMMUNICATIONS AND OUTREACH TEAM HAS GROWN. SEVERAL OF OUR STUDENTS COMPLETED THEIR DEGREES, AND SEVERAL MORE STARTED THEIR STUDIES WITH US

Jonathan Gagné left his postdoctoral research position with us in May 2019 to become a **Scientific Advisor at the Rio Tinto Alcan Planetarium with Space for Life**. In September 2019, he became an **Adjunct Professor at the Université de Montréal**, and joined the iREx again, as an associate member. Jonathan's research focuses on the study of stars, brown dwarfs and young rogue planets in kinematic associations in the solar neighbourhood.



Daniel Thorngren is the **2019 Trottier Postdoctoral Fellow**. He is interested in the composition and internal structure of giant planets in our Solar System, which he compares to those of giant exoplanets. He also studies the processes involved in the formation and evolution of these planets, and compares theoretical model predictions with observations.



Thomas Navarro joined the iREx in 2019. A postdoctoral researcher at the McGill Space Institute, he collaborates with Nicolas Cowan on the study of the climates of exoplanets in synchronous rotation around their star. He is also a specialist in the atmosphere of Mars, Venus and telluric exoplanets, which he studies using numerical models.

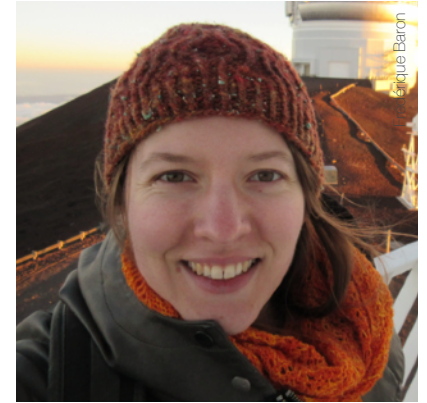


[...] Changes in our Team



James Sikora has been a **postdoctoral researcher** at **Bishop's University** since September 2019, where he works with Jason Rowe. James is the principal investigator of several spectroscopic observing programmes at the CFHT and Gemini Observatories, which are primarily designed to detect and characterise the atmospheres of gas-rich exoplanets.

Frédérique Baron held the position of **Education and Public Outreach Coordinator** on an interim basis from October 2018 to Summer 2020. Since September 2020, she has held the position of **Project Manager** and **Scientific Mediator** with the **Observatoire du Mont-Mégantic** and iREx.



Marie-Eve Naud has returned from her parental leave since June 2020. She has resumed her duties as iREx's **Education and Outreach Coordinator**. She is an astrophysicist fascinated by science communication and education, and also contributes to the *Discover the Universe* programme as a Project Manager.

Congratulations to **Dominic Couture** and **Charles Cadieux** (supervised by René Doyon, UdeM) and **Raphaël Hardy** (supervised by Paul Charbonneau, UdeM, and Andrew Cumming, McGill), who after completing their M.Sc. are pursuing a Ph.D. with us, and to **Prashansa Gupta** (supervised by Björn Benneke, UdeM), who after completing her M.Sc. with us, is now pursuing a career in data science.

We wish a warm welcome to our new graduate students, **Ben Leblanc** (M.Sc. with Jason Rowe, Bishop's), **Michael Radica** (Ph.D. with David Lafrenière, UdeM), **Louis-Philippe Coulombe** (M.Sc. with Björn Benneke, UdeM), **Timothy Hallat** (M. Sc. with Eve Lee, McGill), **Thomas Vandal** (M.Sc. with René Doyon, UdeM), **Myriam Prasow-Émond** (M.Sc. with Julie Hlavacek-Larrondo, UdeM), **Simon Delisle** (M.Sc. with Björn Benneke, UdeM) and **Pierre-Alexis Roy** (M.Sc. with Björn Benneke, UdeM).

Prizes and Grants

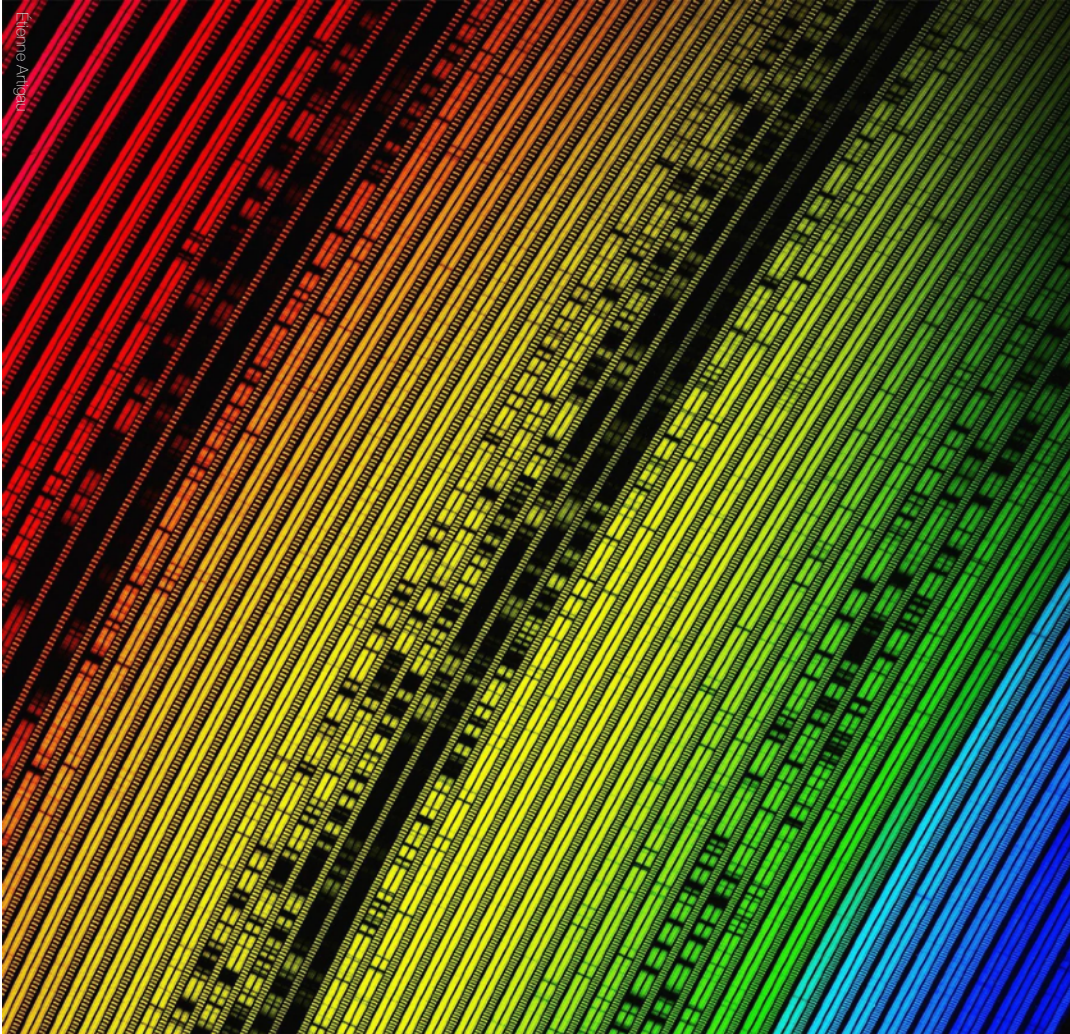
SEVERAL iREx MEMBERS HAVE BEEN AWARDED **PRIZES AND SCHOLARSHIPS** IN 2019-2020.

Our director **René Doyon** received the **Dunlap Award for Innovation in Astronomical Research Tools from the Canadian Astronomical Society** in the Spring of 2020. This award, given every two years, recognises his work as a pioneer and leader in the field of infrared instrumentation. His recent contributions include the design of the SPIRou and NIRPS spectrographs, already in operation in Hawai'i and soon-to-be shipped to Chile respectively, and the Canadian instrument NIRISS, which will be aboard the James Webb Space Telescope, scheduled for launch in 2021. Professor Doyon was also named a **Fellow of the Royal Society of Canada** in September 2020, a title awarded to artists, researchers and scientists who have had a significant impact in their discipline, both nationally and internationally. This appointment highlights Dr. Doyon's leadership role in the field of exoplanet research and astronomical instrumentation.



In the winter of 2020, the iREx was awarded a **DIALOGUE - Volet Chercheur grant** by the Fonds de recherche du Québec. This programme aims to encourage Quebec scientists to talk about scientific research with the general public. The iREx team, led by our Coordinator, astrophysicist and science communicator **Nathalie Ouellette**, has launched the **ExoBites project** through this grant, a series of short videos in French with English subtitles featuring our professors, researchers and students, as well as animated infographics. The topics covered are designed to convey the basics of exoplanet research and life in the Universe in a fun and dynamic way.

[...] Prizes and Grants



An image submitted by **Étienne Artigau**, an iREx researcher at the **Université de Montréal**, was selected as a **finalist in the 2020 *La preuve par l'image* competition**, organised by the Association francophone pour le savoir (Acfas).

The image, entitled *Code-barres extraterrestres*, was developed from data obtained with the SPIRou instrument, installed on the Canada-France-Hawaii Telescope. It shows the light from a star that is cooler than the Sun, analysed by the instrument. It is this kind of observation that allows astronomers using SPIRou to attempt to detect exoplanets, including potentially habitable planets.

In 2019-2020, **4 of our summer interns**, **6 of our master's students** and **11 of our doctoral students** were awarded government or institutional scholarships. For a full list of awardees, see our directory at the end of this report.

Public Talks

MANY iREx MEMBERS ARE FREQUENTLY INVITED TO GIVE TALKS FOR THE GENERAL PUBLIC AND AT SCHOOLS AND LIBRARIES.

In addition to being researchers, our members are also popular science educators throughout Quebec and Canada. We give **public talks** in amateur astronomy clubs, science centres, planetariums and even bars.

Our astronomers are also invited to **meet with elementary, high school, college and university students** in the Montreal area and beyond to talk about exoplanets, space and an astronomer's profession.

For a complete list of our public lectures, see the appendix at the end of this report.

DU 16 AU 22 SEPTEMBRE 2019

Semaine de la culture scientifique

Une semaine de célébration des sciences et de la recherche sur les océans au Canada



The iREx participated in **Science Literacy Week** in September 2019 for the first time. During this edition, which had the theme "O for Oceans", astrophysicists Frédérique Baron and Nathalie Ouellette visited **8 municipal libraries** in the Montreal region. They introduced young and old folks alike to "Ocean Worlds", exoplanets covered in water.

[...] Public Talks



The Institute was pleased to welcome **Sarah Hörst** on October 16th 2019 for the **Grande Conférence de l'iREx**. At this event, over 150 people were able to travel to Titan, Saturn's largest moon, during a presentation entitled "***Titan: Ingredients for Life***".

Sarah Hörst, an Assistant Professor at Johns Hopkins University, is a specialist in the study of the formation and composition of planetary atmospheres. Dr. Hörst is a member of the science team for NASA's newly selected Dragonfly mission, which will explore the surface of Titan.

During her public lecture, Hörst discussed the historical importance of Titan in the search for life. The Dragonfly mission was especially featured: it will allow a robotic helicopter to descend to the surface of Titan to collect and analyse samples in the hope of finding life.

The Grandes conférences de l'iREx was created to **allow a world-class researcher to visit Montreal to interact with iREx members and present his research and his story to the general public**. Previous speakers include David Charbonneau (Harvard) and Vicky Meadows (U of Washington).

Public Events

THE iREx PARTICIPATES IN MANY **ANNUAL AND SPECIAL PUBLIC EVENTS** ORGANISED BY OUR INSTITUTE AND OTHER KEY STAKEHOLDERS IN THE SPACE SECTOR IN COLLABORATION WITH OUR MANY PARTNERS.

The **MIL en fête** event, a large citizen celebration inaugurating the 1st phase of the MIL Project and the UdeM's new MIL campus, took place in **September 2019**. The D-PHY Committee and **Frédérique Baron** were there to represent the Department of Physics and run a booth during the afternoon festivities. Participants of all ages were able to play match games featuring well-known and little-known female physicists, discover moons in the Solar System, and learn more about our department's studies.



Several iREx members participated in the **Montreal Space Symposium** which took place on **October 10 and 11 2019**. This annual meeting aims to bring together the Montreal space community through presentations, booths, workshops and networking activities. **Étienne Artigau, Frédérique Baron, Taylor Bell, Émilie Laflèche** and **Olivier Hernandez** gave talks or participated in panels during the symposium. In addition, **Frédérique Baron** and **Nathalie Ouellette** introduced the iREx and the James Webb Space Telescope through a virtual reality activity at an iREx booth.

Astronomy on Tap

ASTRONOMY ON TAP EVENTS ARE ORGANISED BY THE iREx IN COLLABORATION WITH THE ASTROMcGILL TEAM AND THE CENTRE DE RECHERCHE EN ASTROPHYSIQUE DU QUÉBEC. THESE MONTHLY EVENTS, FREE AND OPEN TO ALL, ARE DELIVERED ALTERNATING BETWEEN FRENCH AND ENGLISH.



The concept for the **Astronomy on Tap** events was created in 2014 in New York as evenings organised by astronomers for the general public. There are now more than thirty franchises around the world that organise this activity. The first edition in Montreal took place in January 2017 at **McLean's Pub**. French editions usually take place at **Pub L'Île Noire**.

On a typical evening, two or three astronomers present various astronomy-related topics in a playful manner, astronomy-flavoured quizzes are hosted and prizes from our partners are offered. During the period covered by this report, **1 event was presented in English** and **2 others were held in French**. In addition, a very special **bilingual edition** was held on **November 27th 2019** at the **Sans-taverne Bar**. Each event attracts an average of 60 participants.



Online Events

IN ORDER TO COMPLY WITH THE HEALTH MEASURES PUT IN PLACE BY THE GOVERNMENT DURING THE COVID-19 PANDEMIC, THE iREx PARTICIPATED IN AND ORGANISED NUMEROUS **ONLINE EVENTS TO CONTINUE TO REACH ITS TARGET AUDIENCES.**

Astro at Home / Astro à la maison is an initiative of Discover the Universe (DU) which is an organisation that provides astronomy training to educators to help them share this fascinating science.



When schools closed in March 2020, DU created the **Astro at Home** programme to reach children aged 8-12 directly. Every weekday from **March 17 to May 29**, a 30-minute astronomy presentation was broadcast live on YouTube. During the presentation, children were invited to chat directly with the Canadian astronomer featured that day and ask them questions. A total of 102 presentations were recorded during the event. iREx astronomers contributed to the success of this programme by participating in **24 of these presentations**, which have been **viewed 30 000 times** to date.



In 2020, the iREx initiated the **Petite école de l'espace** programme, aimed at children aged 3 to 8 and their families. During these free events, broadcast live on the **Institute's YouTube channel (www.youtube.com/exoplanetes)**, astrophysicists **Marie-Eve Naud** and **Frédérique Baron** tell space-themed stories and answer children's questions.

In the first edition **broadcast live on July 11 2020**, Frédérique shared the legend of the Big Dipper constellation and Marie-Eve told the story "Shooting Stars and Hot Dogs", which features two children who see shooting stars for the first time. Frédérique also answered several questions about alien life and the Sun.

After the event, **over 100 youngsters** sent in a drawing that showed something they had learned during the show. This edition attracted almost **1000 families tuning in live**, and has accumulated almost **300 additional views**.

[...] Online Events

The iREx, in collaboration with the UdeM, organises the **astroMIL**, a popular astronomy event that attracts several hundreds of people on the MIL campus, every summer. On **August 12 2020**, the 4th edition of astroMIL (and the 1st entirely virtual edition) was held. The goal of the event's theme, ***Unis sous un même ciel***, was to celebrate the beauty of the sky at the height of the Perseids meteor shower, all together, while each staying in our own home.

The evening, hosted by André Robitaille, began with a panel discussion on traditions and future perspectives entitled 'Regards autochtones sur le ciel'. This was followed by another panel discussion to address the fact that there is no Planet B for humanity. Finally, the Park Rangers, technicians specialised in astronomy, at the ASTROLab du Mont-Mégantic shared their love of the starry sky by showing us live images obtained with the telescope at the Observatoire populaire du Mont-Mégantic.

Listeners were then invited to continue their evening by going outside to observe the stars while tuning in to UdeM's student radio, CISM 89.3, which presented a special programme on the Perseids meteor shower with two iREx astrophysicists.

Nearly **500 people joined us live** on the MIL campus Facebook page and on the Institute's YouTube channel. Comments and questions poured in at such a rate that the speakers had to finish answering them the following day, clearly showing the keen interest the event generated among the public!



In order to stay connected with the general public during the pandemic, the iREx replaced its Astronomy on Tap events that typically take place in bars with **Astronomy Online** events in the form of Facebook Lives on the Institute's page. A total of **three events** took place during the Spring of 2020. These included dynamic presentations by astronomers, a question and answer period and a quiz using the virtual platform Kahoot.

In the News

THE iREx'S **VISIBILITY IN THE MEDIA** REMAINED IMPRESSIVE IN 2019-2020 DESPITE THE FACT THAT THE MEDIA LANDSCAPE WAS DOMINATED BY COVID-19 IN 2020.



In 2019-2020, iREx members participated in **7 television interviews**, **37 radio interviews** and **25 print and online interviews**.

For a complete list of our media interviews, see the appendix at the end this report.

Social Media

THE EXCEPTIONAL CONTEXT OF THE COVID-10 PANDEMIC ENCOURAGED US TO SIGNIFICANTLY EXPAND OUR **VIRTUAL PRESENCE** IN 2019-2020. WE HAVE MORE SUBSCRIBERS ON ALL OUR PLATFORMS THAN EVER BEFORE, AND WE WORKED ON RELAUNCHING OUR YOUTUBE CHANNEL.

As of August 31 2020, the iREx had

1946 followers
Facebook



@iRExoplanetes

947 followers
Twitter



@iExoplanets

53 234 hits
on our website



www.exoplanets.ca

1161 subscribers
to our newsletter



irex@astro.umontreal.ca

Cafés iREx

THE **CAFÉS iREx** ARE WEEKLY MEETINGS THAT ALLOW OUR MEMBERS TO DISCUSS THE LATEST NEWS IN THE FIELD OF EXOPLANETS OR TO PRESENT THEIR MOST RECENT SCIENTIFIC RESULTS.



Every week, the members of iREx meet to **discuss the latest news from the world of exoplanets**, brown dwarfs, instrumentation and more broadly astronomy. The meetings' location alternates between the **Université de Montréal** and the **McGill Space Institute**. During the COVID-19 pandemic in 2020, our meetings continued in a virtual format.

Our **Cafés iREx** come in a variety of formats depending on our needs: presentations with visual support, open roundtable discussions or question and answer sessions. We also often welcome internationally renowned researchers visiting Montreal. These meetings allow our members, especially our students, to interact with experienced researchers in a more informal setting.

In 2020, iREx members took advantage of the virtual format of the meetings to **invite authors of recently published scientific papers** to present their research at our meetings. In addition, some Cafés were devoted to **online seminars and conferences organised by other institutes** elsewhere in the world on topics related to exoplanets. Finally, several sessions were devoted to **discussions related to issues of equity, diversity and inclusion**.

Summer Internships

THE iREx HAS BEEN WELCOMING UNDERGRADUATE STUDENTS AS **SUMMER INTERNS** SINCE OUR INCEPTION. OUR **TROTTIER SUMMER INTERNSHIP EXCELLENCE GRANTS** COMPETITION ATTRACTS CANADA'S TOP STUDENTS TO OUR INSTITUTE.



In the **Summer of 2020**, **ten summer interns**, including **five Trottier Fellows**, joined the iREx team. Our interns from across Canada worked remotely this year in order to comply with the health measures required to address the COVID-19 pandemic. They were integrated into the iREx team during an Orientation Day and during our Cafés iREx throughout the summer. They were also invited to participate in a weekly meeting with each other and the iREx coordinators. They all presented the results of their research in virtual final presentations in August.

The iREx participated in **interdisciplinary internships** for the first time this summer. Guillaume Payeur, co-supervised by René Doyon, Étienne Artigau and Laurence Perrault-Levasseur, worked on machine learning using data from the SPIRou instrument. Louis-Simon Guité, co-supervised by René Doyon, Étienne Artigau and Julie Hlavacek-Larrondo, studied observations of potential exoplanets in orbit around compact objects.

Diversity Committee

THE MISSION OF THE iREx **DIVERSITY COMMITTEE** IS TO PROMOTE THE PROFESSIONAL INTEGRATION WITHIN iREx OF PEOPLE FROM TRADITIONALLY UNDER-REPRESENTED GROUPS IN THE PHYSICS RESEARCH COMMUNITY AND TO HELP INCREASE THE SCIENTIFIC PROSPERITY OF AN INCLUSIVE iREx PROUD OF ITS DIVERSITY.



The Institute's **Diversity Committee** was created to achieve the following objectives:

- To increase the recruitment effort of people from under-represented groups, at all levels of education and employment;
- To promote the integration and retention of these individuals within iREx;
- To promote diversity in science through iREx;
- To promote the pursuit of a research career after a period at iREx.

The committee is currently composed of **Étienne Artigau, Frédérique Baron, David Lafrenière, Marie-Eve Naud** and **Nathalie Ouellette**, and a student representative, **Michael Radica**.

Long Term Plan 2020

EVERY 10 YEARS, THE CANADIAN ASTRONOMICAL COMMUNITY MEETS TO DEVELOP A **LONG RANGE PLAN** (LRP) TO DETERMINE ITS PRIORITIES FOR THE COMING DECADE. IN 2019-2020, SEVERAL iREx MEMBERS PLAYED KEY ROLES IN THIS PROCESS.

David Lafrenière, iREx member and Professor at the Université de Montréal, was a member of the committee who helped coordinate the discussions and meetings that took place across the Canadian community. The LRP2020 committee was also responsible for writing and publishing the final plan.

Several iREx members led the creation of community papers that set the stage for the writing of the LRP2020:

- "The opportunity of young nearby associations with the advent of the Gaia mission" - **Jonathan Gagné et al.**
- "Astronomy Advocacy and Engagement" - **Nathalie Ouellette et al.**
- "Entering a New Era of Astrophysics with the James Webb Space Telescope" - **René Doyon et al.**
- "Exoplanet instrumentation in the 2020s: Canada's pathway towards searching for life on potentially Earth-like exoplanets" - **Björn Benneke et al.**

iREx members are co-authors on several other community papers associated with the LRP2020.

The final version of the LRP2020 can be found on the Canadian Astronomical Society's website:
<http://www.casca.ca>.



School and Library Talks

- *Exploring the Universe*, Nathalie Ouellette, Exploring by the Seat of your Pants, September 11 2019.
- *À la découverte des exoplanètes et des mondes océans*, Frédérique Baron, Bibliothèque Père-Ambroise (Science Literacy Week), September 17 2019.
- *Les mondes océans*, Nathalie Ouellette, Bibliothèque de Saint-Charles (Science Literacy Week), September 17 2019.
- *Les mondes océans*, Nathalie Ouellette, Bibliothèque de Marie-Uguay (Science Literacy Week), September 17 2019.
- *À la découverte des exoplanètes et des mondes océans*, Frédérique Baron, Bibliothèque de L'île-Bizard (Science Literacy Week), September 19 2019.
- *Les mondes océans*, Nathalie Ouellette, Bibliothèque de Hochelaga (Science Literacy Week), September 19 2019.
- *Les mondes océans*, Nathalie Ouellette, Bibliothèque de Cartierville (Science Literacy Week), September 21 2019.
- *Exploring the Universe*, Nathalie Ouellette, Exploring by the Seat of your Pants, October 11 2019.
- *Les exoplanètes et la recherche pour la vie extraterrestre*, Antoine Darveau-Bernier, École Sophie-Barat, October 17 2019.
- *Exoplanets*, Chris Mann, Burnaby High School (RASC), October 22 2019.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist, November 6 2019.
- *Exoplanets*, Caroline Piaulet, High School (RASC), November 15 2019.
- *Exploring the Universe*, Nathalie Ouellette, Exploring by the Seat of your Pants, November 25 2019.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Saint-Gérard, November 27 and December 2 2019.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist, November 28 2019.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Cégep de Ste-Foy, December 13 2019.
- *Les trous noirs*, Nathalie Ouellette, École Joseph-Hermas-Leclerc, December 17 2019.
- *Les exoplanètes*, Frédérique Baron, Central French Immersion Public School (Skype a Scientist), January 27 2020.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Université de Montréal - campus MIL, January 30 2020.
- *Exploring the Universe*, Nathalie Ouellette, Exploring by the Seat of your Pants, January 31 2020.
- *Dark Matter*, Nathalie Ouellette, Virtual Researcher on Call, February 3 2020.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist, February 12 2020.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Collège Stanislas, February 13 2020.
- *Les mondes extraterrestres*, René Doyon & Nathalie Ouellette, École primaire Saint-Laurent, February 21 2020.

[...] Public Talks

[...] School and Library Talks

- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist, February 25 2020.
- *Exploring the Universe*, Nathalie Ouellette, Exploring by the Seat of your Pants, March 25 2020.
- *Explorons l'Univers*, Nathalie Ouellette, Exploring by the Seat of your Pants, March 27 2020.
- *Astrophysique en classe virtuelle*, Charles Cadieux, École secondaire Saint-Laurent, May 8 2020.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist, June 3 2020.
- *Questions et réponses*, Frédérique Baron, École secondaire Marcelle-Mallet, June 6 2020.

Public Talks

- *Galaxies en évolution*, Nathalie Ouellette, Société d'astronomie du Planétarium de Montréal, September 6 2019.
- *À la découverte de nouveaux mondes!*, Frédérique Baron, Cégep de Trois-Rivières (Cercle EinsteinPlus), September 20 2019.
- *Conférence de l'équinoxe: À la recherche de la vie au-delà du Système solaire*, René Doyon, Planétarium Rio Tinto Alcan de Montréal, September 20 2019.
- *Unveiling the Universe with the James Webb Space Telescope*, Nathalie Ouellette, RASC Montréal (Townsend Keynote Lecture), September 21 2019.
- *Naines brunes ou exoplanètes déguisées?*, Frédérique Baron, Club d'astronomes amateurs de Boucherville, October 2 2019.
- *Les mondes extraterrestres*, Nathalie Ouellette, GOCervo, October 5 2019.
- *À la découverte de nouveaux mondes!*, Frédérique Baron, Club d'astronomes amateurs de Rosemère, October 7 2020.
- *Galaxies en évolution*, Nathalie Ouellette, Club d'astronomie du Mont-Tremblant, October 8 2019.
- *Titan: Ingredients for Life*, Sarah Hörst, La grande conférence de l'iREx (campus MIL), October 16 2019.
- *Activité sur les transits d'exoplanètes*, Frédérique Baron, Les Scientifiques, November 5 2019.
- *À la découverte de nouveaux mondes!*, Frédérique Baron, Bibliothèque de Thetford Mines, November 12 2019.
- *Stellar Associations and Planemos and How They Will Help Us Better Understand Exoplanets*, Jonathan Gagné, Mexborough & Swinton Astronomy meetings, December 3 2019.
- *Unveiling the Universe with the James Webb Space Telescope*, Nathalie Ouellette, RASC Ottawa, December 5 2019.
- *Sommes-nous seuls dans l'Univers?*, Frédérique Baron, Société d'astronomie du Planétarium de Montréal, January 24 2020.
- *Le spectrographe SPIRou*, Étienne Artigau, Société d'astronomie du Planétarium de Montréal, February 14 2020.
- *L'Univers multicolore*, Nathalie Ouellette, Club d'astronomie de Boisbriand, February 19 2020.

[...] Public Talks

- *Sommes-nous seuls dans l'Univers?*, Frédérique Baron, Cégep Garneau (Cabaret des sciences), February 25 2020.
- *Est-ce que les extraterrestres existent?*, Frédérique Baron, Astro à la maison, March 20 2020.
- *Do aliens exist?*, Frédérique Baron, Astro at Home, March 23 2020.
- *Les trous noirs*, Nathalie Ouellette, Astro à la maison, March 24 2020.
- *Black Holes*, Nathalie Ouellette, Astro at Home, March 24 2020.
- *Crashing Galaxies*, Nathalie Ouellette, Astro at Home, April 2 2020.
- *Lunes et exo lunes*, Frédérique Baron, Astro à la maison, April 4 2020.
- *Est-ce que les extraterrestres existent?*, Frédérique Baron, Exploring by the Seat of your Pants, April 6 2020.
- *Nouvelles astronomiques*, Nathalie Ouellette, Astro à la maison, April 8 2020.
- *La formation du Système solaire*, Frédérique Baron, Club d'astronomie du Mont-Tremblant, April 14 2020.
- *L'Univers multicolore*, Nathalie Ouellette, Astro à la maison, April 16 2020.
- *Spécial jour de la Terre*, Frédérique Baron, Astro à la maison, April 17 2020.
- *The Kaleidoscopic Universe*, Nathalie Ouellette, Astro at Home, April 24 2020.
- *Rencontre avec une astronome*, Frédérique Baron, ASTROLab en direct, April 28 2020.
- *Lunes et exo lunes, hôtes de vie?*, Frédérique Baron, Société d'astronomie du Planétarium de Montréal, April 29 2020.
- *Les télescopes*, Nathalie Ouellette, Astro à la maison, April 30 2020.
- *Les naines brunes*, Frédérique Baron, Astro à la maison, May 8 2020.
- *Telescopes*, Nathalie Ouellette, Astro at Home, May 11 2020.
- *Le télescope Gaia et ses découvertes*, Jonathan Gagné, Club d'astronomie de Laval, May 13 2020.
- *Do aliens exist?*, Frédérique Baron, Pint of Science for Kids, May 13 2020.
- *Les mondes extraterrestres*, Nathalie Ouellette, Pint of Science, May 13 2020.
- *Les naines brunes et les objets de masse planétaire isolés dans l'espace*, Jonathan Gagné, Club d'astronomie du Mont-Tremblant, May 14 2020.
- *Brown Dwarfs*, Frédérique Baron, Astro at Home, May 15 2020.
- *Self-Isolation Star Party - Brown or Magenta Dwarfs?*, Frédérique Baron, RASC, May 20 2020.
- *Observations at the OMM*, Frédérique Baron, Astro at Home, May 28 2020.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Coeur de sciences, May 29 2020.
- *Black Holes*, Nathalie Ouellette, Cosmic Nights (HR MacMillan Space Centre), June 3 2020.

[...] Public Talks

[...] Public Talks

- *La recherche de biosignatures avec le télescope spatial James Webb*, Loïc Albert, Club d'astronomie du Mont-Tremblant, June 9 2020.
- *Ask an Astronomer*, Nathalie Ouellette, TELUS Spark, June 11 2020.
- *Black Holes*, Nathalie Ouellette, Cosmic Nights (HR MacMillan Space Centre), July 6 2020.
- *Sun & Science*, Nicolas Cowan, en ligne, July 15 2020.
- *Comet C/2020 F3 NEOWISE*, Taylor Bell, AstroMcGill Public AstroPhysics Nights, July 24 2020.
- *Ask an Astronomer*, Nathalie Ouellette, TELUS Spark, July 28 2020.
- *Cereal Science*, Nathalie Ouellette, TELUS Spark, August 12 2020.

Public Events

- *MIL en fête*, Université de Montréal - campus MIL, September 21 2019.
- *Astronomie en fût*, Pub L'Île Noire: September 25 2019, February 4 2020; les Sans-taverne: November 27 2019; Pub McLean's: March 4 2020.
- *Montréal Space Symposium*, Étienne Artigau, Frédérique Baron, Taylor Bell, Émilie Laflèche, Nathalie Ouellette, Montreal Student Space Association, October 10 and 11 2019.
- *Journée d'initiation à la recherche en astrophysique 2020*, Université de Montréal, January 17 2020.
- *Astronomie en ligne*, en ligne, April 8 2020, April 28 2020, May 8 2020.
- *La petite école de l'espace #1*, online, July 11 2020.
- *astroMIL: Unis sous le même ciel*, online, August 12 2020.

Media Interviews

Television Interviews

- *Les aurores boréales*, Nathalie Ouellette, *RDI Matin* (RDI), September 1 2019.
- *Astronomers worry about too many satellites*, Nathalie Ouellette, *The National* (CBC), December 27 2019.
- *Nouvelle découverte d'une planète semblable à la Terre*, Frédérique Baron, *Le Téléjournal 18h* (Radio-Canada), January 7 2020.
- *La terre est ronde*, Nathalie Ouellette, *Infoman* (Radio-Canada), March 12 2020.
- *Apprendre pour comprendre*, Marie-Eve Naud, *Têtes à réflexions* (Savoir.média), June 11 2020.
- *Montrealer helps discover an exoplanet the size of Neptune*, Jonathan Gagné, CTV News, June 26 2020.
- *The Perseids*, Nathalie Ouellette, CTV News, August 7 2020.

Radio Interviews

- *Les galaxies*, Nathalie Ouellette, *Balado AstroPoly*, September 4 2019.
- *Frédérique Baron, Ph.D. Astrophysicienne*, Frédérique Baron, *Réflexions avec Pierre* (CKVL), September 9 2019.
- *Chroniques d'astronomie*, Nathalie Ouellette, *Dutrizac* (QUB Radio), September 13 2019, November 28 2019, January 7 2020, February 24 2020, June 1 2020, August 12 2020, August 14 2020, August 21 2020, August 28 2020.
- *La fille qui aimait les sciences: une histoire d'arbres et de vie de Hope Jahren*, Marie-Eve Naud, *Plus on est de fous plus on lit* (Radio-Canada), September 18 2019.
- *Pourquoi cherche-t-on des exoplanètes si on ne pourra jamais s'y rendre?*, Nathalie Ouellette, *Moteur de recherche* (Radio-Canada), November 25 2019.
- *Temperatures in space*, Nathalie Ouellette, *Let's Go* (CBC), November 27 2019.
- *Astronomers worry about SpaceX's satellite plan*, Nathalie Ouellette, *Quebec AM* (CBC), December 19 2019.
- *Six découvertes et contributions québécoises marquantes de la dernière décennie*, Marie-Eve Naud, *Journal de Québec*, December 23 2019.
- *La science en 2019*, Björn Benneke, Radio-Canada, December 24 2019.
- *Frédérique Baron, astrophysicienne de l'Institut de recherche sur les exoplanètes*, Frédérique Baron, *Midi Actualité* (107.7 FM), January 10 2020.

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[...] Radio Interviews

- *Plus d'une centaine d'exoplanètes avec des nouveaux noms*, Nathalie Ouellette, *Les années lumière* (Radio-Canada), January 17 2020.
- *Solar observations and missions*, Nathalie Ouellette, *Let's Go* (CBC), February 12 2020.
- *Revue de l'actualité en cosmologie*, Nathalie Ouellette, *Les années lumière* (Radio-Canada), February 16 2020.
- *La passion pour l'astrophysique de deux étudiantes et un étudiant*, Anne Boucher, *Pénélope* (Radio-Canada), March 25 2020.
- *Earth Day from an astronomer's point of view*, Nathalie Ouellette, *Let's Go* (CBC), April 22 2020.
- *Astronomy to connect with the Earth*, Nathalie Ouellette, *The Current* (CBC), April 24 2020.
- *The Story of More de Hope Jahren*, Marie-Eve Naud, *Plus on est de fous plus on lit* (Radio-Canada), May 28 2020.
- *Communiquer avec des civilisations extraterrestres intelligentes*, Frédérique Baron, *Bouchard en parle* (FM93), June 17 2020.
- *AU Mic b*, Jonathan Gagné, City TV (radio), June 25 2020.
- *Ce que les exoplanètes nous apprennent sur l'Univers*, Jonathan Gagné, *Dessureault* (QUB Radio), June 25 2020.
- *AU Mic b*, Jonathan Gagné, CJAD, July 2 2020.
- *Une étoile massive disparue*, Nathalie Ouellette, *Les années lumière* (Radio-Canada), July 5 2020.
- *Comet NEOWISE*, Taylor Bell, *The Elias Makos Show* (CJAD 800), July 22 2020.
- *The Perseids*, Nathalie Ouellette, *Let's Go* (CBC), July 29 2020.
- *Un premier hélicoptère sur Mars*, Nathalie Ouellette, *Dessureault* (QUB Radio), July 30 2020.
- *Un beau succès pour Space X et la NASA*, Nathalie Ouellette, *Pierre Nantel* (QUB Radio), August 3 2020.
- *Début de la saison des Perséides*, Nathalie Ouellette, *15-18* (Radio-Canada), August 10 2020.
- *Perseids meteor shower*, Nathalie Ouellette, CBC Radio Syndication (12 entrevues), August 11 2020.
- *astroMIL*, Frédérique Baron et Nathalie Ouellette, *Jimmy et Neutron* (CISM 89.3 FM), August 12 2020.

Press and Online Interviews

- *An infrared selfie*, Nicolas Cowan, *Nature Astronomy*, September 15 2019.
- *Habitable zones on a tidally locked planet?*, Nicolas Cowan, *Universe Today*, September 26 2019.
- *Un Canadien reçoit le prix Nobel de physique*, Nathalie Ouellette, *La presse*, October 9 2019.
- *Des prix Nobel sur fond de controverse*, Nathalie Ouellette, *Les années lumière* (Radio-Canada), October 13 2019.
- *Finding Earth-Like Planets*, Nicolas Cowan & Evelyn MacDonald, *Weekly Space Hangout* (Universe Today), October 30 2019.

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- *From scientific revolution to alien life: what the transit of Mercury really means*, Eve Lee, *The Globe and Mail*, November 10 2019.
- *Astronomers surprised to find a star similar to our Sun devouring the atmosphere of a giant planet*, Eve Lee, *CBC News*, December 9 2019.
- *Et si 2030, c'était maintenant?*, René Doyon, *Radio-Canada*, January 1 2020.
- *Mort d'un portraitiste de l'Univers*, Björn Benneke, *Le devoir*, February 1 2020.
- *This gas giant exoplanet has water-rich clouds. Here's why it thrills astronomers*, Björn Benneke, *Space*, March 9 2020.
- *Weather forecast for this exoplanet: iron rain*, Eve Lee, *CBC News*, March 11 2020.
- *De l'astronomie dehors à l'école*, Marie-Eve Naud, *Des sciences dehors à l'école avec Jean-Philippe Ayotte-Beaudet* (Facebook Live), April 16 2020.
- *Some hot giant planets get larger as they are heated by their stars*, Daniel Thorngren, *NewScientist*, June 19 2020.
- *Transit spectroscopy in action*, Nicolas Cowan, *ScientistLive*, June 22 2020.
- *Découverte d'une planète de la taille de Neptune*, Jonathan Gagné, *Québec Science*, June 24 2020.
- *Neptune-sized planet found orbiting a young star 32 light years away*, Jonathan Gagné, *The Daily Mail*, June 24 2020.
- *Un Québécois participe à la découverte d'une planète*, Jonathan Gagné, *TVA Nouvelles*, June 25 2020.
- *Un Québécois participe à la découverte d'une planète*, Jonathan Gagné, *Journal de Montréal*, June 25 2020.
- *NASA discovers 'unique laboratory' exoplanet able to reveal Earth's evolution*, Jonathan Gagné, *Express*, June 25 2020.
- *Astrophysicists find the exoplanet they wanted*, Jonathan Gagné, *Cosmos Magazine*, June 25 2020.
- *A planet the size of Neptune has been discovered thanks to a Montreal scientist*, Jonathan Gagné, *NarCity*, June 26 2020.
- *New exoplanet discovered*, Jonathan Gagné, *MTL Blog*, June 26 2020.
- *Une comète s'offre en spectacle*, Mohamad Ali-Dib, *Journal de Montréal*, July 9 2020.
- *Citizen scientists help discover two exotic brown dwarfs in Milky Way*, Jonathan Gagné, *Mirage News*, July 11 2020.
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7. "The evolution of carbon-polluted white dwarfs at low effective temperatures", Blouin, S.; **Dufour, P.**, *MNRAS*, 490, 3, 2019.
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10. "A Hubble PanCET Study of HAT-P-11b: A Cloudy Neptune with a Low Atmospheric Metallicity", Chachan, Y.; Knutson, H. A.; Gao, P.; Kataria, T.; Wong, I.; Henry, G. W.; **Benneke, B.**; Zhang, M.; Barstow, J.; Bean, J. L.; Mikal-Evans, T.; Lewis, N. K.; Mansfield, M.; López-Morales, M.; Nikolov, N.; Sing, D. K.; Wakeford, H., *AJ*, 158, 244, 2019.
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