

# Institute for Research on Exoplanets



## ANNUAL REPORT

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2018 - 2019

Université   
de Montréal



McGill



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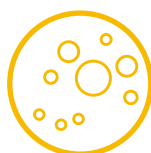


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# About the Institute

## Mission and Objectives

**WE ARE LIVING IN A PIVOTAL TIME IN THE HISTORY OF HUMANITY,  
WHEN TECHNOLOGY IS BECOMING CAPABLE OF ANSWERING ONE  
OF THE GREATEST QUESTIONS OF ALL TIME:  
**ARE WE ALONE IN THE UNIVERSE?****

This question alone justifies the 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 in orbit around a star other than the Sun in 1995, astronomers have confirmed the existence of several thousands of exoplanets. Thousands of other candidates have also been identified and include rocky planets similar to Earth. Over the next decade, the new generation of **telescopes** and **instruments** will, for the first time, **probe the atmospheres of extrasolar planets** similar to our own for water vapour and possible **signatures of biological activity** such as oxygen, ozone or methane.

The **Institute for Research on Exoplanets** - iREx - brings together the best researchers and their students to take full advantage of major observational projects currently underway or to come, with the ultimate goal of **finding life elsewhere in our Universe**.

# A Word from our Director

On behalf of the entire iREx team, I am proud to present to you this report covering the period from **January 1, 2018 to August 31, 2019**. During this period, we reached new heights. Our membership has never been more large and diverse. The SPIRou instrument, whose scientific team is made up of several iREx members, began its scientific campaign with very promising preliminary results! The construction of the James Webb Space Telescope crossed several important milestones and our entire team is actively preparing the science programs that will feed this powerful observatory shortly after its launch in 2021.

At the root of our success lies an exceptional team of passionate and dedicated researchers and students. In just a few short years, the iREx has quickly established itself as the largest exoplanet research group in Canada with a very enviable position on the world stage. I am also very proud of the strong and growing presence of iREx members in the media and with the general public.

I would like to emphasise that this great scientific adventure would not be possible without the strong support of our universities and the contributions of our generous donors. I hope that this report will give you a glimpse into our daily lives and make you want to continue following our journey.

**We are only getting started!**



René Doyon  
Director, iREx  
Professor, Université de Montréal

Amélie Philibert/UnicM

# The Year in Review

## IN 2018-2019...

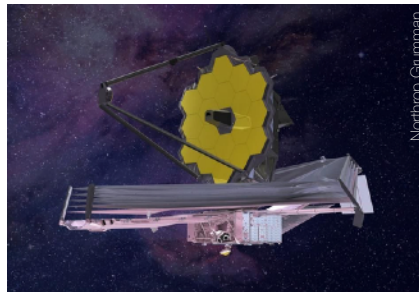
Funding for the Observatoire du Mont-Mégantic was secured from the governments of Quebec and Canada for the next five years.

Two of our postdoctoral researchers conducted international studies that have taught us more about the formation of exoplanets and the evolution of brown dwarfs.

The SPIRou instrument was installed at the Canada-France-Hawai'i Telescope and began its ambitious observation campaign in search of rocky exoplanets orbiting around red dwarf stars.

Members of iREx wrote several scientific papers on the subject of mini-Neptunes, the most common type of exoplanets currently known while still being very poorly understood.

Despite a launch delay which allowed more thorough testing, the James Webb Space Telescope passed several important milestones and was assembled in one piece for the first time since the beginning of the project.



# [...] The Year in Review

## IN 2018-2019...

iREx researchers authored and co-authored 122 scientific articles published in peer-reviewed journals.



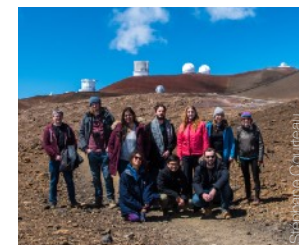
Members of iREx participated in 30 television interviews, 81 radio interviews and 60 print and online interviews.



The iREx welcomed several new members, bringing our total membership to a record of 62! This includes 26 graduate students and 14 interns during the summer of 2019.



We reached thousands of people in Quebec and around the world through 80 talks in educational institutions ranging from elementary schools to universities, 44 public talks and 16 public events.



Our members won eight awards, including a very prestigious NSERC Research Chair in Exoplanet Science for Professor Jason Rowe at Bishop's University. 66% of our students are scholarship or bursary holders: 9/16 of the M.Sc. students, 14/16 of the Ph.D. students and 14/24 of the summer interns.

# Scientific Overview

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TO CARRY OUT THEIR MISSION EFFECTIVELY, 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.**

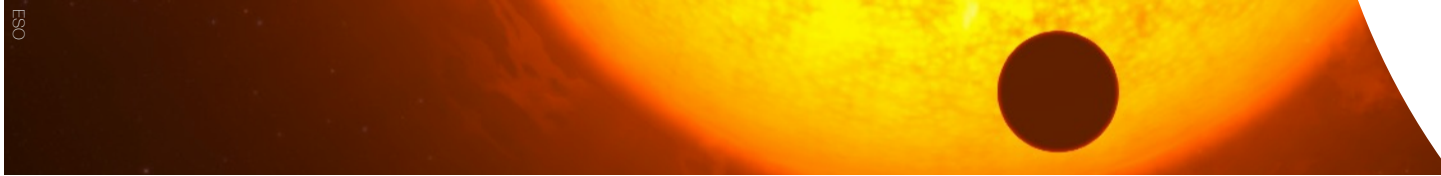
In addition to exoplanets, iREx researchers are interested in related celestial bodies such as **stars, brown dwarfs, white dwarfs, moons, comets** and **asteroids**. Several iREx members also specialise in the study of the **formation and evolution of planets** using theoretical models.

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

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### 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 Governors 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.

**2018-2019 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 program 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**.

**2018-2019 Membership:** René Doyon, Sébastien Sauvé, Björn Benneke, David Lafrenière, Nathalie Ouellette, Nicolas Cowan

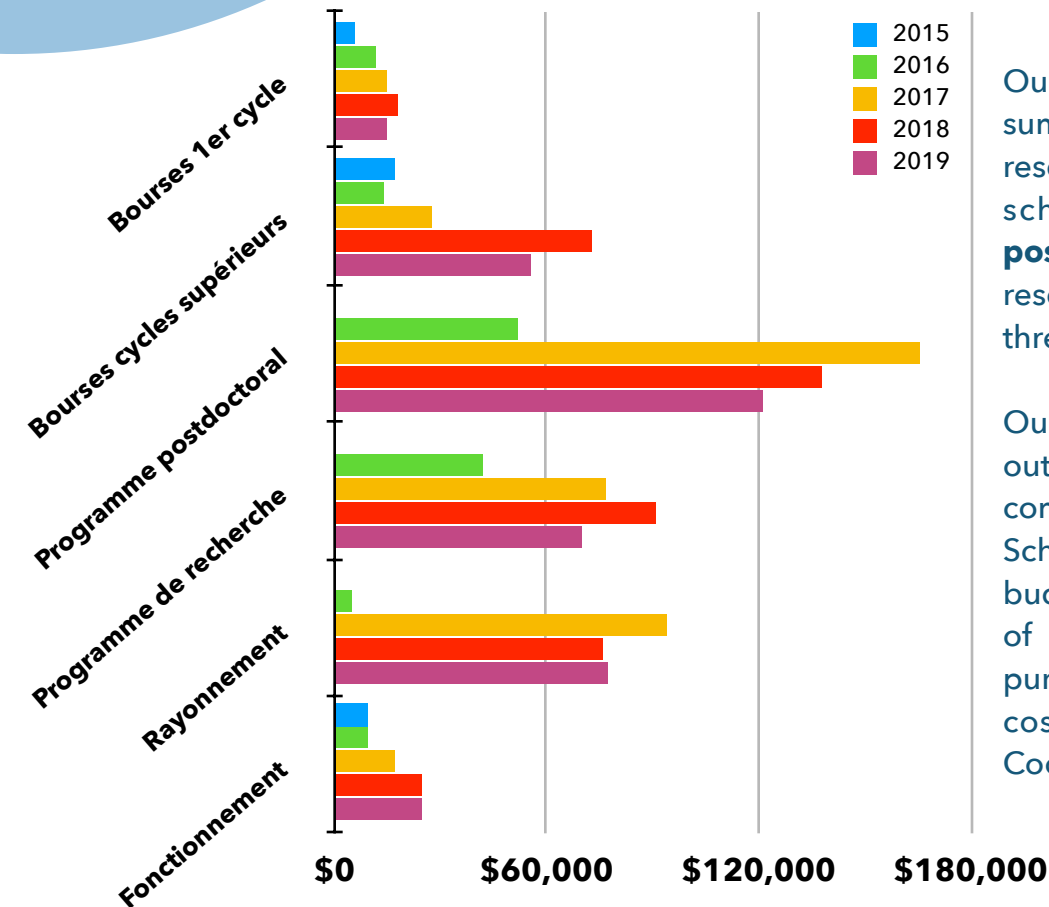
### Governing Board

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'S FUNDS IS ALSO DEDICATED TO THE DISSEMINATION OF OUR DISCOVERIES, WHICH IS AN IMPORTANT PILLAR OF OUR MISSION.



Our **student awards** include scholarships for our undergraduate summer interns as well as scholarships for our graduate student researchers. Many of our students are also recipients of external scholarships from NSERC, FRQ-NT and universities. 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 **75%** of the total iREx budget.

Our **outreach program** 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, an average of **20%** of the iREx budget, also covers part of the salaries of our coordinators in charge of these activities. Finally, iREx **operations**, which include the purchase of equipment and software, photocopying and telephone costs, other administrative expenses and a portion of our Coordinator's salary, only averages **5%** of our total budget.

# Our Donors

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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 BE IMPOSSIBLE.



We would like to thank



**Philippe Sureau**

**Stéphanie Codsí**

**Hortense Michaud-Lalanne**

**Marie-Hélène Paquette**

**Jean-François Bertrand**

**Carole Kleingrib**

**Isabelle Morin**

**Martin Périard**

**our other private donors**

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



# Research Highlights

## Multiplanetary Systems

AN INTERNATIONAL TEAM LED BY **LAUREN WEISS**, TROTIER POSTDOCTORAL RESEARCHER AT iREx, HAS REVEALED THAT EXOPLANETS ORBITING THE SAME STAR TEND TO BE SIMILAR IN SIZE AND ARE AT A REGULAR DISTANCE FROM EACH OTHER. THIS PICTURE SUGGESTS THAT MOST PLANETARY SYSTEMS DID NOT FORM IN THE SAME WAY AS OUR SOLAR SYSTEM.

A new analysis of the data collected by the California-Kepler Survey at the W.M. Keck Observatory led by Lauren Weiss focused on 909 planets belonging to 355 **multiplanetary systems**. Using a statistical analysis, the team found that **neighbouring exoplanets in a system all appear to be the same size**: if one planet is small, the neighbouring planet orbiting the same star is likely to be small; and if one planet is large, its orbital neighbour is also large. Second, **planets orbiting the same star are spaced a regular distance from each other**.

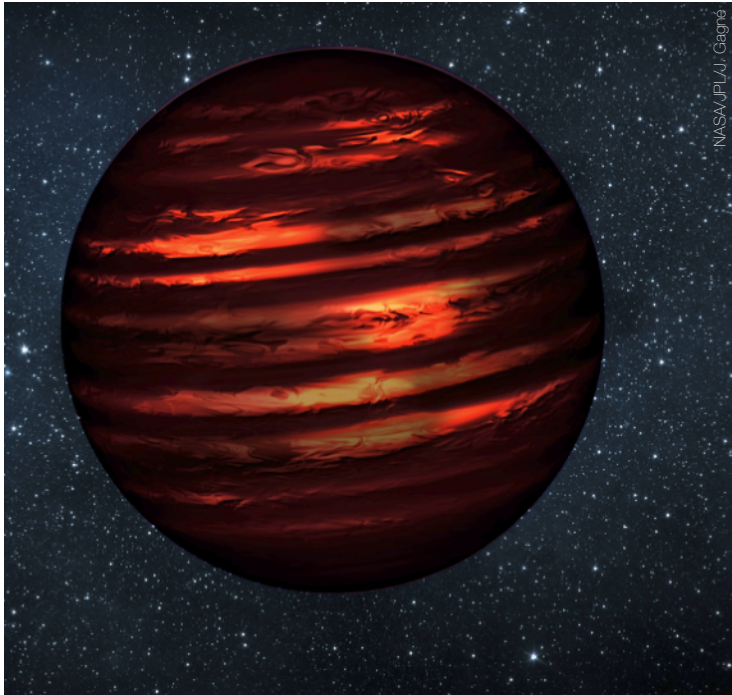
The similar size of the planets and the regular distance between them give us clues as to how most systems form. According to classical theory, planets are born in the disc of gas and dust that surrounds newly formed stars. They can appear in compact groups, be similar in size and at equal distances from each other, as new patterns observed in exoplanetary systems seem to demonstrate.

In our own Solar System, planets close to the Sun are of varying sizes and surprisingly distant from each other. There is ample evidence that Jupiter and Saturn disrupted the early structure of the Solar System, leading to the formation of the four widely-spaced telluric planets that we know of. The fact that the planets in most systems are similar in size and spacing may indicate that **they have undergone little disturbance since their formation**.

"The California-Kepler Survey V. Peas in a Pod: Planets in a Kepler Multi-planet System are Similar in Size and Regularly Space", *The Astronomical Journal*, 2018.

# Brown Dwarf Clouds

A STUDY LED BY JONATHAN GAGNÉ, POSTDOCTORAL RESEARCHER AT iREx, ÉTIENNE ARTIGAU, SENIOR RESEARCHER AT iREx, AND THEIR COLLEAGUES TELLS US MORE ABOUT BROWN DWARFS, THE MASSIVE COUSINS OF GIANT GAS PLANETS, AND THEIR EVOLUTION.



NASA/JPL/J. Gagné

Brown dwarfs, the mysterious objects that could be described as being halfway between giant gas planets and stars, cannot sustain the fusion of hydrogen in their hearts and therefore cool down over time. Below a certain temperature, their clouds plunge into the depths of their atmospheres and are no longer visible to our instruments.

Jonathan Gagné, Étienne Artigau and their colleagues focused on the brown dwarf **2MASS J13243553+6358281** in a recent study published in *The Astrophysical Journal Letters*. This object turned out to be one of the closest planetary mass objects to our Solar System, about 40 light years away. The team also confirmed that this brown dwarf is part of the AB Doradus group, a group of about 80 young stars of similar composition that move together in space. Since the ages of this group's stars are well known, it can be inferred that this object is about 150 million years old. Using the object's age and luminosity, the team was able to determine its radius, mass and, most importantly, its **temperature**.

According to observations of this brown dwarf in several filters, it has **no cloud cover**. However, another brown dwarf from the AD Doradus group, this one only slightly warmer, appears to have a thick cloud layer. The team concluded that **brown dwarfs lose their cloud cover when their temperature dips below 870 degrees Celsius**. Since brown dwarfs can be more easily studied than exoplanets, which are often drowned in the glare of their star, studies like these can help us **better understand some of the evolutionary processes that have taken place here in our Solar System**.

"2MASS J13243553+6358281 is an Early T-Type Planetary-Mass Object in the AB Doradus Moving Group", *The Astrophysical Journal Letters*, 2018.

# Funding of the OMM

IN AUGUST 2018, THE FEDERAL AND PROVINCIAL GOVERNMENTS COMMITTED TO PROVIDING FUNDING FOR THE NEXT FIVE YEARS TO THE **OBSERVATOIRE DU MONT-MÉGANTIC**, WHICH JUST CELEBRATED ITS 40<sup>TH</sup> ANNIVERSARY.

After months of uncertainty, the Member of Parliament for Compton-Stanstead and Minister of International Development, Marie-Claude Bibeau, and the Member of Parliament for D'Arcy McGee and Parliamentary Assistant to the Minister of Higher Education, David Birnbaum, announced funding for this important research centre for the next five years.



René Doyon, Director of the Observatory and iREx, says that this funding recognises the national and international stature and importance of the OMM and will allow Quebec and Canadian astrophysicists to remain at the forefront of astrophysics on the international scene.

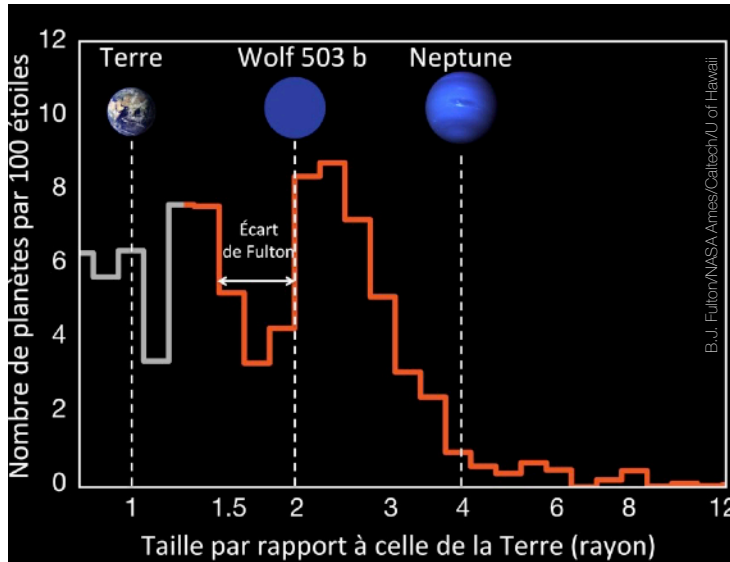
The **federal government has confirmed \$500,000 of funding per year for the next five years**, while the **provincial government will be adding \$300,000 per year** for the same period. The Observatoire du Mont-Mégantic, which celebrated its **40<sup>th</sup> anniversary** in 2018, is the result of a partnership between the **Université de Montréal** and **Université Laval**.

The observatory is a unique place for research and training: it is the only place in Canada where future astronomers and astrophysicists can be trained with a telescope, the most competitive telescope in the country. Researchers, many of whom are also members of iREx, also develop cutting-edge astronomical instruments in the associated **Laboratoire d'Astrophysique Expérimentale** (LAE). For example, one of the four scientific instruments of the James Webb Space Telescope, soon to be launched by NASA and its partners, was designed at the Observatory in collaboration with the Canadian Space Agency, Canadian industry and the National Research Council of Canada.

To find out more on the OMM: <http://omm.craq-astro.ca>.

# Between Earth and Neptune

DISCOVERED BY **MERRIN PETERSON**, A UdeM STUDENT AND MEMBER OF iREx, WOLF 503 B IS AN EXOPLANET THAT MAY REVEAL THE SECRETS OF PLANETS OF INTERMEDIATE SIZE BETWEEN EARTH AND NEPTUNE.



**Wolf 503 b, an exoplanet twice the size of the Earth**, was discovered by an international team in 2018 using the Kepler telescope. Merrin Peterson, a student at the Université de Montréal working with Professor Björn Benneke, led the writing of the article describing this find.

Wolf 503 b is interesting in large part because of its size. We now know that most of the planets in the Milky Way whose orbits are close to their stars have sizes between those of Earth and Neptune, similar to Wolf 503b. Since there is no such planet in our Solar System, astronomers are left to wonder whether these planets are rocky super-Earths or gaseous mini-Neptunes. Wolf 503 b therefore represents a golden opportunity to better understand **exoplanets that are somewhere between the size of Earth and Neptune**.

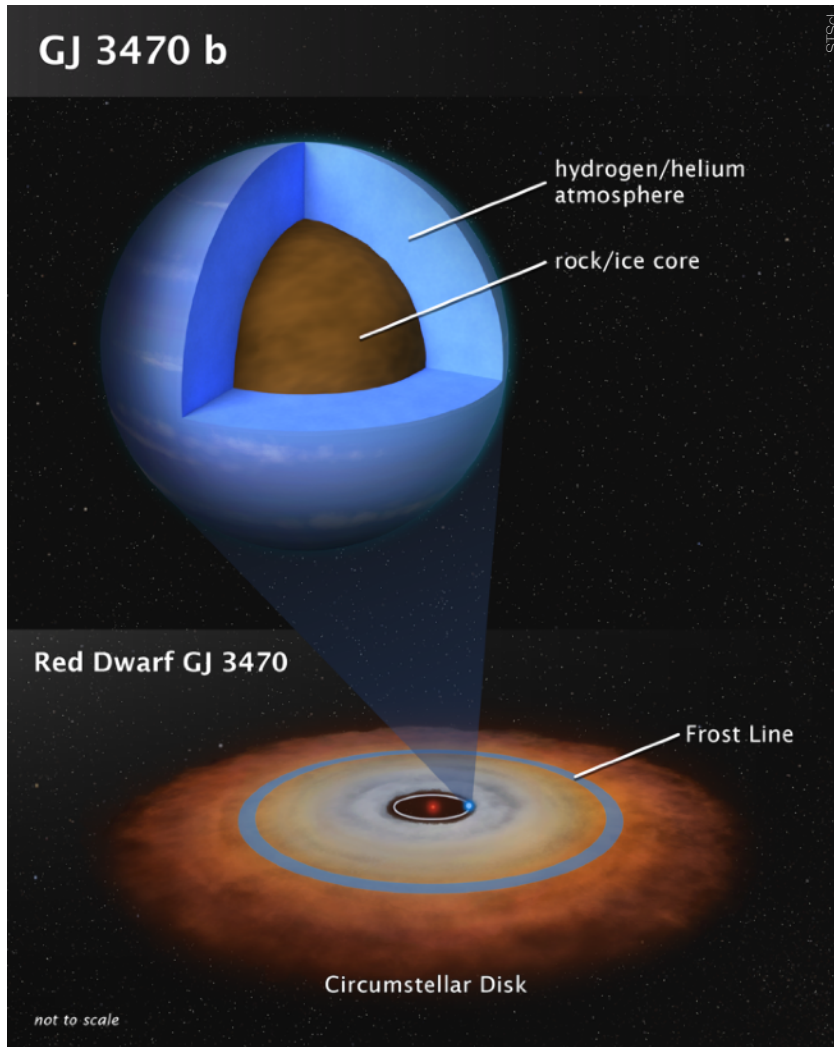
A recent discovery also tells us that there are far fewer planets between 1.5 and 2 times the size of the Earth than planets smaller or larger than that. According to what researchers are saying related to this discovery published in 2017, this difference, known as the "**Fulton gap**" could separate rocky planets from gas ones.

Wolf 503 will be a prime target for the James Webb Space Telescope. Using the technique of transit spectroscopy, it will be possible to study the chemical composition of the planet's atmosphere and detect the presence of molecules such as hydrogen and water. This information is essential to determine whether the atmosphere of Wolf 503b is similar to that of Earth, Neptune or something completely different altogether from the atmospheres of the planets in our Solar System. Such observations cannot be made for most of the planets found by Kepler because their host star is usually much less luminous. As a result, the apparent densities and atmospheric compositions of many exoplanets remain unknown.

"A 2 Earth Radius Planet Orbiting the Bright Nearby K-Dwarf Wolf 503 ", *The Astronomical Journal*, 2018.

# Mini-Neptune Atmosphere

AN INTERNATIONAL TEAM LED BY **BJÖRN BENNEKE**, PROFESSOR AT UdeM AND MEMBER OF iREx, IS DRAWING A CLEARER PICTURE OF WHAT MAY BE THE MOST COMMON TYPE OF PLANETS IN THE UNIVERSE BY EXAMINING THEIR ATMOSPHERES.



The team led by Björn Benneke, Professor of Physics at the Université de Montréal, has succeeded, for the first time, in **reconstructing the "fingerprint" of the chemical composition of a new class of planet different from all those in our Solar System** by compiling data from NASA's Hubble and Spitzer space telescopes over the course of five years.

This new planet, **GJ 3470 b**, could be a **cross between Earth and Neptune**, with a vast rocky core covered with an atmosphere composed of hydrogen and helium so heavy that it crushes everything beneath its surface. The mass of GJ 3470 b is 12.6 times that of the Earth, but less than that of Neptune, whose mass is about 17 times that of the Earth.

Many similar exoplanets have been discovered by NASA's Kepler Space Observatory. In fact, 80% of the exoplanets in our galaxy could be of similar mass and size. That said, astronomers have been unable to understand the chemical nature of such planets – until now.

It was by conducting an inventory of the atmospheric components of GJ 3470 b that the team was able to identify clues about the nature and origin of this planet.

# [...] Mini-Neptune Atmosphere



Björn Benneke, whose team includes 16 researchers in the United States and one in the Netherlands, says this is a very important discovery about **how planets are formed**. GJ 3470 b has an orbit very close to its star and is 30 times smaller than Jupiter, but has managed to amass the same type of atmosphere as Jupiter, composed of hydrogen and helium, with almost no contamination from heavier elements. **There is no equivalent of this planet in the Solar System.**

To probe the planet, astronomers used the multiple wavelengths offered by the Hubble and Spitzer space telescopes. They measured changes in stellar light as the planet passed in front of its star (transit) and behind its star (eclipse). In total, the two space telescopes observed **12 transits** and **20 eclipses**. This study represents the first observation of the **spectroscopic signature** of such a planet.

Prof. Benneke's team was able to accurately characterise the atmosphere of GJ 3470 b, which is mostly clear and covered only with light haze that are transparent under infrared light, allowing researchers to examine it in depth. Astronomers expected to find an atmosphere highly enriched in heavier elements such as oxygen and carbon, which create a lot of vapour and methane, but instead discovered an **atmosphere so poor in heavy elements that its composition resembles the hydrogen and helium-rich composition of the Sun.**

For Björn Benneke, this new clue suggests that, unlike other exoplanets that are suspected to have migrated to their star from much farther away in the galaxy, **GJ 3470 b would have formed right at its current location.** Why would this happen? Probably because the planet was born dangerously close to its star, a red dwarf. According to Prof. Benneke's hypothesis, it first took the form of a dry, rocky mass one and a half to two times the diameter of the Earth, and then rapidly accreted hydrogen from the primordial disc of gas surrounding its star. The team explains that the circumstellar disc could have dissipated before the exoplanet could grow any larger, allowing it to remain in the "mini-Neptune" stage.

*"A Sub-Neptune Exoplanet with a Low-Metallicity Methane-Depleted Atmosphere and Mie-Scattering Clouds", Nature Astronomy, 2019.*



# Earth's Fingerprint

A STUDY BY **EVELYN MACDONALD**, AN iREx STUDENT AT MCGILL UNIVERSITY, AND HER RESEARCH SUPERVISOR, **NICOLAS COWAN**, PRESENTS THE EARTH'S SPECTRAL FINGERPRINT IN THE HOPE OF FINDING HABITABLE PLANETS BEYOND THE SOLAR SYSTEM.



Two iREx members, Evelyn Macdonald and her research director, Prof. Nicolas Cowan, measured the **spectral fingerprint of the Earth** which could be used to identify planets capable of supporting life outside our Solar System. The team used observations of the Earth's atmosphere collected by the *SCISAT* satellite over more than a decade to build a transit spectrum, a kind of fingerprint of our planet's atmosphere in infrared light that reveals the presence of molecules essential for the search for habitable worlds. In particular, these fingerprints are used to identify **biosignatures** such as the simultaneous presence of ozone and methane on the observed planet.

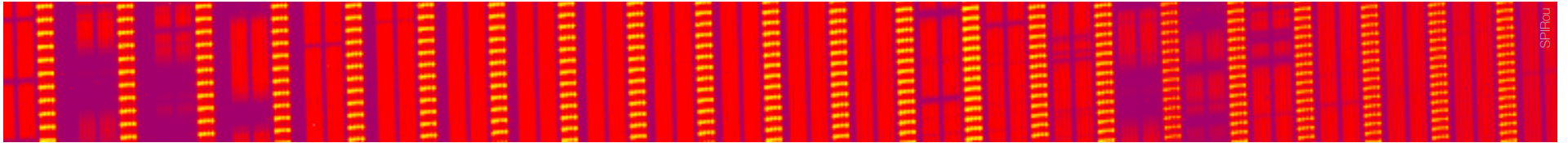
The results of this study represent the first empirical **infrared transit spectrum of the Earth ever observed**, which is what an extraterrestrial astronomer would see if they observed a passage of the Earth in front of the Sun. The analysis could help scientists determine what type of signal they need to look for in order to find Earth-like exoplanets.

The *SCISAT* satellite, designed by the Canadian Space Agency, was originally intended to help scientists understand the depletion of the ozone layer by studying particles in the atmosphere through which sunlight passes. This technique is similar to the **transit spectroscopy** used in the field of exoplanets to identify molecules such as CO<sub>2</sub>, oxygen or water vapour, which can indicate that a **planet is habitable or even inhabited**. A promising system that may contain such planets, TRAPPIST-1, will be targeted by the James Webb Space Telescope. Macdonald and Cowan were able to simulate a signal showing what we might expect from an Earth-like planet seen through the lens of this telescope. In their analysis, they claim that the **Webb telescope will be sensitive enough to detect CO<sub>2</sub>, water vapour, and perhaps even the biosignature of methane and ozone** if it observes the target planet long enough.

"An empirical infrared transit spectrum of Earth: opacity windows and biosignatures ", *MNRAS*, 2019.

# SPIRou and NIRPS

IT WAS A PIVOTAL YEAR FOR THE **SPIRou** INSTRUMENT, WHICH SAW ITS FIRST LIGHT IN APRIL 2018 AND BEGAN ITS SCIENTIFIC CAMPAIGN IN FEBRUARY 2019 AT THE CFHT. THE iREx TEAM ALSO CONTINUED ITS WORK ON THE DEVELOPMENT AND INTEGRATION OF THE **NIRPS** INSTRUMENT, WHICH WILL BE INSTALLED AT LA SILLA IN CHILE.



On April 24, 2018, the new **SpectroPolarimètre InfraRouge** (SPIRou) instrument collected light from a star for the first time. The first star observed with SPIRou was AD Leonis, located 16 lightyears from Earth in the Leo constellation, famous for its powerful stellar eruptions and strong magnetic fields. Among other things, we were able to verify that the instrument was able to detect its magnetic fields. During its first scientific mission, which took place from April 24 to 30 2018, SPIRou observed 440 spectra of 24 different red dwarf stars.

Installed at the **Canada-France-Hawai'i Telescope** on the summit of Maunakea, SPIRou was designed to detect Earth-like exoplanets using velocimetry to measure the radial velocity of stars to detect minute variations that indicate the presence of planets, and to study the magnetic fields of star systems. Led by Jean-François Donati (University of Toulouse, IRAP) and iREx Director René Doyon, SPIRou pays particular attention to **Earth-like rocky exoplanets orbiting red dwarfs**, stars colder and less massive than our Sun that are very abundant in the solar neighbourhood.

The idea of building an instrument such as SPIRou came about in 2010. By then, the Kepler Space Telescope had already begun its observing campaign and was uncovering a surprising number of candidate exoplanets using the transit method. Although this method is very efficient, it does not reveal some important characteristics of the host stars and their detected planets, such as the mass of the planet. Researchers from France, Canada, Brazil, Taiwan, Switzerland and Portugal therefore decided to build an instrument that could fill this gap in information and answer several important questions: "**Where are the nearest habitable exoplanets?**" and "How is the formation of planets and stars affected by their magnetic fields?"

Following its first light, SPIRou was subjected to rigorous testing by the project team to measure its performance on important observational parameters, including **its high precision in radial velocity**. Performance tests and a review panel confirmed that the instrument was ready to begin scientific operations. SPIRou therefore **began its ambitious observation campaign in February 2019**.

Étienne Artigau and Neil Cook, both members of iREx, played a particularly critical role in reaching the current precision threshold of 2 m/s in radial velocity, one of the best performances to date for an infrared instrument of comparable scope. The SPIRou team is confident that improved data reduction algorithms, as well as algorithms responsible for correcting for spectral lines due to the Earth's atmosphere, will increase the **precision of SPIRou to the 1 m/s level** which was the original goal of the project. This is the level of accuracy required to detect the movement of red dwarfs due to the presence of an Earth-like planet in orbit around such a star and is equivalent to the average walking speed of a human on Earth.

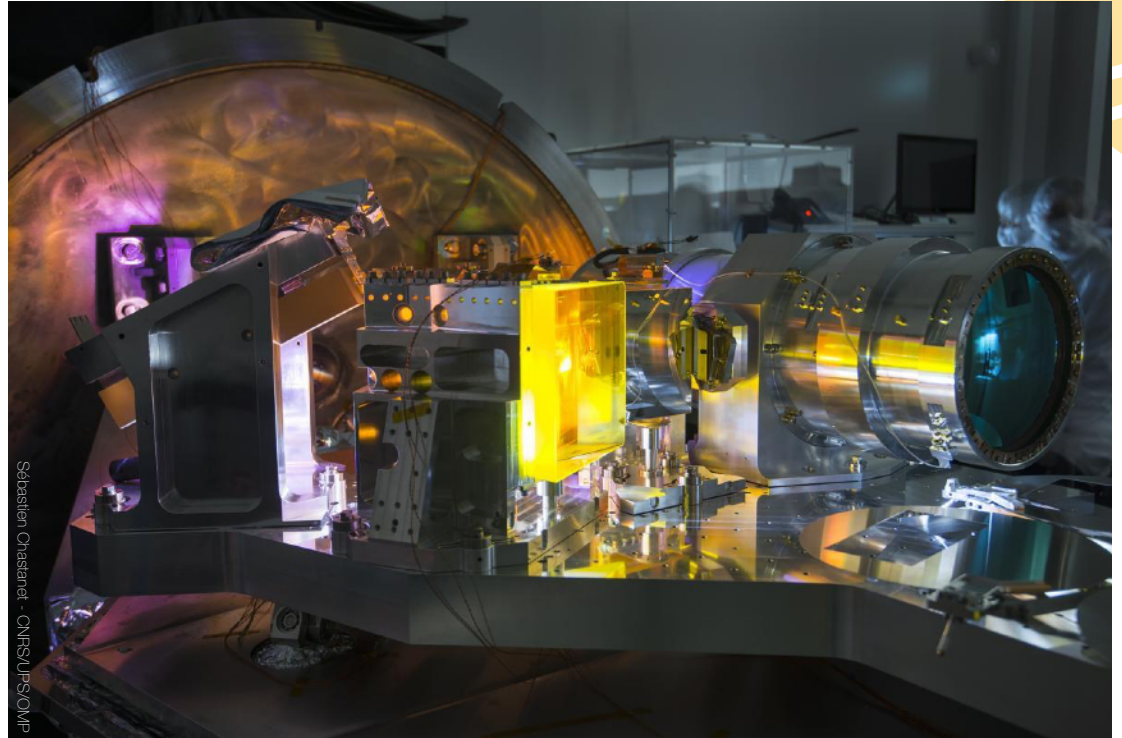
Fifty nights have been allocated for the 2019A semester to the **SPIRou Legacy Survey**, which seeks to answer SPIRou's most important scientific questions, and **300 nights have been allocated to this program over the next four years**. The exoplanets studied by SPIRou will be ideal candidates for follow-up observations taken during the JWST mission, which will use transit spectroscopy to characterise the atmospheres of exoplanets and determine their potential for life.

Building on their strong expertise in instrumentation, the astronomy research group at the Université de Montréal and the optical engineering research group at Université Laval were well positioned to assist with the construction of SPIRou. The two universities have a long history of development of astronomical instruments which has led to the creation of the Laboratoire d'astrophysique expérimentale at the Observatoire du Mont-Mégantic, which they jointly manage.

Professor at Université Laval and associate member of iREx, Simon Thibault and his team have greatly contributed to the optical design of the SPIRou spectrograph and scientific camera. The team also worked on the optomechanical integration of the SPIRou camera, which required that the lenses be centred with micrometer precision. The Université de Montréal team, led by Prof. René Doyon, led the design and development efforts for the SPIRou camera and infrared detector and contributed to a number of its other components.

## [...] SPIRou and NIRPS

Following the success of SPIRou, the iREx team obtained a grant from the **Canada Foundation for Innovation** to build an infrared spectrometer called the **Near-Infrared Planet Searcher (NIRPS)**. Its development is being carried out in the framework of a broad international collaboration, which includes the Geneva Observatory. The Geneva team, which operates the HARPS instrument, a spectrometer observing visible light, is a world leader in the detection of exoplanets using the radial velocity method. Work with HARPS has revolutionised our understanding of planetary systems in the vicinity of the Sun. The HARPS instrument was the first to achieve radial velocity measurements with a precision better than 1 m/s in visible light, which is still the cutting edge of what is possible in this field.



NIRPS will soon be installed at the **3.6-m telescope in La Silla**, Chile. This telescope is operated by the European Southern Observatory (ESO), an organization that manages various observatories in Chile, including the 4 giant telescopes that make up the Very Large Telescope (VLT). 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 provide the project team with unique capabilities for **tracking and characterising exoplanets**. Aware of the strategic importance of this duo, **ESO has granted 740 nights of observations distributed over 5 years** to the NIRPS team.

The development of the NIRPS instrument has progressed well during 2018-2019. **The cryostat for the spectrograph was delivered** to Université Laval in Quebec City in May 2019, and **the assembly and integration of the various spectrograph subsystems is now underway**. In parallel, our colleagues at the Geneva Observatory are about to deliver the adaptive optics unit that will power the spectrograph. It will be delivered to the observatory in La Silla, Chile in the fall of 2019.

# James Webb Space Telescope

**FOLLOWING AN INDEPENDENT REVIEW IN 2018, THE LAUNCH WINDOW FOR THE JWST WAS MOVED TO 2021. SINCE THEN, THE TELESCOPE HAS UNDERGONE A SERIES OF TESTS TO ENSURE THAT IT WILL SURVIVE ITS JOURNEY INTO SPACE AND HAS ALSO BEEN FULLY ASSEMBLED FOR THE FIRST TIME.**



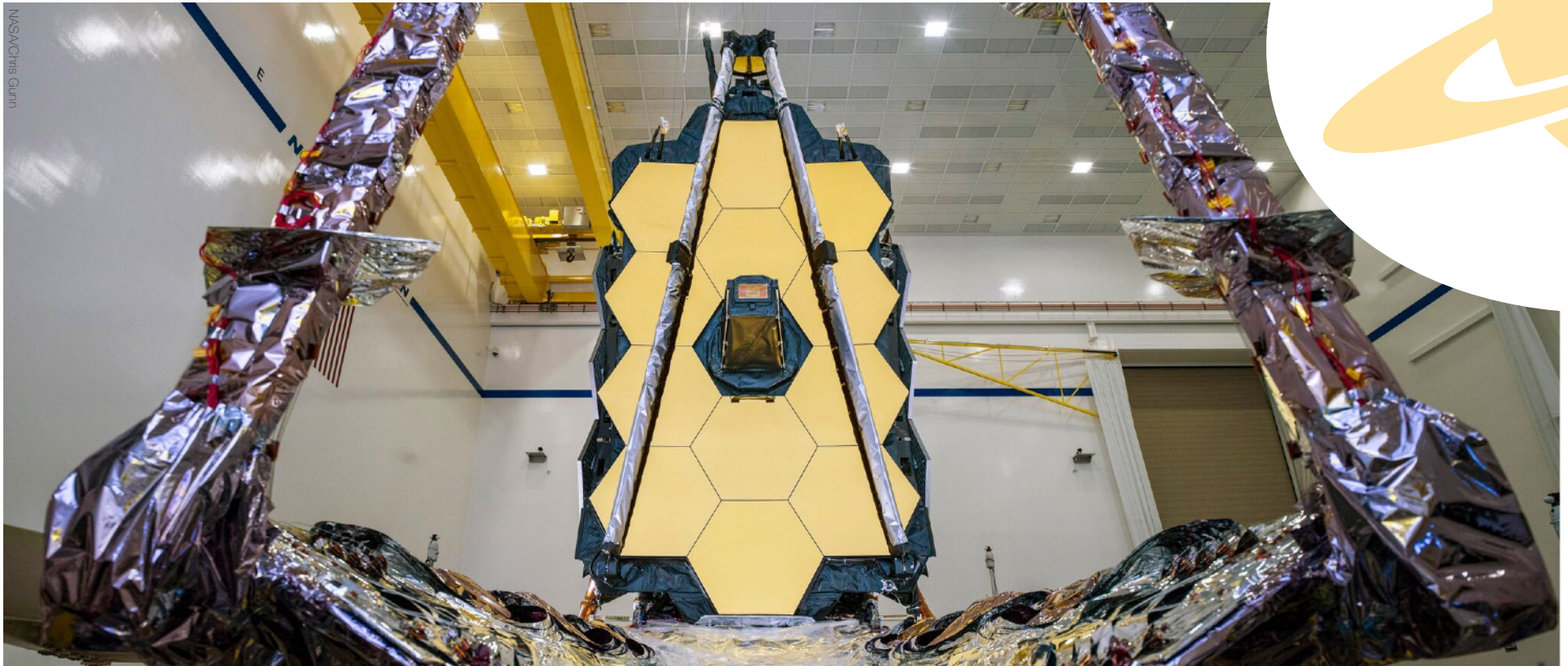
The **James Webb Space Telescope** will be the successor to the Hubble Space Telescope and the most important observatory of the next decade serving thousands of astronomers from around the world. This mission is a collaboration between NASA, the European Space Agency and the **Canadian Space Agency**.

The Canadian contribution, led by iREx Director René Doyon, includes the **Fine Guidance Sensor** (FGS), an infrared camera capable of pinpointing a star's position with very high precision, and the **Near-InfraRed Imager and Slitless Spectrograph** (NIRISS), a fully-fledged scientific instrument that will be able to determine the composition of the atmospheres of exoplanets, observe the spectra of distant galaxies and study objects with very small apparent separations in the sky.

In recent years, the various components of the observatory have been tested and integrated into the rest of the structure. After evaluating the findings of an independent JWST review panel, NASA has set a **new launch date for the telescope from October 2018 to the spring of 2021**. This new schedule will resolve some of the difficulties encountered during the integration and testing of Webb's sunshield and propulsion system. The mission team determined that more time was needed to verify the integrity of the main structure, attach the telescope component to it and perform environmental tests with the observatory fully assembled.

In April 2019, the telescope completed **a series of tests to simulate the extreme conditions of a rocket launch**. These tests were particularly important since it was during these same tests in 2018 that several problems with the sunshield were identified. During its stay at Northrop Grumman, one of NASA's main subcontractors for this project, Webb's spacecraft was subjected to sound waves and vibrations by a team of engineers.

## [...] JWST



After undergoing several separate tests, **the two halves of the James Webb Space Telescope were finally assembled into one piece** in August 2019, the first time since the project began. Engineers at Northrop Grumman in Redondo Beach, California, had to lift the section with the mirror and instruments to place it on the half with the sunshield and the spacecraft. This delicate maneuver was accomplished using a crane and allowed the mechanical connection of the contact points of the two sections of the telescope. The next step will be to establish and test the electrical connection between the two halves.

Webb's team will now have to deploy the five layers of sunscreen to ensure that it can maintain the proper shape to protect the mirror and instruments from the light of the Sun, Earth and Moon. The Webb telescope will undergo additional environmental and deployment tests to ensure that it can survive the extreme launch and space environment. The launch of the telescope is still planned for **March 2021**.

# Team

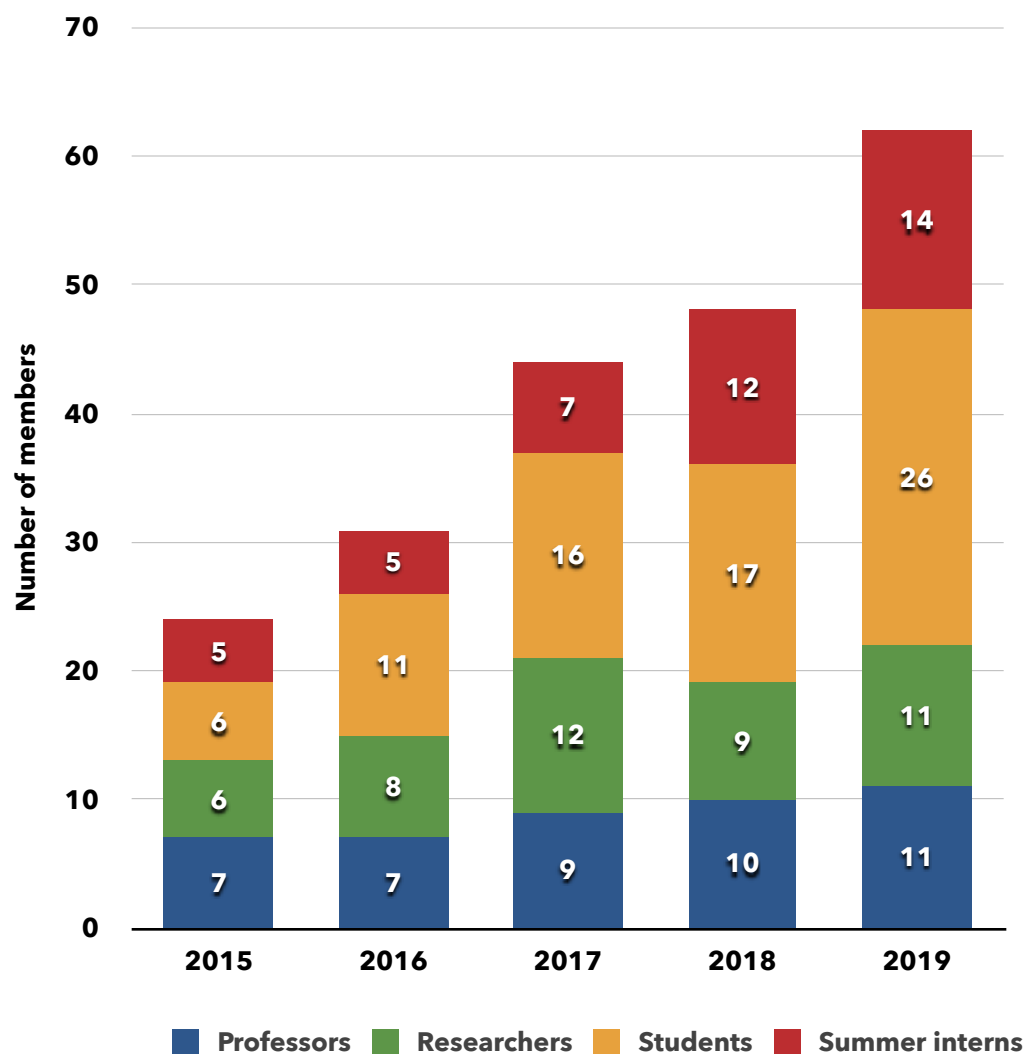
**iREx MEMBERS ARE UNDERGRADUATE AND GRADUATE STUDENTS, POSTDOCTORAL AND SENIOR RESEARCHERS, AND PROFESSORS. OUR MEMBERS ARE DIVIDED BETWEEN THE **UNIVERSITÉ DE MONTRÉAL**, **MCGILL UNIVERSITY**, **BISHOP'S UNIVERSITY**, **UNIVERSITÉ LAVAL** AND THE **RIO TINTO ALCAN MONTREAL PLANETARIUM**.**

**TOGETHER, WE FORM THE LARGEST EXOPLANET RESEARCH CENTRE IN CANADA AND ONE OF THE MOST COMPETITIVE ON THE GLOBAL STAGE.**



# Our Team's Growth

SINCE ITS INCEPTION IN 2014 WITH BARELY A DOZEN MEMBERS, THE iREx TEAM HAS UNDERGONE **IMPRESSIVE GROWTH** THANKS TO THE RECRUITMENT OF NEW STUDENTS, RESEARCHERS AND PROFESSORS AND RECORD NUMBERS OF SUMMER INTERNS.



Several new members joined our team in 2018-2019. In particular, our number of graduate students has increased significantly.

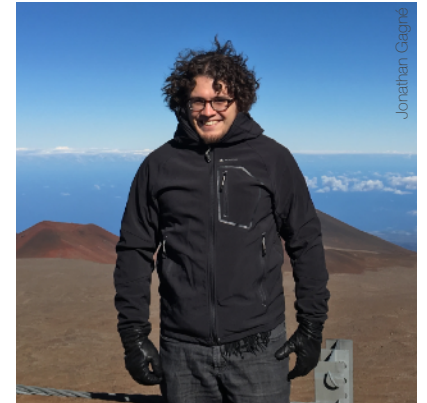
By the summer of 2019, the iREx had **62 members**. This includes 14 summer interns, our largest cohort of trainees since the founding of the Institute.

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.

# Changes in our Team

SEVERAL **NEW RESEARCHERS** JOINED THE iREx TEAM IN 2018-2019. THE DEPARTURE OF OUR COORDINATOR ALSO RESULTED IN MANY NEW OPPORTUNITIES.

**Jonathan Gagné** joined the iREx in 2018 as a **Banting Postdoctoral Fellow**. His research focuses on the kinematics of stars in the vicinity of the Sun, young stellar associations, brown dwarfs and exoplanets.



**Mohamad Ali-Dib** is interested in the theory of the formation of planets, the Solar System and exoplanets. He is also interested in the applications of machine learning in astrophysics. Mohamad is the 2018 **Trottier Postdoctoral Fellow**.

**Geert Jan Talens** joined the iREx in 2019 as a **Postdoctoral Researcher for the James Webb Space Telescope**. He is involved in the improvement and development of algorithms for the analysis of the atmospheric spectra of exoplanets obtained by space telescopes.



## [...] Changes in our Team



**Eve Lee**, a specialist in the formation of planetary systems, joined the Department of Physics at **McGill University** as an **Assistant Professor** and became a regular member of the iREx in 2019. She received her B.Sc. in Physics and Astronomy from the University of Toronto. She then obtained her Ph.D. at UC Berkeley under the supervision of Eugene Chiang in 2017, and spent two years as a Sherman Fairchild Postdoctoral Fellow in Theoretical Physics at the California Institute of Technology.

After an illustrious career at the Université de Montréal that includes the founding of the iREx in 2014 and the management of several astronomical instrumentation projects, our Coordinator **Olivier Hernandez** left the Institute to become the new **Director of the Rio Tinto Alcan Montreal Planetarium**. Rather than announcing the end of this professional relationship with the iREx, Olivier's new position has opened up new avenues of outreach and research between the Planetarium and the iREx.



**Nathalie Ouellette**, an astrophysicist and science communicator, became the new **Coordinator of iREx** in 2018, following the departure of Olivier Hernandez. In addition to her iREx duties, Nathalie holds the position of **Outreach Scientist for the James Webb Space Telescope**, both at the **Université de Montréal**, where many of the researchers associated with this space observatory are located, and at the **Canadian Space Agency**.

# Prizes and Grants

**MANY MEMBERS OF THE iREx WERE AWARDED A NUMBER OF INSTITUTIONAL, PROVINCIAL AND NATIONAL AWARDS AND SCHOLARSHIPS IN 2018-2019.**

**Jason Rowe**, a professor at **Bishop's University**, was awarded a new **NSERC Canada Research Chair in Exoplanet Science in 2018**. This honour comes with \$100,000 per year for five years, which will allow Jason and his team to explore the detection and characterisation of Earth-like exoplanets. Jason was also the recipient of the **Emerging Scholar Award from Bishop's University in 2019**. This award recognises outstanding young researchers and creators whose work has had a significant impact in their field.



Our Director, **René Doyon**, was awarded a **Killam Research Fellowship from the Canada Council for the Arts in 2018**. These fellowships provide release time and are intended to assist researchers with exceptional expertise to carry out large-scale research projects of general interest in the humanities, social sciences, natural sciences, health sciences, engineering, or studies linking any of these disciplines. Through his Killam Fellowship, René will have the opportunity to focus on his ongoing astronomical instrumentation projects such as SPIRou, NIRPS and NIRISS on the JWST.

## [...] Prizes and Grants



**Olivier Hernandez**, former iREx Coordinator and Director of Operations at the Observatoire du Mont-Mégantic, received a **Coup de coeur mention in the Inspiration category of the 2018 Université de Montréal Rector's Awards**. The Rector's Awards, presented in five categories, are intended to reward exceptional contributions by members of the university community.

After earning his Ph.D. at the **Université de Montréal** in 2015 and obtaining a prestigious postdoctoral fellowship in the United States, **Jonathan Gagné** returned to Quebec and the Udm with a prestigious **NSERC Banting Postdoctoral Fellowship in 2018**. The Banting Fellowships are offered annually to top researchers from around the world so that they can remain leaders in their field of research and contribute to Canada's economic, social and scientific development.



**Lisa Dang**, a Ph.D. student at **McGill University** and member of iREx, was awarded a **Relève Étoile Louis-Berlinguet prize from the Fonds de recherche du Québec in May 2018** for her paper on the detection of an atmospheric anomaly of the gas giant CoRoT-2b.

## [...] Prizes and Grants

**Marie-Eve Desrochers**, an M.Sc. student at the **Université de Montréal** and member of iREx, was awarded a **Relève Étoile Louis-Berlinguet prize from the Fonds de recherche du Québec in August 2018** for her paper on the discovery of a new brown dwarf around a young low-mass star.



**Nicolas Cowan**, Professor at **McGill University** and member of iREx, was the recipient of the **Canadian Astronomical Society's 2019 Harvey B. Richer Gold Medal**. This CASCA award, presented every two years, recognises major contributions made by a Canadian astrophysicist early in his or her career. It was established through a donation from Harvey B. Richer, former Director of the Society and Professor at the University of British Columbia. The first award was presented to David Lafrenière, also a member of iREx, in 2017.

In 2018-2019, **14 of our summer interns, 9 of our M.Sc. students and 13 of our Ph.D. students were awarded government or institutional scholarships**. For a complete list of our prize recipients, please consult our directory at the end of the appendices of this report.

## Public Talks

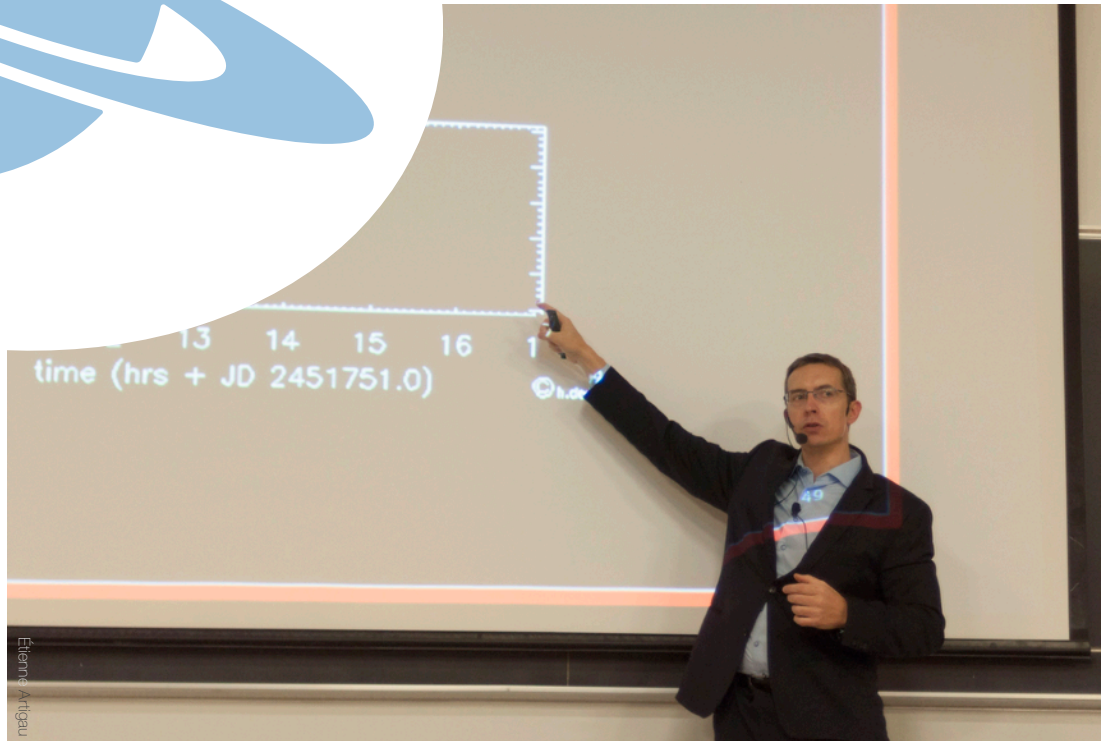
SEVERAL MEMBERS OF THE iREx ARE INVITED TO GIVE **PUBLIC TALKS AND LECTURES IN EDUCATIONAL ESTABLISHMENTS**. IN ADDITION, WE ORGANISE THE **GRANDE CONFÉRENCE DE L' iREx EVERY FALL**.

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



Our astronomers are also invited to meet with **elementary and high school students** throughout the Montreal area and beyond to talk to them about space and the profession of astronomy. In addition to these meetings and visits, we participate in several **virtual classroom visits** with the help of organizations such as Skype a Scientist and École en réseau.

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



For the **Grande conférence de l'iREx 2018**, we had the pleasure to welcome **Michaël Gillon**, Senior Research Fellow working at the STAR Institute (Space Sciences, Technologies and Astrophysics Research) at the University of Liège in Belgium. He is well known for leading the team that discovered the famous TRAPPIST-1 planetary system. It is a rather amazing system that contains seven rocky planets the size of the Earth, at least three of them appearing to be in the habitable zone.

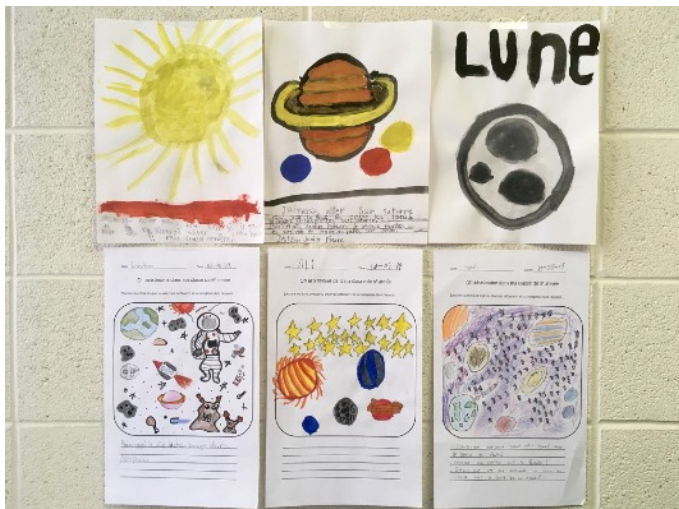
Nearly 200 people attended the Grande conférence on the evening of Wednesday October 24<sup>th</sup> during which Gillon discussed **humanity's quest for extraterrestrial worlds over the years through science and science fiction**.

Many of the current and future scientific missions and possible discoveries presented by Gillon seemed almost harder to believe than the fictional stories featured during the conference. After the conference, one lucky winner walked away with an interstellar travel poster created by NASA for TRAPPIST-1e, one of the planets in the system's habitable zone. The iREx team was honoured to have been able to host an event that attracted such a large audience, and we warmly thank Michaël Gillon for his captivating presentation.

The Grande conférence 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 NUMEROUS PUBLIC EVENTS SUCH AS THE **EUREKA! FESTIVAL AND ANNUAL AND SPECIAL EVENTS** ORGANISED BY OUR OWN INSTITUTE IN COLLABORATION WITH OUR MANY PARTNERS.



As part of *Science pour tous's 24h of Science*, the iREx, in collaboration with the **Centre de recherche en astrophysique du Québec**, proposed the **Astronomer in your Classroom** activity. Each year, over 90 classes from grades 4, 5 and 6 applied to be selected for this activity. The winning classes were chosen in accordance with Ministry of Education and Higher Education's deprivation indices in order to favour the classes from the most disadvantaged backgrounds.

During the **2018** edition, **one of our astronomers visited four elementary schools in Montreal**. In **2019**, **nine astronomers from the Université de Montréal visited eighteen Montréal elementary school classes**.

The iREx, in collaboration with the UdeM, organises the **astroMIL** Day, a popular astronomy event on the MIL Campus site, every summer. These events attract several hundreds of people each year.

On **August 11<sup>th</sup> 2018**, the 2<sup>nd</sup> edition of astroMIL was held at the Virage-Campus MIL. The event, titled **Un oeil québécois sur l'Univers**, was held to celebrate the **40<sup>th</sup> anniversary of the Observatoire du Mont-Mégantic**.

**Fun activities** were organised for children and their families in the afternoon. In the evening, a **constellation of talks** honoured the OMM. The event ended with an **observing session of the Perseids** accompanied by the Gypsy Jazz quartet from the UdeM Student Music Agency.



Mayse Boyce

## [...] Public Events

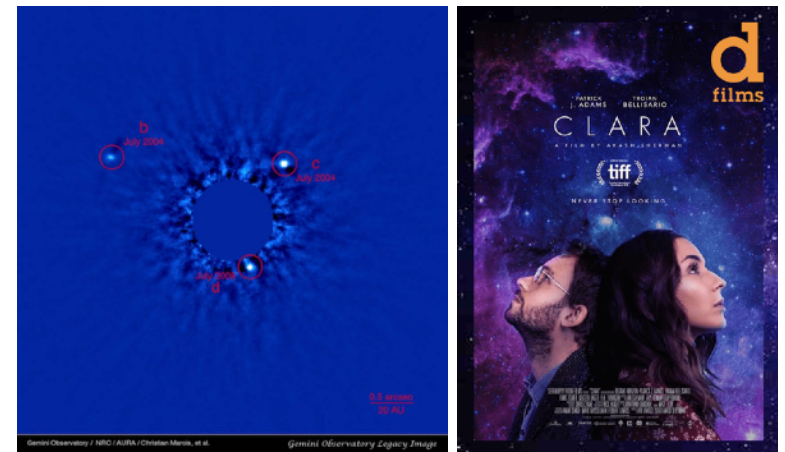


The 3<sup>rd</sup> edition of **astroMIL** took place on **July 21<sup>st</sup> 2019**. Entitled ***astroMIL: la Lune, 50 ans plus tard***, the event attracted more than 700 people and was held to celebrate the **50<sup>th</sup> anniversary of the Apollo 11 mission** and the first step on the Moon.

Booths presenting **fun science experiments and activities** were set up by the UdeM's Chemistry, Geography, Physics and Biological Sciences' departments, as well as by numerous collaborators. Visitors of all ages were also able to enjoy the various activities offered at the MIL library, including virtual reality and a wall of touch screens. During the day, participants were also able to attend a **variety of public talks** focusing on space exploration.

The day concluded with an **outdoor screening of the film *First Man***, which offers a more intimate glimpse into the life of Neil Armstrong, the first man to set foot on the Moon. Late in the evening, amateur astronomers delighted participants by **pointing their telescopes towards Jupiter and Saturn**, which were on display that evening.

To mark the **10<sup>th</sup> anniversary of the first image taken of a real exoplanet system, HR 8799**, the iREx hosted a **free screening of the science-fiction movie *CLARA*** at the Ciné-Campus of the Université de Montréal, a Montreal premiere. The screening was followed by a discussion with real exoplanet hunters.



## [...] Public Events



To celebrate **International Astronomy Day on May 11<sup>th</sup> 2019**, the iREx joined the **Rio Tinto Alcan Montreal Planetarium** and the **Royal Astronomical Society of Canada** for a day filled with **bilingual activities** celebrating space. The iREx welcomed hundreds of people of all ages to their booth, which offered a **virtual reality experience** exploring the James Webb Space Telescope and the many discoveries it promises.



The iREx, in collaboration with the **Centre de recherche en astrophysique du Québec**, was present at the 2019 edition of the **Eurêka! Festival**, the largest science festival in Quebec. From **June 7 to 9 2019** at the Old Port of Montreal, a dozen students from UdeM and McGill University were able to share their passion for astronomy with festival-goers of all ages. Under the theme **Voyage vers de nouveaux mondes**, visitors were invited to discover exoplanets.

Through association games, they were able to learn more about the Hot Jupiters, ocean worlds and Earth-like planets. The festival was a great success, welcoming **several tens of thousands of visitors**.

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

# 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.



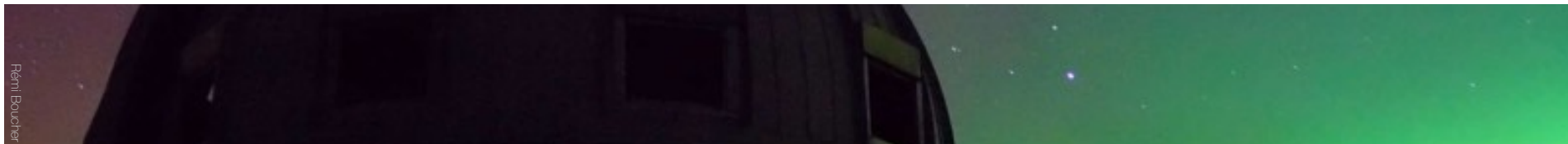
The concept for the **Astronomy on Tap** events was created in 2014 in New York as evenings organised by astronomers for the general public. There are now more than thirty franchises around the world that organise this activity. The first edition in Montreal took place in January 2017 at **McLean's Pub**. 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, **six events were presented in English and seven evenings were held in French**. Nine iREx members were able to present at these events. Each event attracts an average of about 60 participants.



# Internships and Career Days

HIGH SCHOOL AND CEGEP STUDENTS HAVE THE OPPORTUNITY TO EXPLORE THE WHAT IT IS LIKE TO BE AN ASTRONOMER THROUGH INTERNSHIPS AT iREx RANGING FROM A CAREER DAY TO A RESEARCH INTERNSHIP LASTING SEVERAL MONTHS.



The iREx organises several **Career Days** each year to give **high school students** the opportunity to interact with professional astronomers and discover the **profession of astronomy**. Throughout these days, students meet researchers in the UdeM astrophysics and astronomy group, attend seminars or discussions on current astronomical topics, visit our instrumentation laboratories and learn more about the tools astronomers use in their research. For an extended experience, two secondary 5 students from Collège Sainte-Anne spent **a week at iREx** to learn a bit more about the day in the life of an astronomer.

We also offer CEGEP students the possibility of longer internships at iREx to undertake a research project with our researchers. Two CEGEP André-Grasset students from the DEC+ Program completed a **galaxy imaging project at the Observatoire du Mont-Mégantic (OMM)** under the supervision of an iREx doctoral student, Frédérique Baron, during the winter 2018 session.

Two CEGEP students from Collège Jean-de-Brébeuf, one in summer 2018 and one in summer 2019, participated in **instrumentation projects at the OMM** under the supervision of Jonathan St-Antoine, researcher and M.Sc. student at iREx.

Three of our researchers, Loïc Albert, Frédérique Baron and Nathalie Ouellette, supervised a CEGEP student from Collège Sainte-Anne for a **science communication project**, namely the creation of posters presenting the subject of exoplanets to the general public.

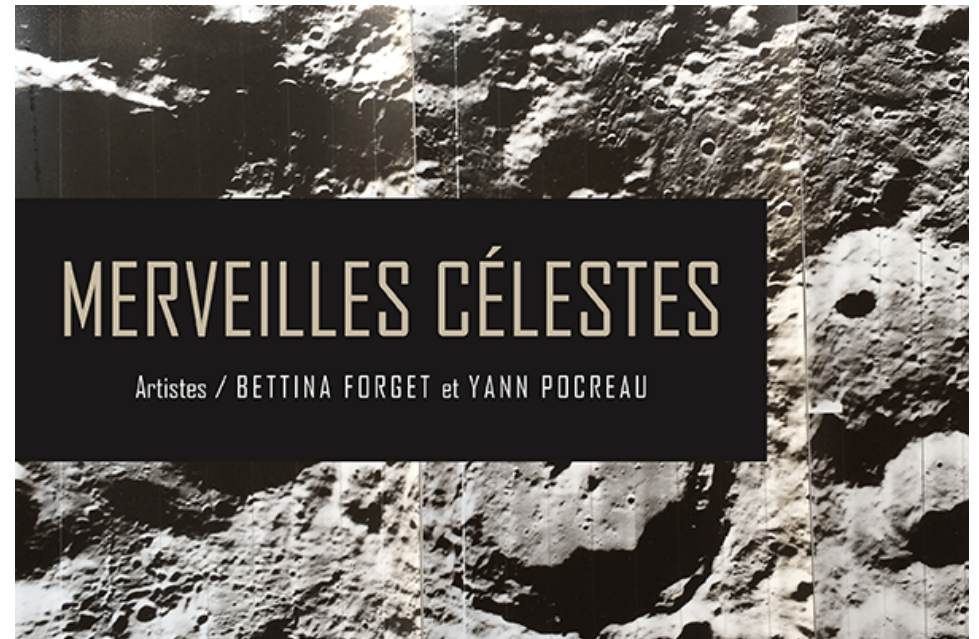
The iREx also organises the **Astronomer for a Night** contest every summer. This activity allows a few high school students to **spend a night at the OMM** and assist our astronomers in taking astronomical observations on site.

# Artists in Residence

A **RESEARCH-CREATION RESIDENCY** WAS SET UP IN 2018 TO MARK THE 40<sup>TH</sup> ANNIVERSARY OF THE OBSERVATOIRE DU MONT-MÉGANTIC AND THE 20<sup>TH</sup> ANNIVERSARY OF THE CENTRE D'EXPOSITION DE L'UNIVERSITÉ DE MONTRÉAL. THE SELECTED ARTISTS INTERACTED WITH iREx ASTRONOMERS TO GAIN INSPIRATION FOR THEIR PIECES CREATED DURING THE RESIDENCY.

**Bettina Forget** and **Yann Pocreau**, the artists selected through a competitive process, completed their research-creation residencies at the Observatoire du Mont-Mégantic in collaboration with astrophysicists from the Université de Montréal and the iREx.

This residency allowed Forget and Pocreau to deepen their respective research: the recognition of the contribution of women in the discipline for Forget and the aesthetic work of Pocreau on light which has been at the heart of his practice for the past fifteen years. Above all, this residency made it possible for the artists to **explore new avenues, places and technologies and to initiate exchanges with researchers.**



The work was presented during the exhibition ***Merveilles célestes - Bettina Forget et Yann Pocreau***, from **September 27<sup>th</sup> 2018 to January 26<sup>th</sup> 2019** at the **Centre d'exposition de l'Université de Montréal**. Overall, this exhibition was more of an installation than the classic exhibition format. It included traces of research, artifacts found within the Université de Montréal that were the driving force behind the reflections, works in progress and other pieces.

**Part of the exhibition was then displayed in the summer of 2019** at the library of the Complexe des sciences de l'Université de Montréal during the iREx **astroMIL** event. We plan to organise future editions of this research-creation residency.

# In the News

IN 2018-2019, THE iREx EXPERIENCED A REAL BOOM IN ITS **MEDIA PRESENCE**. SEVERAL OF OUR RESEARCHERS' **DISCOVERIES** WERE SHOWCASED ON THE INTERNATIONAL STAGE. IN ADDITION, OUR RESEARCHERS ARE NOW RECOGNISED ACROSS CANADA FOR THEIR EXPERTISE IN ASTRONOMY AND ARE REGULARLY CALLED UPON TO COMMENT ON **SCIENTIFIC NEWS**.



In 2018-2019, iREx members were involved in **30 television interviews**, **80 radio interviews** and **59 print and online interviews**.

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

# Social Media

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THE iREx BUILT AN EVEN STRONGER ONLINE PRESENCE ON **SOCIAL MEDIA** AND OUR **WEBSITE** IN 2018-2019. IN ADDITION, WE NOW HAVE A RECORD NUMBER OF SUBSCRIBERS TO OUR **NEWSLETTER** PUBLISHED FIVE TIMES A YEAR.

**As of August 31, 2019, the iREx had**

**1456 Facebook  
followers**



**@iRExoplanetes**

**824 Twitter  
followers**



**@iExoplanets**

**79 283 hits  
on our website  
since January 2018**



**www.exoplanets.ca**

**1018 subscribers  
to our newsletter**



**irex@astro.umontreal.ca**

## Scientific Meetings

GIVEN THE SIGNIFICANT INVOLVEMENT OF iREx MEMBERS IN PROJECTS OF INTERNATIONAL SCOPE, WE ORGANISED SEVERAL **SCIENTIFIC CONFERENCES** IN 2018-2019 ON A VARIETY OF ASTRONOMICAL SUBJECTS.



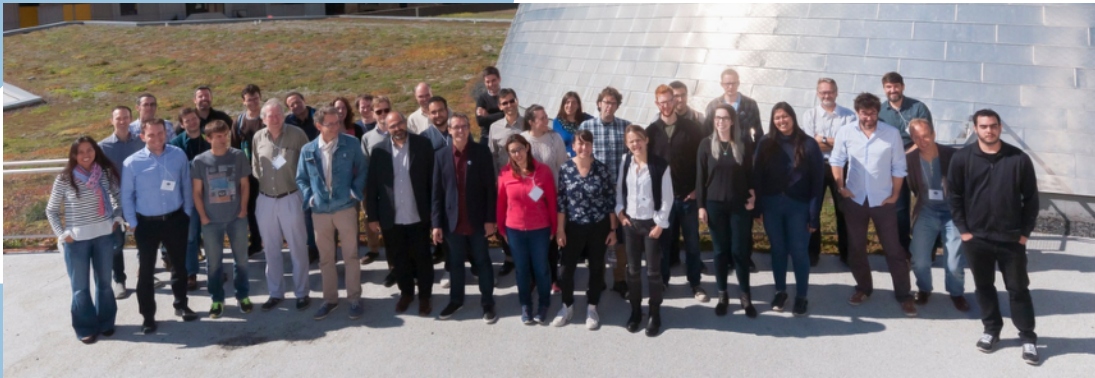
On **November 6<sup>th</sup> and 7<sup>th</sup> 2018**, the iREx hosted the ***Future of Space Astronomy in Canada* workshop**. The purpose of this two-day workshop was to bring together all stakeholders (academia, industry, the Canadian Space Agency) to discuss Canada's participation in future space astronomy projects at all scales and wavelengths.

The objective was to stimulate ideas and make plans for the **Canadian Astronomical Society's 2020 Long Range Plan**.

It was an opportunity to learn about the status of current and upcoming space astronomy projects and to discuss, among other things, current issues related to government funding.

In total, close to **70 participants** from across Canada and around the world joined us in the Roger-Gaudry Pavilion at the Université de Montréal. We enjoyed interesting presentations, engaging discussions and active participation during this workshop. Participants left with a renewed sense of purpose and a list of actions to be taken back to help our community improve Canada's status in space astronomy.

## [...] Scientific meetings



The **NIRPS scientific team** held its first meeting in **September 2018 at the Rio Tinto Alcan Montreal Planetarium**. The team in charge of the construction of the instrument gave an update on the progress made in the assembly of the various components of NIRPS. Overall, the team noted that the project is closely following the initial schedule, and entire modules of the instrument have already been completed.

The researchers also provided an update on their personal work and the key questions they will seek to answer with NIRPS. The team has been allocated **745 nights of observation by ESO** as soon as the instrument's scientific operations begin. This very large number of nights opens the door to very ambitious projects, but also requires careful planning. The team intends to divide the time into three major sub-projects: 1) to identify the planets orbiting the stars closest to the Sun, less than 15 lightyears away, 2) to characterise exoplanets detected by transit surveys, and 3) to directly characterise the chemical composition of the atmosphere of exoplanets in transit.

Two important scientific meetings took place in Montreal in **May 2019** and were co-organised by iREx: the **12<sup>th</sup> Canada-France-Hawaii Telescope Users' Meeting** (celebrating the 40<sup>th</sup> anniversary of the CFHT) at the DoubleTree Hilton and the **SPIRou scientific team meeting** at UdeM's Roger-Gaudry Pavilion.

The triennial CFHT Users' Meetings are important opportunities for our community to share recent discoveries and perspectives that help guide the future of CFHT. It was also an important meeting for the SPIRou science team, the first since the beginning of the instrument's scientific observation campaign. Several iREx members presented their projects at both of these meetings.



# 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**.

We also welcome several internationally renowned researchers to Montreal during our **Cafés iREx**, which allows our members, especially our students, to interact with experienced researchers in a more informal setting.

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. In 2018-2019, we introduced a **virtual anonymous question box** that allows our members to ask questions that puzzle or intrigue them in a judgement-free way. This has already allowed us to devote some of our Cafés to very useful and appreciated review sessions on basic concepts in astrophysics.

# Summer Interns

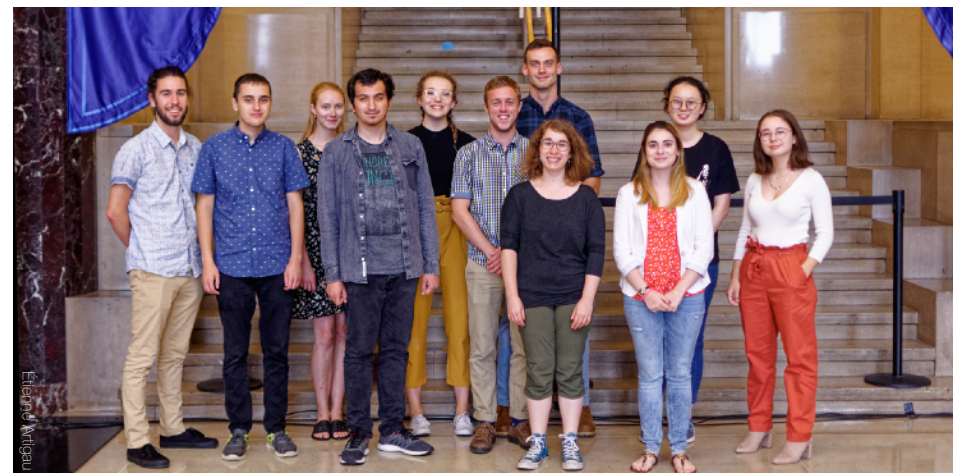
THE iREx HAS BEEN WELCOMING UNDERGRADUATE STUDENTS AS **SUMMER INTERNS** SINCE OUR INCEPTION. AMONG OTHER THINGS, OUR **TROTTIER SUMMER INTERNSHIPS EXCELLENCE GRANTS** COMPETITION ATTRACTS CANADA'S TOP STUDENTS TO OUR INSTITUTE.



The iREx welcomed **twelve new research students in the summer of 2018, including six Trottier fellows**. The iREx summer students worked from May to August with iREx researchers at the Université de Montréal, McGill University and Bishop's University on various projects related to the detection and study of exoplanets. Our Trottier fellows (five women and one man) were selected from more than seventy applications received from across Canada. One of our fellows, **Mariya Krasteva**, had the opportunity to stay in Hawai'i for a month to work with the **Canada-France-Hawai'i Telescope** team on the SPIRou instrument.

In the **summer of 2019, a record number of fourteen summer interns** joined the iREx team. Our **five Trottier fellows** (all women) were selected from nearly one hundred applications.

We also awarded the first **Sureau Fellowship** to **Ariane Deslières**, a student from the University of Ottawa, which allowed her to spend one month of her **internship at the Canada-France-Hawai'i Telescope** to collaborate with the SPIRou team. This scholarship is made possible by a generous donation from **Mr. Philippe Sureau**, co-founder of Air Transat and Chairman of the Board of Tourisme Montréal.



# Maunakea School

SINCE THE SUMMER OF 2018, THE iREx HAS BEEN PROUD TO BE ASSOCIATED WITH THE **MAUNAKEA GRADUATE SCHOOL** WHICH ALLOWS GRADUATE STUDENTS FROM CANADIAN INSTITUTIONS TO LEARN MORE ABOUT OBSERVATIONAL ASTRONOMY AND THE OPERATION OF LARGE TELESCOPES ON SITE IN HAWAI'I.



This school, for graduate students from Canadian institutions, took place from **May 29<sup>th</sup> to June 8<sup>th</sup> 2018** and **April 2<sup>nd</sup> to 13<sup>th</sup> 2019** on the Big Island of Hawai'i.

It is the result of a unique partnership between the iREx, **Queen's University**, the **Canada-France-Hawai'i Telescope** and the **Gemini Observatory**. Other participating observatories located on the summit of Maunakea are the W Observatory, M. Keck Observatory, the Subaru Telescope and the James Clerk Maxwell Telescope.

Under the supervision of professional astronomers including **Stéphane Courteau** from Queen's University, students were able to design observing programs and were given telescope time to obtain data during their stay. They were able to learn about astronomical instruments, the operation of large observatories, and Hawaiian culture. **Six Canadian students, including two from the iREx, participated in the 2018 edition** of the school accompanied by **Loïc Albert**, researcher at the iREx. **Five Canadian students, including two from the iREx, participated in 2019** accompanied by our EPO Coordinator **Frédérique Baron**.



### School Talks

- *Sur le thème des exoplanètes*, Marie-Eve Naud, École primaire Les berges de Lachine, January 29 2018.
- *Space Explorers Mission 1 Workshop*, Lisa Dang, Edgewater Elementary School, February 2 2018.
- *Mon parcours*, Marie-Eve Naud, CÉGEP de Thetford Mines, March 2 2018.
- *Seuls dans l'univers? L'humanité à la recherche d'autres mondes habités*, Marie-Eve Naud, CÉGEP du Vieux-Montréal, April 4 2018.
- *Space Explorers Mission 2 Workshop*, Lisa Dang, Edgewater Elementary School, April 13 2018.
- *Voyage interstellaire vers les nouveaux mondes*, Marie-Eve Naud, Discover the Universe (online), May 8 2018.
- *Une astronome dans votre classe*, Marie-Eve Naud, CSDM schools, May 14 2018.
- *Looking for Other Worlds*, Jason Rowe, Discover the Universe (online), May 17 2018.
- *Space Explorers Mission 3 Workshop*, Lisa Dang, Edgewater Elementary School, June 1 2018.
- *Space Breakfast*, Lisa Dang, Exploration Summer Camp, July 12 2018.
- *Seuls dans l'univers? L'humanité à la recherche d'autres mondes habités*, Marie-Eve Naud, Collège Jean-de-Brébeuf, August 31 2018.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist (online), September 19 2018.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist (online), September 24 2018.
- *SPIRou et NIRPS à la recherche des exoplanètes*, Étienne Artigau, École Technique Supérieur, October 9 2018.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist (online), October 10 2018.
- *Les exoplanètes et la recherche pour la vie extraterrestre*, Antoine Darveau-Bernier, École Sophie-Barat, October 11 2018.
- *Les 40 ans de l'Observatoire du Mont-Mégantic*, Nathalie Ouellette, Discover the Universe (online), October 18 2018.
- *Exoplanet Hunting 101*, Lisa Dang, Marianopolis College, October 23 2018.
- *Comment trouver des exoplanètes?*, Frédérique Baron, École de la Montée, November 21 2018.
- *Galaxies: îles cosmiques*, Nathalie Ouellette, CÉGEP du Vieux-Montréal, November 28 2018.
- *La chasse aux exoplanètes*, Nathalie Ouellette, Collège de Notre-Dame, December 10 2018.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist (online), December 11 2018.
- *La chasse aux exoplanètes*, Nathalie Ouellette, Collège Reine-Marie, January 23 2019.
- *Dark Matter*, Nathalie Ouellette, Virtual Researcher on Call (online), February 1 2019.
- *Voyage vers Proxima du Centaure*, Frédérique Baron, Séminaire Saint-Joseph, February 1 2019.

# **[...] Public Events**

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## **[...] School Talks**

- *Les exoplanètes*, Jonathan Gagné, Centre de recherche des études littéraires et culturelles sur la planétabilité de l'UdeM, February 6 2019.
- *Searching for exoplanets*, Frédérique Baron, CanYES (online), February 11 2019.
- *Les exoplanètes et la recherche pour la vie extraterrestre*, Antoine Darveau-Bernier, École St-Arsène, February 14 2019.
- *Le télescope spatial James Webb*, René Doyon, Polytechnique de Montréal, February 18 2019.
- *À la recherche d'exoplanètes*, Frédérique Baron, Villa Sainte-Marceline, February 21 2019.
- *Jusqu'où va le ciel?*, Frédérique Baron, École en réseau (online), February 21 2019.
- *Jusqu'où va le ciel?*, Frédérique Baron & Nathalie Ouellette, Centre William-Hingston, March 7 2019.
- *L'Institut de recherche sur les exoplanètes*, Frédérique Baron, SAPHARI de l'UdeM, March 9 2019.
- *Searching for exoplanets!*, Frédérique Baron, Dawson College, March 13 2019.
- *Jusqu'où va le ciel?*, Frédérique Baron, École des Mélèzes, March 18 2019.
- *Entre rêves et réalité des sciences: Témoignages*, Frédérique Baron, AstroPoly, March 19 2019.
- *L'Univers multicolore*, Nathalie Ouellette, CÉGEP du Vieux-Montréal, March 19 2019.
- *Astronome dans votre classe*, Marie-Eve Naud, École Val-des-Ormes, March 25 2019.
- *Jusqu'où va le ciel?*, Frédérique Baron, École en réseau (online), March 28 2019.
- *Astronome dans votre classe*, Marie-Eve Naud, École alternative Les Colibris, March 29 2019.
- *The Universe and the James Webb Space Telescope*, Nathalie Ouellette, Skype a Scientist (online) April 15-16-18-24 2019.
- *Trouver la Terre 2.0 en étudiants les spectres d'exoplanètes*, Caroline Piaulet, École secondaire Louis-Riel, April 24 2019.
- *The Universe and the James Webb Space Telescope*, Nathalie Ouellette, Skype a Scientist (online), May 1-13 2019.
- *Inquiry Institute Science Workshop with Lester B. Pearson School Board*, Lisa Dang, Lindsay's Place High School, May 3 2019.
- *Jusqu'où va le ciel?*, Frédérique Baron Antoine Darveau-Bernier, Prashansa Gupta, Christopher Mann & Caroline Piaulet, Montreal primary schools (9 classrooms for *Astronomer in your classroom*), week of May 13 2019.
- *Les mondes extraterrestres*, Nathalie Ouellette, Montreal primary schools (2 classrooms for *Astronomer in your classroom*), week of May 13 2019.
- *Sommes-nous seuls dans l'Univers?*, Frédérique Baron, Discover the Universe (online), May 14 2019.
- *À la recherche de la Terre 2.0*, Caroline Piaulet, Académie de Roberval, May 24 2019.
- *La Lune et les planètes*, Étienne Artigau, Primary school, May 28 2019.
- *Astronome dans votre classe*, Marie-Eve Naud, École alternative Les Colibris, May 29 2019.

### [...] School Talks

- *Searching for exoplanets*, Nathalie Ouellette, CanYES (online), May 30 2019.
- *Astronome dans votre classe*, Marie-Eve Naud, École alternative Les Colibris, June 3 2019.
- *Astronome dans votre classe*, Marie-Eve Naud, École alternative Les Colibris, June 12 2019.
- *Science Communication 101*, Frédérique Baron, CASCA Graduate Student Committee, June 17 2019.
- *Les exoplanètes*, Frédérique Baron, CASCA Teacher Workshop, June 19 2019.
- *L'Observatoire du Mont-Mégantic*, Nathalie Ouellette, CASCA Teacher Workshop, June 19 2019.
- *Fantastic Planets and How to Find Them*, Taylor Bell, Loyola High School, July 25 2019.

### Public Talks

- *Seuls dans l'univers? L'humanité à la recherche d'autres mondes habités*, Marie-Eve Naud, Club d'astronomie Les Boréales du Lac-Saint-Jean, February 23 2018.
- *Le télescope spatial James Webb: le compte à rebours est lancé!*, René Doyon, Club d'astronomie du Mont-Tremblant, May 8 2018.
- *Planetary Systems: Laboratories for our Cosmic Origin*, Lauren Weiss, McGill Public AstroNight, May 24 2018.
- *Exoplanètes "made-in Québec": les contributions de nos chercheurs dans la quête de nouveaux mondes*, Étienne Artigau, Festival populaire d'astronomie du Mont-Mégantic, July 5 2018.
- *40 ans d'astronomie infrarouge à l'Observatoire du Mont-Mégantic*, René Doyon, Festival populaire d'astronomie du Mont-Mégantic, July 6 2018.
- *Dernières nouvelles de Jupiter: ce que nous révèle la sonde Juno*, Loïc Albert, Festival populaire d'astronomie du Mont-Mégantic, July 19 2018.
- *Les instruments de l'OMM*, Lison Malo, astroMIL, August 11 2018.
- *40 ans d'astronomie infrarouge à l'Observatoire du Mont-Mégantic*, René Doyon, astroMIL, August 11 2018.
- *Voyage interstellaire vers les nouveaux mondes*, Frédérique Baron, Club d'astronomie des Vagabonds du ciel, September 8 2018.
- *Mieux comprendre Jupiter à travers les yeux de Juno*, Loïc Albert, Bibliothèque de Victoriaville, September 18 2018.
- *Galaxies: îles cosmiques*, Nathalie Ouellette, AstroPoly, October 2 2018.
- *Converging Art and Astronomy: New Perspectives on Lunar Nomenclature and Exoplanet Research*, Bettina Forget, Montreal Space Symposium, October 18 2018.

# **[...] Public Events**

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## **[...] Public Talks**

- *Data Visualisation for Exoplanet Instrument SPIRou*, Marina Krasteva, Montreal Space Symposium, October 18 2018.
- *A Virtual Tour of the James Webb Space Telescope*, Loïc Albert, Montreal Space Symposium, October 18 2018.
- *Aligning Canada with International Partners for the Advancement of Space Exploration*, René Doyon, Montreal Space Symposium (panel), October 19 2018.
- *La vie au-delà du Système solaire: de la science-fiction à la science*, Michaël Gillon, Grande conférence de l'iREx, October 24 2018.
- *Jupiter: quel est l'état des connaissances sur cette planète et qu'est-ce qui en motive l'exploration?*, Loïc Albert, Centre communautaire Sarto-Desnoyers, November 10 2018.
- *Les 40 dernières années de l'Observatoire du Mont-Mégantic*, Lison Malo, Société d'astronomie du Planétarium de Montréal, November 16 2018.
- *En quête de traces de vie avec le télescope spatial James Webb*, Loïc Albert, Cosmodôme de Laval, November 21 2018.
- *Canadian Space Astronomy with the James Webb Space Telescope*, René Doyon, Canadian Space Summit, November 29 2018.
- *Les exoplanètes*, Frédérique Baron, Cabaret scientifique, December 13 2018.
- *L'Univers multicolore*, Nathalie Ouellette, Société d'astronomie du Planétarium de Montréal, January 25 2019.
- *En quête de traces de vie dans les atmosphères d'exoplanètes avec le télescope spatial James Webb*, Loïc Albert, Club d'astronomie Bois-de-Belle-Rivière-Mirabel, February 26 2019.
- *Galaxies en évolution*, Nathalie Ouellette, Conférence de l'équinoxe du Planétarium Rio Tinto Alcan de Montréal, March 20 2019.
- *Exoplanètes géantes à grande séparation ou naines brunes déguisées?*, Frédérique Baron, Club d'astronomes amateurs de Laval, March 27 2019.
- *Ajustez vos télescopes – zoo d'exoplanètes en vue*, Loïc Albert, Institut national d'optique, March 2 2019.
- *Le satellite Gaia et ses découvertes*, Jonathan Gagné, Club d'astronomie de Mont-Tremblant, April 9 2019.
- *Les exoplanètes*, Frédérique Baron, Planétarium Rio Tinto Alcan de Montréal (International Astronomy Day), May 11 2019.
- *Femmes en astronomie: Discussions et carrières*, Frédérique Baron & Nathalie Ouellette, Planétarium Rio Tinto Alcan de Montréal (International Astronomy Day), May 11 2019.
- *Galaxies fracassantes*, Nathalie Ouellette, Pint of Science FR, May 20 2019.
- *Les exoplanètes: comment les détecter?*, René Doyon, Pint of Science FR, May 22 2019.
- *Exoplanètes 101*, Frédérique Baron, Pint of Science FR, May 22 2019.

### [...] Public Talks

- *Leaving the Earth Behind: Mars & Beyond*, Nicolas Cowan, Pint of Science EN, May 22 2019.
- *Studying the Invisible with the James Webb Space Telescope*, Nathalie Ouellette, Astronomy on Tap Kingston, June 13 2019.
- *Unveiling the Universe with the James Webb Space Telescope*, Nathalie Ouellette, Royal Astronomical Society of Canada General Assembly, June 14 2019.
- *Héroïnes de la Lune: célébrez les femmes en astronomie*, Bettina Forget, Festival populaire d'astronomie du Mont-Mégantic, July 4 2019.
- *Révéler l'Univers avec les télescope spatial James Webb*, Nathalie Ouellette, Festival populaire d'astronomie du Mont-Mégantic, July 5 2019.
- *Le télescope spatial James Webb et les exoplanètes*, Loïc Albert, Observatoire de la Montagne Coupée, July 6 2019.
- *La chasse aux MACHOs*, Lisa Dang, Festival populaire d'astronomie du Mont-Mégantic, July 11 2019.
- *Lunes et exolunes, hôtes de vie?*, Frédérique Baron, Festival populaire d'astronomie du Mont-Mégantic, July 13 2019.
- *Galaxies en évolution*, Nathalie Ouellette, Club d'astronomie Les Vagabonds du Ciel de Lanaudière, August 10 2019.
- *The Universe and the James Webb Space Telescope*, Nathalie Ouellette, Skype a Scientist LIVE! (online), August 15 2019.
- *Searching for new worlds*, Frédérique Baron, 4th of Space - Space Concordia, August 15 2019.
- *Naines brunes ou exoplanètes déguisées?*, Frédérique Baron, Rendez-vous des observateurs du ciel, August 24 2019.

### Public Events

- *Journée d'initiation à la recherche en astrophysique 2018*, Université de Montréal, January 16 2018.
- *Astronomy on Tap*, Pub L'Île Noire, February 27 2018, April 17 2018, September 14 2018, October 30 2018, January 29 2019, March 26 2019, May 28 2019.
- *astroMIL: Un oeil québécois sur l'univers*, Virage-Campus MIL, August 11 2018.
- *Exposition Merveilles Célestes*, Centre d'exposition de l'Université de Montréal, September 27 2018 to January 26 2019.
- *Visionnement du film CLARA*, Ciné-Campus de l'Université de Montréal, November 8 2018.
- *Journée d'initiation à la recherche en astrophysique 2019*, Université de Montréal, January 18 2019.
- *JeunesExplo 2019*, Université de Montréal, April 11 2019.
- *International Astronomy Day*, Planétarium Rio Tinto Alcan de Montréal, May 11 2019.
- *Festival Eurêka!*, Vieux-Port de Montréal, June 7 to 9 2019.
- *astroMIL: la Lune, 50 ans plus tard*, Campus MIL, July 21 2019.

# Media Interviews

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## Television Interviews

- *Chronique sur l'astronomie*, René Doyon, *Entrée principale* (Radio-Canada), January 8 2018; January 22 2018; February 12 2018; March 26 2018; April 9 2018; April 23 2018; September 10 2018; October 1 2018; October 29 2018; November 27 2018; December 10 2018; January 14 2019; February 4 2019; March 18 2019; April 18 2019.
- *Un trou noir dans la communauté scientifique*, Marie-Eve Naud, *Tout le monde en parle* (Radio-Canada), March 18 2018.
- *À la recherche d'exoplanètes*, René Doyon & David Lafrenière, *Le Téléjournal* (Radio-Canada), April 18 2018.
- *Les Perséides*, Marie-Eve Naud, *RDI Matin Weekend* (Radio-Canada), August 10 2018.
- *Demain le monde: la conquête de l'espace*, Nathalie Ouellette, *Les francs-tireurs* (Télé Québec), October 3 2018.
- *Le télescope spatial Kepler prend sa retraite*, René Doyon, *Le Téléjournal* (Radio-Canada), October 31 2018.
- *David Saint-Jacques dans l'espace*, Nathalie Ouellette, *Dumont* (LCN), December 3 2018.
- *La capsule Dragon amerrit sans accroc dans l'Atlantique*, Nathalie Ouellette, *TVA Nouvelles*, March 8 2019.
- *Première sortie dans l'espace du Québécois David Saint-Jacques*, Nathalie Ouellette, *Dumont* (LCN), April 8 2019.
- *First image of a black hole ever taken*, Nathalie Ouellette, *CBC News Network*, April 10 2019.
- *First image of a black hole ever taken*, Nathalie Ouellette, *CTV News*, April 10 2019.
- *Significance of first ever black hole photo*, Nathalie Ouellette, *Global News*, April 10 2019.
- *C'est quoi, un trou noir?*, Nathalie Ouellette, *Temps Mort* (Curium), May 27 2019.
- *Emerging fields in astrophysics*, Nicolas Cowan, *Global News*, June 17 2019.
- *Fêtez le 50e anniversaire d'Apollo 11*, Nathalie Ouellette & Olivier Hernandez, *RDI Matin Weekend* (Radio-Canada), July 20 2019.
- *L'humanité a-t-elle créé une colonie animale sur la Lune?*, Frédérique Baron, *Le téléjournal* (Radio-Canada), August 7 2019.

## Radio Interviews

- *De l'eau extraterrestre*, René Doyon, *Les années-lumière* (Radio-Canada), January 7 2019.
- *Connaissez-vous vraiment Stephen Hawking?*, Robert Lamontagne, *Les années-lumière* (Radio-Canada), March 18 2018.
- *Microbial life on Venus*, Nicolas Cowan, *Natasha Hall Show* (CJAD 800 AM), April 5 2018.
- *Un pas de plus vers la découverte de la vie extraterrestre*, René Doyon, *Radio-Canada*, April 16 2018.
- *Exoplanètes: un professeur de Bishop's dans l'équipe de TESS*, René Doyon & Jason Rowe, *Gravel le matin* (Radio-Canada), April 16 2018.

## **[...] Radio Interviews**

- *Le NASA lance le télescope TESS pour détecter des exoplanètes*, René Doyon & Jason Rowe, *Écoutez l'Estrée* (Radio-Canada), April 16 2018.
- *Le nouveau télescope spatial TESS en orbite*, Étienne Artigau, *Le café show* (Radio-Canada), April 18 2018.
- *Un nouveau télescope lancé par la NASA pour explorer d'autres planètes*, Étienne Artigau, *Point du jour* (Radio-Canada), April 18 2018.
- *TESS: un télescope chasseur de planètes*, Étienne Artigau, *Le réveil* (Radio-Canada), April 18 2018.
- *Avancée dans la recherche de vie extraterrestre avec le télescope TESS*, Björn Benneke, René Doyon & Marie-Eve Naud, *Les années-lumière* (Radio-Canada), April 22 2018.
- *Vie extraterrestre: la recherche avance lentement, mais sûrement*, David Lafrenière, *Médium large* (Radio-Canada), July 18 2018.
- *L'Observatoire du Mont-Mégantic, chef de file dans l'exploration astronomique*, Frédérique Baron & Marie-Eve Naud, *Médium large* (Radio-Canada), August 6 2018.
- *Une pluie d'étoiles filantes en fin de semaine*, Marie-Eve Naud, *Cet après-midi* (Radio-Canada), August 10 2018.
- *Découverte d'une exoplanète*, Merrin Peterson & Björn Benneke, *Le réveil* (Radio-Canada), September 10 2018.
- *Carl Sagan*, Marie-Eve Naud, *Plus on est de fous, plus on lit!* (Radio-Canada), October 2 2018.
- *Exomoon discovered*, Nathalie Ouellette, CBC Radio (*Information Morning; Ottawa Morning; Windsor Morning; West Coast Morning; Central Morning; The Trailbreaker; Daybreak Kamloops; Edmonton AM; Daybreak South; On the Island; Daybreak North; Saskatoon Morning*), October 4 2018.
- *Oumuamua, le cigare extraterrestre*, Frédérique Baron, *Médium large* (Radio-Canada), November 7 2018.
- *Talking Exoplanets, James Webb, Kepler, TESS and galaxy formation*, Nathalie Ouellette, *Den of Lore* (podcast), November 16 2018.
- *Le 20e anniversaire de la Station spatiale internationale*, Nathalie Ouellette, *Dutrizac* (QUB Radio), November 20 2018.
- *La sonde InSight atterrit sur Mars*, Nathalie Ouellette, *Le retour de Mario Dumont* (QUB Radio), November 26 2018.
- *Partir dans l'espace pour apprécier la Terre*, Nathalie Ouellette & Olivier Hernandez, *Faites du bruit* (Radio-Canada), November 30 2018.
- *David Saint-Jacques dans l'espace*, Nathalie Ouellette, *Dutrizac* (QUB Radio), December 3 2018.
- *Une astrophysicienne découvre une nouvelle galaxie*, Nathalie Ouellette, *Dutrizac* (QUB Radio), December 10 2018.
- *The Geminids*, Nathalie Ouellette, CBC Radio (*Ottawa Morning; London Morning; Metro Morning; Saskatoon Morning; Information Morning; Edmonton AM; Daybreak Kamloops; A New Day; The Early Edition*), December 13 2018.

# **[...] Media Interviews**

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## **[...] Radio Interviews**

- *Bilan scientifique de l'année 2018*, Nathalie Ouellette, *Dutrizac* (QUB Radio), December 21 2018.
- *Les Chinois sur la face cachée de la Lune et le Super Bowl de l'astronomie*, Nathalie Ouellette, *Dutrizac* (QUB Radio), January 11 2019.
- *For every exoplanet we see transiting a star, how many go unseen?*, Nicolas Cowan, *Quirks & Quarks* (CBC), January 12 2019.
- *La journée internationale des femmes et des filles*, Nathalie Ouellette, *Dutrizac* (QUB Radio), February 11 2019.
- *Le Canada participe à la passerelle lunaire de la NASA*, Nathalie Ouellette, CBC Radio (*Ça parle au Nord*; *Sur le vif*; *L'actuel*; *Écoutez l'Estrie*; *Boulevard du Pacifique*), February 28 2019.
- *Le Canada participe à la passerelle lunaire de la NASA*, Nathalie Ouellette, *Dutrizac* (QUB Radio), March 1 2019.
- *La mise en service de SPIRou*, René Doyon, *Les années-lumière* (Radio-Canada), March 2 2019.
- *NASA spacesuit sizing mistake*, Nathalie Ouellette, CBC Radio (*Mainstreet*; *Radio Active*; *Home Run*; *On the Go*; *All in a Day*; *Up to Speed*), March 26 2019.
- *La première photo d'un trou noir prise*, Nathalie Ouellette, *Franchement dit* (QUB Radio), April 10 2019.
- *First image of a black hole ever taken*, Nathalie Ouellette, CBC Radio (*All in a Day*; *Trail's End*; *Mainstreet PEI*; *Home Run*; *Up to Speed*; *Up North*; *Breakaway*; *All Points West*; *Homestretch*; *Airplay*; *Afternoon Edition*; *Radio Active*), April 10 2019.
- *Pourquoi les planètes gazeuses ne s'évaporent-elles pas?*, Frédérique Baron, *Moteur de recherche* (Radio-Canada), April 19 2019.
- *Le projet lunaire Artémis*, Nathalie Ouellette, *Dutrizac* (QUB Radio), May 24 2019.
- *Apprendre pour comprendre*, Marie-Eve Naud, *Têtes à réflexions* (Savoir média), June 1 2019.
- *Exoplanètes: le Canada de l'ombre à la lumière*, Nathalie Ouellette, Québec Science, June 24 2019.
- *Exoplanets and the James Webb Space Telescope*, Nathalie Ouellette, *The State of the Universe* (podcast), July 9 2019.
- *Fêtez le 50e anniversaire d'Apollo 11*, Nathalie Ouellette, 98.5, July 18 2019.
- *Le chaînon manquant des exoplanètes*, Nathalie Ouellette, *Les années lumière* (Radio-Canada), August 4 2019.
- *Stephen Hawking et l'art de la vulgarisation scientifique*, René Doyon, *Dessine-moi un été* (Radio-Canada), August 11 2019.

## Press and Online Interviews

- *Notre Système solaire serait particulier*, Lauren Weiss, Radio-Canada, January 9 2018.
- *Astroboffins say our Solar System is a dark violent cosmic weirdo*, Lauren Weiss, The Register, January 9 2018.
- *C'est la pagaille dans notre Système solaire et ce serait la faute de Jupiter et Saturne*, Lauren Weiss, Huffington Post France, January 11 2018.
- *Tous les systèmes planétaires de ressemblent – ou presque*, Laurence Weiss, Science Post, January 13 2018.
- *Notre Système solaire serait exceptionnel!*, Lauren Weiss, Futura Sciences, January 20 2018.
- *Des vents défient nos théories sur l'exoplanète CoRoT-2b*, Lisa Dang & Nicolas Cowan, Radio-Canada, January 23 2018.
- *Weird winds blow the "wrong way" on scorching hot exoplanet*, Lisa Dang, Space.com, January 23 2018.
- *Les vents de cette exoplanète surprennent les astrophysiciens*, Lisa Dang, Futura Sciences, January 25 2018.
- *Exoplanètes: des découvertes aux spéculations*, Marie-Eve Naud, Agence Science Presse, February 19 2018.
- *Exoplanet Everests may be detectable when giant telescopes come online*, Nicolas Cowan, Scientific American, March 6 2018.
- *Sous les vents de Jupiter*, Loïc Albert, La Presse, March 8 2018.
- *Cyclopes géants: ces télescopes qui scruteront le ciel*, Olivier Hernandez, Québec Science, April 11 2018.
- *Un satellite à la chasse aux exoplanètes*, René Doyon, Le Devoir, April 12 2018.
- *TESS: un nouveau chasseur d'exoplanètes à l'assaut du ciel*, Björn Benneke & René Doyon, Québec Science, April 12 2018.
- *Un chasseur de planètes part pour l'espace*, René Doyon, La Presse, April 16 2018.
- *L'Estrie contribue à un satellite de la NASA*, René Doyon & Jason Rowe, Radio-Canada, April 16 2018.
- *La NASA lance un télescope TESS pour détecter des exoplanètes*, René Doyon & Jason Rowe, Radio-Canada, April 16 2018.
- *Le satellite TESS part à la chasse aux exoplanètes lundi soir*, René Doyon & Jason Rowe, Le Soleil, April 16 2018.
- *Un peu d'Estrie dans la chasse aux exoplanètes*, Jason Rowe, La Tribune, April 18 2018.
- *À la recherche de la vie sur les exoplanètes*, René Doyon & Olivier Hernandez, Le Devoir, April 21 2018.
- *14e édition du colloque des techniciens en travaux pratiques du Québec*, René Doyon, Courrier Frontenac, April 29 2018.
- *Un chasseur d'exoplanètes à la tête du Planétarium*, Olivier Hernandez, Le Devoir, April 30 2018.
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**Jason Rowe**

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### **Antoine Darveau-Bernier**

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### **Dylan Keating**

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### **Olivia Lim**

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### **Keavin Moore**

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### **Caroline Piaulet**

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## Summer Interns

**Agnibha Banerjee** (2019)  
ISER Kolkata

**Claudia Bielecki** (2018)  
McGill University

**Simon Delisle** (NSERC Fellow, 2019)  
McGill University

**Danielle Dineen** (Trottier and NSERC Fellow, 2019)  
McMaster University

**Juliette Geoffrion** (2018)  
McGill University

**Tareq Jaouni** (2019)  
University of Ottawa

**Emilie Laflèche** (Trottier and NSERC Fellow, 2019)  
McGill University

**Evelyn Macdonald** (2018)  
McGill University

**Laurence Marcotte** (Trottier and NSERC Fellow, 2019)  
Université de Montréal

**Emily Pass** (Trottier Fellow, 2018)  
University of Waterloo

**Maryum Sayeed** (Trottier Fellow, 2018)  
University of British Columbia

**Thomas Vandal** (Trottier Fellow, 2018-2019)  
McGill University

## [...] Directory

**Youssef Bestavros** (TEPS Fellow, 2019)  
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**Sabrina D'Amour** (2018)  
Bishop's University

**Ariane Deslières** (Sureau Fellow, 2019)  
University of Ottawa

**Shereen Elaidi** (2018)  
McGill University

**Antoine Herrmann** (2019)  
Université de Paris-Sud

**Mariya Krasteva** (Trottier Fellow, 2018)  
Concordia University

**Benjamin Leblanc** (NSERC Fellow, 2018)  
Bishop's University

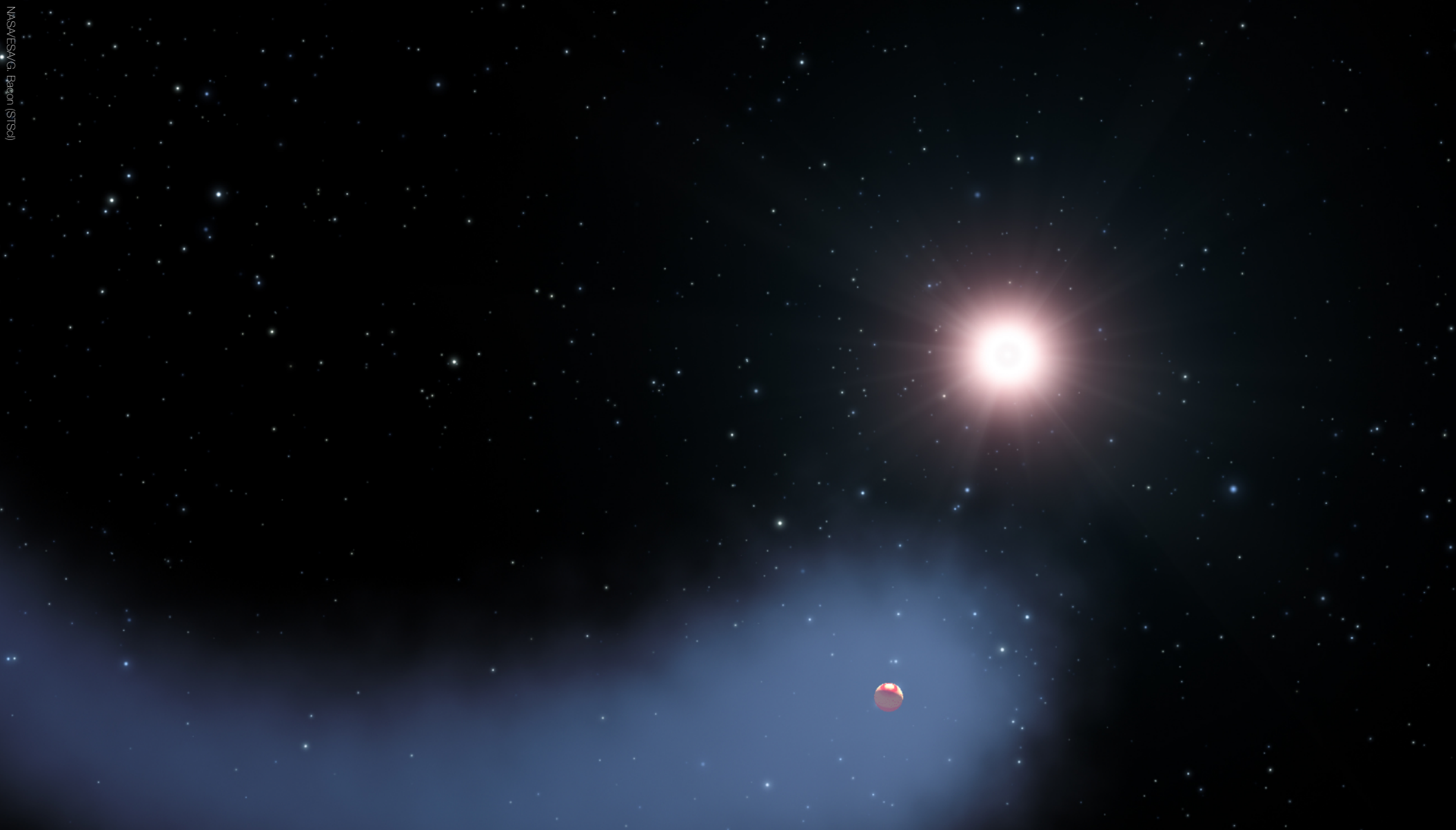
**Mathilde Malin** (2019)  
McGill University

**Mathilde Papillon** (Trottier and NSERC Fellow, 2019)  
McGill University

**Pierre-Alexis Roy** (NSERC Fellow, 2019)  
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**Jessica Speedie** (Trottier Fellow, 2018)  
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**Lan Xi Zhu** (2019)  
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