

# Institute for Research on Exoplanets



## ANNUAL REPORT

2020 - 2021



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# About the Institute

## Mission and Objectives

THE INSTITUTE FOR RESEARCH ON EXOPLANETS WAS CREATED TO  
SEARCH FOR NEW WORLDS BEYOND THE SOLAR SYSTEM AND TO ANSWER  
ONE OF THE GREATEST 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 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 a team of dynamic and motivated students who take full advantage of the major observational projects underway or to come, and to share this research through our sustained education and science communication efforts, with the ultimate goal of **finding life elsewhere in our Universe**.

# A Word from our Director

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It has been another year that no one could have predicted, filled with many challenges as well as opportunities to grow. We still had to contend with the COVID-19 pandemic, but we caught a glimpse of the light at the end of the tunnel thanks to the impressive scientific innovation required for the rapid development of vaccines. As this progressed, I have the privilege to witness my colleagues also showing great creativity in overcoming the obstacles surrounding them and continuing their research, instrumentation, and outreach work.

During the period covered by this annual report, **September 1<sup>st</sup> 2020 to August 31<sup>st</sup> 2021**, our iREx team, which was composed of a record number of members, produced more science than ever before, thanks in part to the beginning of science operations on the SPIRou instrument. The launch of the historic Webb Telescope has never felt closer following the announcement of the Canadian astronomers who will be among the first to receive time on it, a third of whom are iREx members. And online conferences and events in our communities have shown us a host of new possibilities for reaching the four corners of the world remotely.

This year was a great glance into a new world filled with innovative ways for us to better collaborate with each other and better connect with the general public. I know that next year, which will be filled with even more incredible milestones, will be even better!



René Doyon  
Director, iREx  
Professor, Université de Montréal



# The Year in Review

## IN 2020-2021...

Members of the iREx studied a variety of distant worlds and have made many discoveries that have important implications for our understanding of the formation, evolution, habitability and diversity of these exoplanets.

These worlds include the hot Neptune LTT 9779 b, the lava planet K2-141 b, the Beta Pictoris system, the "cotton candy" exoplanet WASP 107 b, super-Earths, and the dry hot Jupiter Tau Boötis b.

The SPIRou Legacy Survey has accumulated 108 nights on the Canada-France-Hawai'i Telescope in 2021, and the NIRPS team has continued preparations for its upcoming shipment and integration into the 3.6 metre telescope at La Silla. The POMM instrument is also back at the OMM.

Environmental testing of the Webb Telescope was completed and the observatory is now ready for delivery to its launch site in Kourou. The observing proposals for the telescope's first year of operations were also selected. Five of the fourteen Canadians leading selected proposals are iREx members.

# [...] The Year in Review

## IN 2020-2021...

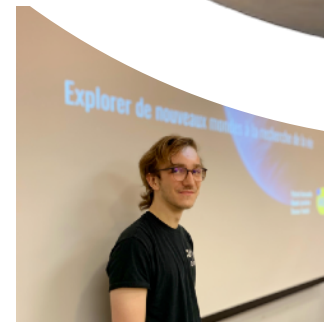
iREx researchers were involved in 108 scientific papers published in peer-reviewed journals.

iREx members participated in 17 television interviews, 77 radio interviews and 34 print and online interviews.

The size of the iREx team has reached new heights: 80 members! This includes record numbers of graduate students (34) and summer interns (21).

We reached tens of thousands of people in Quebec and internationally, in person and virtually, through 149 presentations given in primary and secondary schools, cégeps and universities, 19 public talks and 13 public events, as well as via several new content creation initiatives.

Caroline Piaulet, Ph.D. student at iREx, received several prestigious awards to highlight her academic excellence and community involvement. In total, 42% of our students were awarded scholarships and grants. The iREx also received a major NovaScience grant of \$63k from the provincial Ministry of Economy and Innovation for a new training programme for Quebec teachers on exoplanets.







# Scientific Overview

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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 exploit several different methods: **direct high-contrast imaging, high-precision infrared velocimetry** and **transit spectroscopy**.

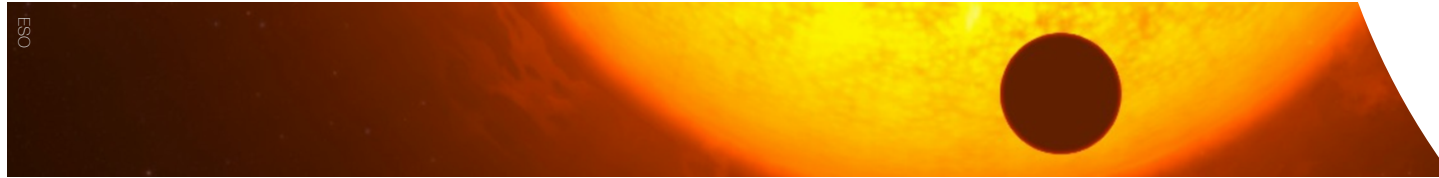
In addition to exoplanets, iREx researchers are interested in related celestial bodies such as **stars, brown dwarfs, white dwarfs, moons, comets** and **asteroids**. Several iREx members also specialise in the study of the **formation and evolution of planets** using theoretical models.

Through its collaborations with the **Laboratoire d'Astrophysique Expérimentale** (LAE) of the **Observatoire du Mont-Mégantic** (OMM), the iREx enjoys unparalleled access to 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 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.

**2020-2021 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**.

**2020-2021 Membership:** René Doyon, Sébastien Sauvé, Björn Benneke, David Lafrenière, Nathalie Ouellette, Nicolas Cowan

### Board of Governors

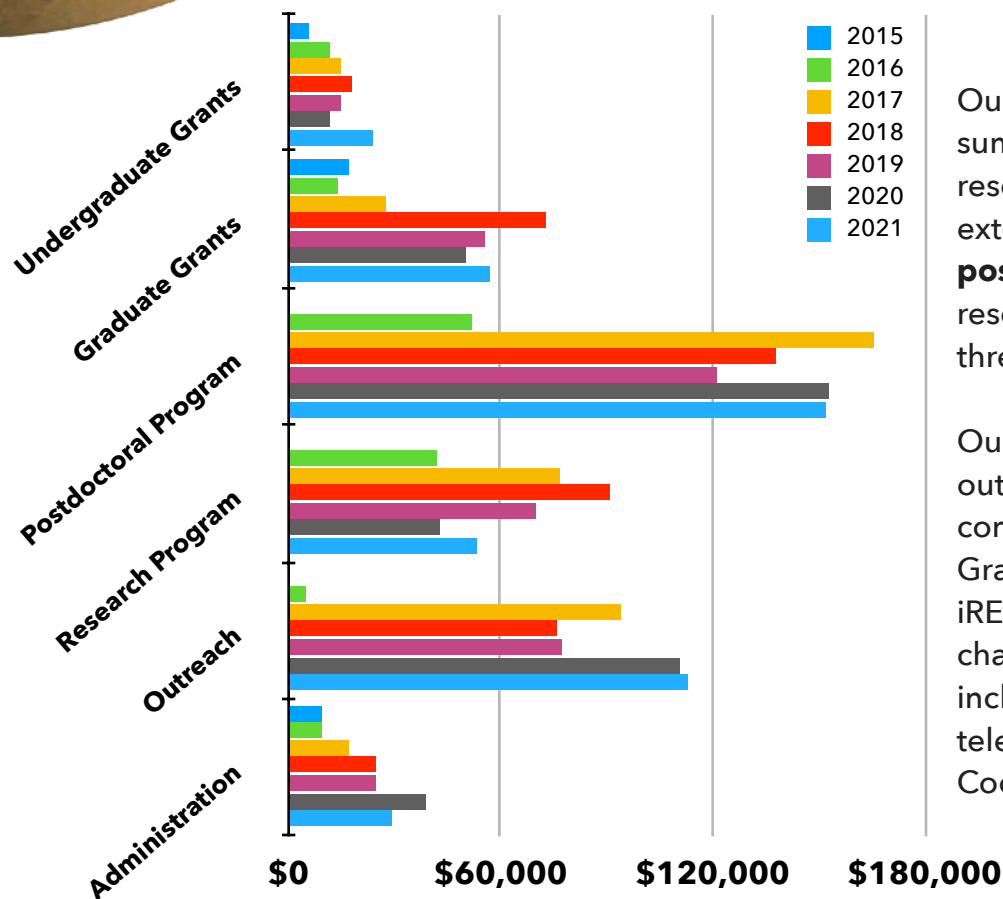
The Director of iREx is also advised by the Board of Governors on all matters related to the proper functioning of the Institute, its outreach and funding. The Governing Board is made up of **external representatives from a variety of backgrounds with an interest in iREx's fields of research**.



# 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 program** includes all of our educational and public outreach activities, including public talks and events, workshops, communications and marketing, online content and the Maunakea Graduate School. This portion of the budget, averaging **22%** of the iREx budget, also covers part of the salaries of our employees in charge of these activities. Finally, iREx **administrative costs**, which include 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

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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 NOT BE POSSIBLE.



We would like to thank



**Philippe Sureau**

**Jean-François Bertrand**

**Sylvain Lumbroso**

**Carole Kleingrib**

**Marie-Hélène Paquette**

**nos autres donateurs privés**

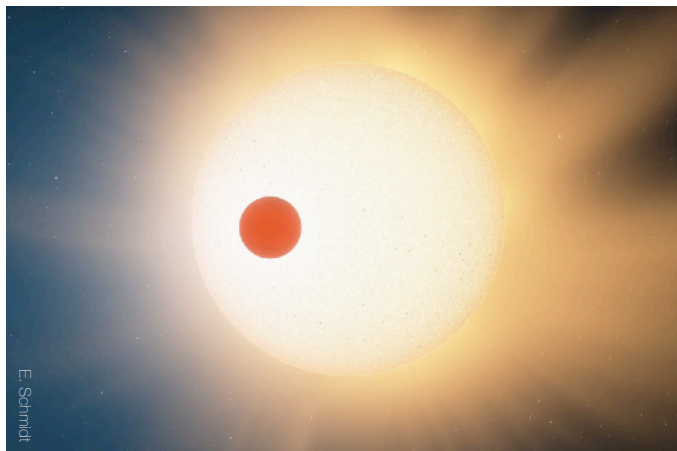
as well as our many supporters across planetary systems near and far!



# Research Highlights

## A Hot Neptune in the Spotlight

TWO iREx RESEARCHERS, **BJÖRN BENNEKE** AND **NICOLAS COWAN**, HAVE CONTRIBUTED TO TWO STUDIES USING DATA FROM THE SPITZER TELESCOPE WHICH UNVEIL MORE THAN EVER BEFORE ABOUT **LTT 9779 b**, A NEPTUNE-SIZED EXOPLANET VERY CLOSE TO ITS STAR.



The exoplanet **LTT 9779 b** was discovered in 2020 at 260 light years from Earth using the transit method. The planet is 4.6 times the size of the Earth and 29 times its mass, so it is **quite similar to the planet Neptune**. What surprised the scientific team was **its close proximity to its star**. It is 60 times closer than the Earth is to the Sun and completes an orbit in less than a day!

Because their gravity is weaker than that of planets with masses similar to Jupiter, such **“hot Neptune” type exoplanets should not exist so close to their star**. Indeed, scientists expect the intense radiation from the central star to have completely vaporised the planet’s atmosphere. These studies focusing on LTT 9779 b represent **the first observations of this type of planet**.

The iREx professors **Björn Benneke** and **Nicolas Cowan** contributed to the observing program using the now-retired Spitzer Space Telescope and to the analysis of the project data. They say that **understanding the physical and chemical processes of uninhabitable worlds like LTT 9779 b allows us to better identify potentially habitable worlds** that can be studied by future large observatories like the James Webb Space Telescope.

“Spitzer reveals evidence of molecular absorption in the atmosphere of the Hot Neptune LTT 9779 b”, D. Dragomir, I. Crossfield, [B. Benneke](#), et al., *ApJL*, 2020.

“Phase Curves of Hot Neptune LTT 9779 b suggest a high-metallicity atmosphere with nonzero albedo”, I. Crossfield, D. Dragomir, [N. Cowan](#), et al., *ApJL*, 2020.

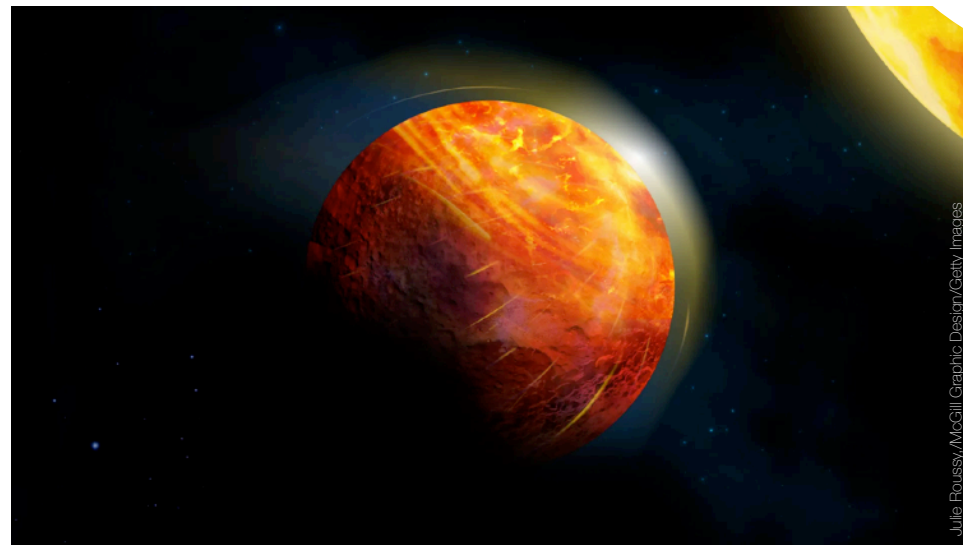
# A Lava World's Weather Conditions

ACCORDING TO A STUDY BY A TEAM THAT INCLUDES iREx MEMBER **NICOLAS COWAN**, "ROCKY" WEATHER CONDITIONS MAY BE CHANGING THE SURFACE AND ATMOSPHERE OF EXOPLANET **K2-141 b**.

Lava planets are among the most inhospitable planets in the galaxy. These glowing balls orbit so close to their host star that **part of their surface is likely covered in oceans of molten lava**. According to a scientific team led by iREx member **Nicolas Cowan** and one of his graduate students, **the atmosphere and weather cycle of one of these exoplanets, K2-141 b, are most unusual**: rock precipitations, supersonic winds blowing at up to 5000 km/h and an magma ocean 100 km deep!

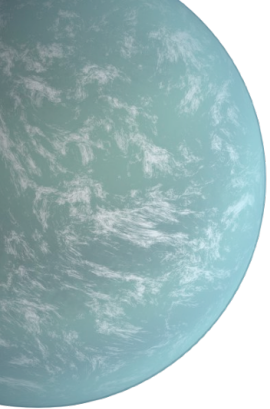
Professor Cowan's team used numerical simulations to predict the **conditions on K2-141b, an Earth-sized exoplanet** whose surface, ocean and atmosphere are

composed of the same ingredient: rocks. According to the researchers' modelling, extreme weather events on this planet could permanently alter its surface and atmosphere over time.



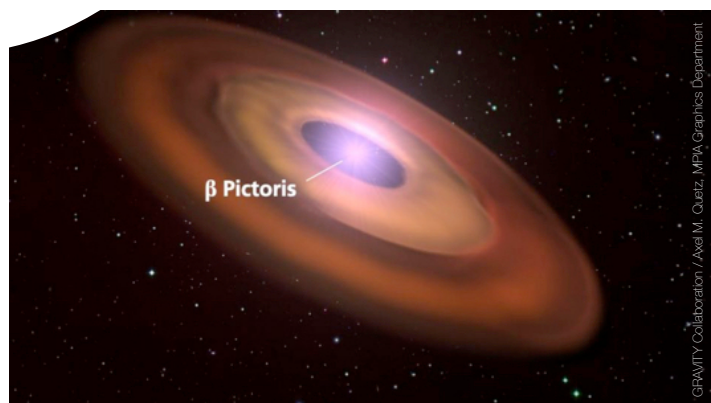
By analysing the illumination pattern of the exoplanet, the team found that **two thirds of K2-141b are permanently illuminated**. On the night side, the temperature drops below  $-200^{\circ}\text{C}$ . On the day side, **temperatures of  $3\,000^{\circ}\text{C}$**  are recorded, hot enough to melt and vaporise the rocks. This vapour can then be carried by **supersonic winds** to the night side, where it falls as "rain" **into an ocean of magma**. This study is **the first to make predictions about the weather conditions on K2-141 b**, which will be detectable from hundreds of light-years away using next-generation telescopes such as the Webb Telescope.

"Modelling the atmosphere of lava planet K2-141 b: implications for low and high resolution spectroscopy", T.G. Nguyen, [N. Cowan](#), [A. Banerjee](#), J. Moores, *MNRAS*, 2020.



# The Beta Pictoris System

RECENT WORK CARRIED OUT BY Ph.D. STUDENT **THOMAS VANDAL** AND HIS SUPERVISOR **RENÉ DOYON** HAS MADE IT POSSIBLE TO CONSTRAIN THE CHARACTERISTICS OF PLANETS AROUND THE STAR **BETA PICTORIS** USING A NEW STATISTICAL METHOD.



Located just 63 light years from the Sun, **Beta Pictoris is a star with a rich system including a disc of gas and debris and at least two giant exoplanets.** The farthest from the star, Beta Pictoris b, was **one of the first planets to be discovered using direct imaging** in 2008. The closest planet, Beta Pictoris c, was discovered in 2019 using the velocimetry method. Most recently, Beta Pictoris c was imaged directly with the GRAVITY instrument, which is located on a telescope at the European Southern Observatory in Chile.

Detecting exoplanets in the Beta Pictoris system is challenging because the central star is **much younger than our Sun** and **variable**, and its pulsations make the use of velocimetry difficult. In order not to confuse the pulsations with the signal of a planet, it is necessary to understand the star well.

This is precisely the objective of the work carried out by **Thomas Vandal**, an iREx student at UdeM under the supervision of **René Doyon**, on the Beta Pictoris system. The team used archival data from the *Antarctica Search for Transiting Extrasolar Planets* and the European Southern Observatory's HARPS instrument to model the star's activity using a **Gaussian Process**: a statistical process that makes predictions from previously obtained data. The activity of the star is typically modelled with several parameters corresponding to the physical properties of the system, which makes the calculation very complex. The process used by the authors allowed to **simplify the calculation and to constrain the masses and orbits of the planets Beta Pictoris b and c.** Combining data from several other instruments, the authors obtained **a mass of 11.7 times the mass of Jupiter for Beta Pictoris b and 8.5 times the mass of Jupiter for Beta Pictoris c**, which is similar to estimates made by other teams using different methods.

"Dynamical Mass Estimates of the  $\beta$  Pictoris Planetary System through Gaussian Process Stellar Activity Modeling", [T. Vandal](#), J. Rameau et [R. Doyon](#), *AJ*, 2020.



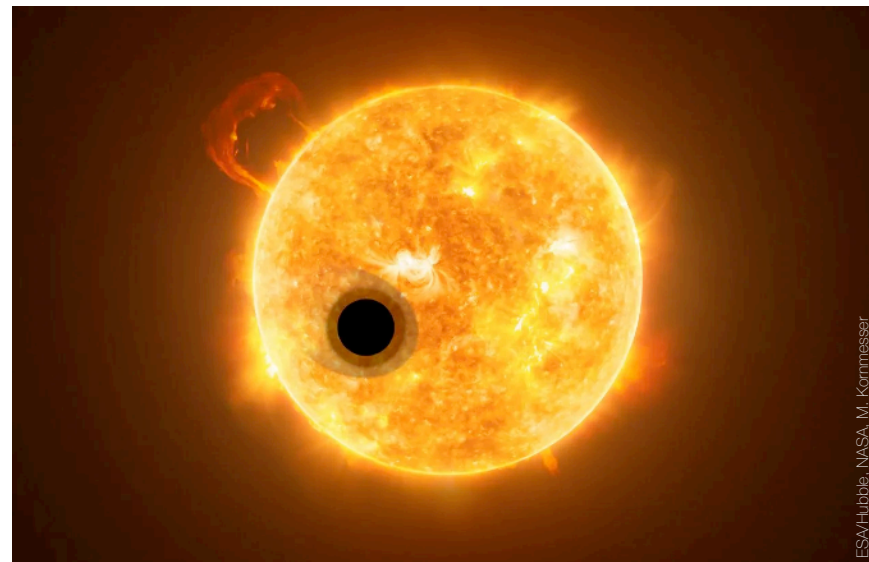
# A “Cotton Candy” Exoplanet

A TEAM LED BY **CAROLINE PIAULET** AND SEVERAL OTHER iREx MEMBERS HAS DISCOVERED THAT THE EXOPLANET **WASP-107 b** HAS A SOLID CORE THAT IS LESS MASSIVE THAN PREVIOUSLY THOUGHT NECESSARY TO FORM A GAS GIANT PLANET.

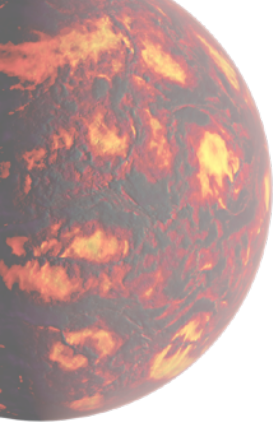
A team of astronomers led by **Caroline Piaulet**, a UdeM Ph.D. student at iREx, and her supervisor, **Björn Benneke**, also an iREx member and professor at UdeM, has found that the mass of the solid core of the **giant exoplanet WASP-107 b** is much less than previously thought necessary to build up the thick envelope of gas surrounding giant planets like Jupiter and Saturn. This intriguing discovery suggests that **gas giant planets may form much more easily than previously thought**. Published in *The Astronomical Journal*, this new analysis provides concrete evidence that massive accretion from a gas envelope can be triggered for **solid cores that are much less massive** than previous models thought necessary.

The exoplanet WASP-107 b was first detected in 2017 around WASP-107, a star located about 212 light years from Earth in the constellation Virgo. The planet is **very close to its star** – more than 16 times closer than the Earth is from the Sun. With a size similar to Jupiter and a mass about ten times lighter, **WASP-107 b is one of the least dense exoplanets known**. It is a type of planet that astrophysicists have nicknamed “**cotton candy**” or **super-puff planets**. Caroline Piaulet and her team used data on WASP-107b obtained at the W. M. Keck Observatory in Hawai‘i to estimate the planet's mass more accurately.

The team then performed an analysis to determine the most likely internal structure of the planet. With such a low density, the planet appears to have a **solid core of at most four times the mass of the Earth**. This means that more than **85% of its mass is located in the thick layer of gas that surrounds the core**. By comparison, this proportion is only 5-15% for Neptune, which has a mass similar to that of WASP-107 b.



ESA/Hubble, NASA, M. Kornmesser



## [...] A "Cotton Candy" Exoplanet

This is surprising, because according to classical models of gas giant planet formation based on Jupiter and Saturn, a solid core at least 10 times more massive than the Earth is needed to accumulate a large amount of gas before the disc dissipates. **Without a massive core, it was thought that gas giant planets could not cross the critical threshold needed to accumulate and maintain large large envelopes of gas.** For WASP-107 b, the most plausible scenario is that **the planet formed far away from the star**, where the gas in the disc is not available the star, where the gas in the disc is cold enough for accretion to occur very quickly. The planet could then have **migrated to its present position** through interactions either with the disc or with other planets in the system.



The observations of the star WASP-107 taken in Hawai'i cover a much longer period of time than previous observations, allowing the research team to make an additional discovery: **the existence of a second planet, WASP-107 c.** It is thought to have a **mass of more than a third that of Jupiter**, which is considerably more massive than WASP-107 b.

WASP-107 c is also **much further away from the central star**: it takes three years to complete a full orbit, compared with only 5.7 days for WASP-107 b. The eccentricity of this second planet is also high, which means that **its path around its star is more oval than circular.** Its large eccentricity suggests a rather **chaotic past**, with interactions

between the planets that could have led to large displacements, such as that suspected for WASP-107 b.

Another surprise from exoplanet WASP-107 b: it contains **much less methane than expected** for this type of planet. The science team must now investigate the mechanisms that could explain the destruction of methane. WASP-107 b will be **a very interesting target for the Webb Telescope** and will allow us to better understand the mechanisms of planet formation in general and the resulting variety of exoplanets.

"WASP-107b's density is even lower: a case study for the physics of gas envelope accretion and orbital migration", [C. Piaulet](#), [B. Benneke](#), [D. Thorngren](#), [M. Peterson](#), [T. Jaouani](#), et al., *AJ*, 2021.

# Mysterious Super-Earths

A STUDY BY EVE LEE REVEALING THAT SUPER-EARTHS ARE LIKELY NOT ANCIENT MINI-NEPTUNES CHALLENGES OUR KNOWLEDGE OF THEIR FORMATION.



Until recently, we believed that super-Earths were in fact the rocky cores of mini-Neptunes whose gaseous atmosphere had been blown away. Now, in a study published in *The Astrophysical Journal*, a team led by iREx member Eve Lee, a Professor at McGill University, shows that **some of these exoplanets never had a gaseous envelope**, shedding new light on their mysterious origin.

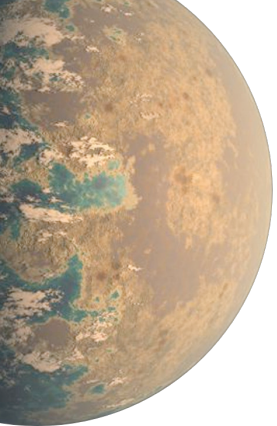
**Super-Earths and mini-Neptunes, planets up to four times the size of the Earth, make up the majority of exoplanets discovered to date.** It is theorised that most of these exoplanets begin as mini-Neptunes. radiation from the host star, and only the dense rocky cores remain in

these cases. Our galaxy would therefore have very few exoplanets the size of the Earth or smaller. However, according to the models presented in the study by the team, **some exoplanets may not be able to form a gaseous atmosphere**. This suggests that **not all super-Earths are former mini-Neptunes**. Rather, exoplanets may have arisen from **a single distribution of rocks** in a disc of gas and dust rotating around the host star. In some cases, a gaseous layer would have formed around the rocky cluster, but in others, the rocky mass would have shed its atmosphere and remained a super-Earth.

Scientists believe that planets are born in a disc of gas and dust rotating around a star. Rocky clusters larger than the Moon would have enough gravitational pull to attract the surrounding gases, which would form the planet's atmosphere. It would be **the ability of these rocky masses to grow and retain their gaseous shells that would distinguish a super-Earth from a mini-Neptune**. The study's findings shed light on **the origin of the two populations of exoplanets** and, perhaps, on their abundance.

"Primordial Radius Gap and Potentially Broad Core Mass Distributions of Super-Earths and Sub-Neptunes ", [E. Lee, et al., ApJ, 2021.](#)





# No Water on Tau Boötis b

A TEAM LED BY **STEFAN PELLETIER** HAS MEASURED THE COMPOSITION OF THE ATMOSPHERE OF A HOT JUPITER-LIKE EXOPLANET CALLED **TAU BOÖTIS b**, PROVIDING A BETTER UNDERSTANDING OF THESE GIANT PLANETS.

Using the **SPIRou** instrument, a team led by iREx and UdeM Ph.D. student **Stefan Pelletier** has studied the atmosphere of the gas giant exoplanet **Tau Boötis b**, a hot world that takes just three days to orbit its host star. Located only 51 light years from Earth, it is a planet that is six times more massive than Jupiter and eight times closer to its host star than Mercury is to the Sun.

A detailed study published in *The Astronomical Journal* shows that the atmosphere of the gaseous planet contains carbon monoxide, as expected, but **did not identify any water**. Assuming that the star Tau Boötis formed in an environment similar to that of our Solar System in its early days, the models show that water vapour should be present in large quantities in the atmosphere of Tau Boötis b and therefore be easily detectable by SPIRou. Convinced of the veracity of their results, the team looked for formation mechanisms that could



explain this excess of carbon monoxide and lack of water.

Hot Jupiters like Tau Boötis b offer an unprecedented opportunity to **analyse the formation of giant planets**. The key to revealing where and how giant planets formed lies in the molecular composition of their atmospheres. Some molecules, such as water, are frozen and hidden in the depths of their atmosphere. We therefore know very little about their abundance. The study of hot Jupiters allows us to better understand our own giant planets. The small amount of water on Tau Boötis b, for example, could mean that **Jupiter is also drier than we previously thought**.

“Where is the Water? Jupiter-like C/H ratio but strong H<sub>2</sub>O depletion found on Tau Boötis b using SPIRou”, [S. Pelletier](#), [B. Benneke](#), [A. Darveau-Bernier](#), [A. Boucher](#), [N.J. Cook](#), [C. Piaulet](#), [L.-P. Coulombe](#), [É. Artigau](#), [D. Lafrenière](#), [S. Delisle](#), [R. Allart](#), [R. Doyon](#), [C. Cadieux](#), [T. Vandal](#), et al., *AJ*, 2021.

# Observatoire du Mont-Mégantic

THE **OMM** IS A UNIQUE RESEARCH FACILITY WHERE FUTURE ASTRONOMERS CAN BE TRAINED TO USE A TELESCOPE. ITS **LABORATOIRE D'ASTROPHYSIQUE EXPÉRIMENTALE** IS A UNIQUE DESIGN FACILITY FOR INSTRUMENTS SUCH AS **SPIRou** AND **NIRPS** DEVELOPED FOR INTERNATIONAL TELESCOPES.



The **POMM polarimeter** returned to the OMM to resume its operations at the end of 2020 after a four-year absence. After an engineering mission, POMM was able to **continue on to its scientific activities in May 2021** for the benefit of several researchers at the Université de Montréal, McGill University, and the University of New Brunswick. POMM is an instrument of choice for the observation of exoplanets, stars, brown dwarfs, debris discs, comets, and for the study of the polarisation of the interstellar medium.

The **SpectroPolarimètre InfraRouge (SPIRou)** instrument was designed to study the magnetic fields of stellar systems and to detect Earth-like exoplanets. It has been in operation at the **Canada-France-Hawai'i Telescope (CFHT)** since 2018. During 2020-2021, several iREx researchers obtained **observing time on the instrument**. The **SPIRou Legacy Survey**

alone obtained **108 nights of observations**, which represents one third of nights with good weather at the CFHT. In addition, numerous scientific papers based on SPIRou data have been published, including **an impressive observation of the young AU Mic system**.

SPIRou's sister instrument, the **Near-Infrared Planet Searcher (NIRPS)**, which will be installed on the **European Southern Observatory's 3.6m telescope in La Silla, Chile**, underwent **several thermal cycles** in preparation for the start of its science operations next year. Members of the OMM's Laboratoire d'astrophysique expérimentale and their partners at the Université Laval, the Geneva Observatory, the National Research Council of Canada and several other institutions have continued **preparations for NIRPS's grand voyage to Chile**.

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

# Webb Telescope

THE TESTING PHASE OF THE **WEBB TELESCOPE** WAS FINALLY COMPLETED IN THE SUMMER OF 2021, AND THE GENERAL OBSERVER PROGRAMS FOR THE FIRST YEAR OF THE TELESCOPE'S OPERATIONS HAVE BEEN SELECTED. **FIVE iREx RESEARCHERS** ARE AMONG THE FOURTEEN CANADIANS WHO WILL LEAD SELECTED CYCLE 1 OBSERVING PROGRAMS.

After more than two decades of twists and turns, challenges and successes, **the James Webb Space Telescope finally completed its battery of tests** designed to ensure that it will survive its journey into space in August 2021. The tests, aimed at ensuring the observatory and its many redundant systems will function flawlessly once in orbit, included **the complete and successful extension of its massive sunshield.**

that The Webb Telescope will be spending its final weeks before its maritime voyage to **Kourou in French Guiana** from where it will launch on an **Ariane 5 rocket** in a clean room at Northrop Grumman in California, in its stowed configuration,.



The deadline for submitting telescope time proposals for observing time for the first year of operations under the Webb General Observers (GO) program was November 24<sup>th</sup> 2020. The international community submitted a total of **1173 proposals for approximately 24 500 hours of observing time**, which is more than four times the number of hours available for these projects.

A committee of astronomy experts **selected 266 proposals** from all those received. **Fourteen Canadian-led proposals were selected** for the Cycle 1 GO program, in addition to numerous other proposals on which astronomers based in Canada collaborated. **Five iREx researchers led successful proposals: Loïc Albert, Lisa Dang, Olivia Lim, Stefan Pelletier and James Sikora.**



# Team

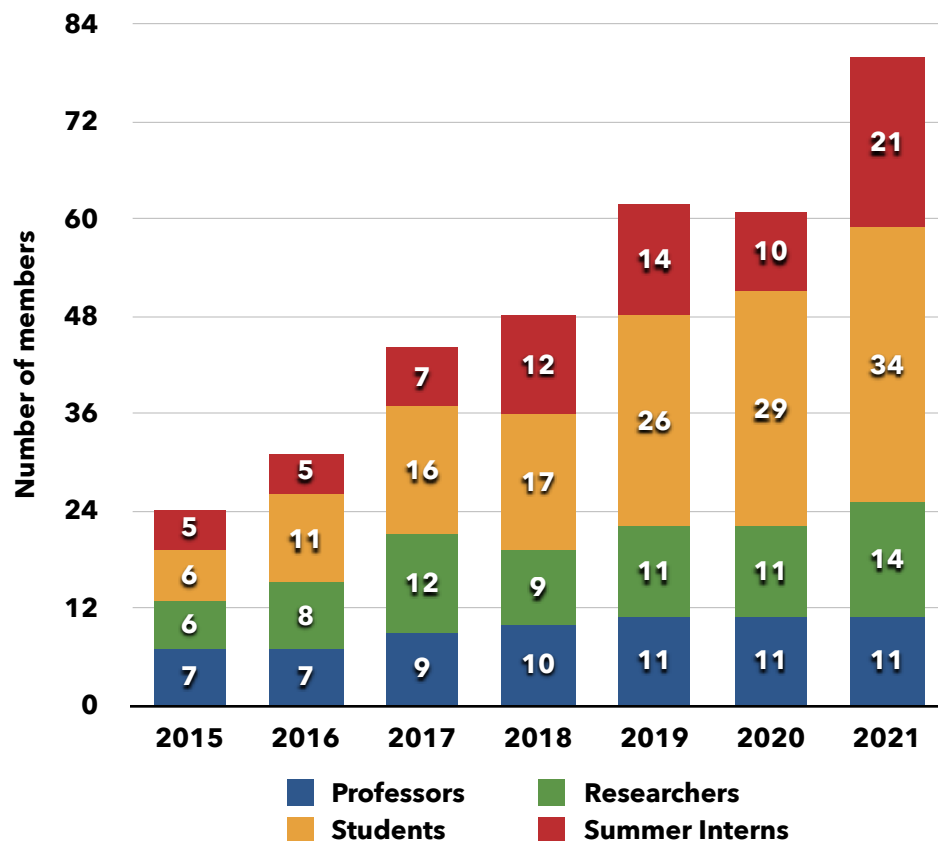
THE iREx TEAM CONSISTS OF UNDERGRAD AND GRADUATE STUDENTS, POSTDOCTORAL AND SENIOR RESEARCHERS, AND PROFESSORS. OUR MEMBERS ARE SPREAD ACROSS THE **UNIVERSITÉ DE MONTRÉAL**, **McGILL UNIVERSITY**, **BISHOP'S UNIVERSITY**, THE **UNIVERSITÉ LAVAL** AND THE **RIO TINTO ALCAN PLANETARIUM** IN MONTREAL.

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



# 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 AND RESEARCHERS. OUR NUMBER OF TEAM MEMBERS EVEN REACHED **NEW HEIGHTS** IN 2020-2021.



Several new students and a few new postdoctoral researchers joined our team in 2020-2021. In addition, we welcomed (virtually) 21 interns during the summer 2021 session.

By the summer of 2021, the iREx had **80 members: a record number** since the Institute's beginnings! This feat is even more impressive given that it was achieved during the COVID-19 pandemic.

The total number of iREx members fluctuates each year as team members come and go, but **our research network continues to grow** as our students and researchers move on after their stay with us.

# Changes in our Team

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THE STRENGTH OF iREx LIES IN THE QUALITY OF ITS TEAM, WHICH INCLUDES RESEARCHERS WHO ARE PURSUING CAREERS ALL OVER THE GLOBE. IN 2020-2021, WE WELCOMED **SEVERAL NEW STUDENTS AND RESEARCHERS.**



**Romain Allart** is the **2020 Trottier Postdoctoral Fellow at the Université de Montréal**. He obtained his Ph.D. at the University of Geneva. He is interested in the atmosphere of exoplanets and their formation and evolution. Romain is a specialist in data extraction using high precision spectrographs such as ESPRESSO and SPIRou.



**Amy Steele** is a **postdoctoral researcher at McGill University** since the summer of 2021. She is interested in the circumstellar matter of stars at different stages of their evolution. Prior to coming to Montreal, she completed her Ph.D. in 2020 at the University of Maryland, and she worked at the Space Telescope Science Institute, where she studied white dwarfs that have circumstellar gas.



**Jake Taylor** is a **NEAT postdoctoral researcher** who started in the summer of 2021 at the **Université de Montréal**. Previously, he completed a Ph.D. in atmospheric and planetary physics at Oxford University in the United Kingdom. He is interested in studying the atmosphere of exoplanets and is now a member of the Webb team.



## [...] Changes in our Team

**Mohamad Ali-Dib**, the **2018 Trottier Postdoctoral Fellow**, left us in October 2020 to pursue his research career at the Center for Astro, Particle and Planetary Physics at NYU Abu Dhabi in the United Arab Emirates. During his time in Montreal, he was particularly interested in the origin and evolution of super-Earths. He emphasises that working with iREx researchers, who have extensive observational experience, has allowed him to develop skills that are complementary to those he already has.



**Neil Cook**, who joined the iREx in September 2017 as a **Trottier Postdoctoral Fellow**, became a **Research Associate** at the **Université de Montréal** in September 2021. He will therefore be able to continue his essential role in the team, notably in the processing of data obtained with the SPIRou and NIRPS instruments. He is also a member of the Webb Telescope team.



Congratulations to **Thomas Vandal**, **Frédéric Genest**, **Déreck-Alexandre Lizotte**, **Simon Delisle**, **Pierre-Alexis Roy**, and **Louis-Philippe Coulombe**, who advanced to the doctorate program this year. They are all continuing on with their supervisors at the same university, with René Doyon (UdeM) for Thomas, David Lafrenière (UdeM) for Frédéric, Björn Benneke (UdeM) for Simon, Louis-Philippe and Pierre-Alexis, and Jason Rowe (Bishop's) for Déreck-Alexandre. Congratulations also to **Merrin Peterson**, who completed her M.Sc. degree in the spring of 2021 under the supervision of Björn Benneke (UdeM), and **Taylor Bell**, who completed his Ph.D. in the summer of 2021 under the supervision of Nicolas Cowan (McGill).

Welcome to our new graduate students: **Ariane Deslières**, **William Frost** and **André Beaudoin** (M.Sc., René Doyon, UdeM), **Margaret Bruna** (M.Sc., Nicolas Cowan, McGill) and **Pierrot-Baptiste Lemée-Jolicoeur** (M.Sc., David Lafrenière, UdeM).

# Awards and Grants

SEVERAL iREx MEMBERS RECEIVED **AWARDS AND GRANTS** IN 2020-2021. IN ADDITION, THE iREx RECEIVED PROVINCIAL FUNDING TO INTRODUCE EXOPLANETS TO PRIMARY AND SECONDARY SCHOOL CLASSROOMS IN QUÉBEC.

**Caroline Piaulet**, a doctoral student at the UdeM, is one of the winners of the prestigious **NSERC Vanier Scholarships**. Her research projects focus on the study of exoplanets of intermediate size between that of Earth and Neptune. This prestigious award recognises **her academic excellence, research potential and leadership skills**.

Caroline also distinguishes herself by her **sustained commitment to science communication**. In particular, she is involved in the **ExoBouchées** project and has conceived and developed the **Initiascience** project with a team of graduate students from several institutions. Caroline is also committed to issues of equity, diversity and inclusion, being a member of the Physics Department's diversity committee (D-PHY). In the spring, she was awarded an **engagement scholarship from the Faculté des arts et des sciences at the Université de Montréal**.

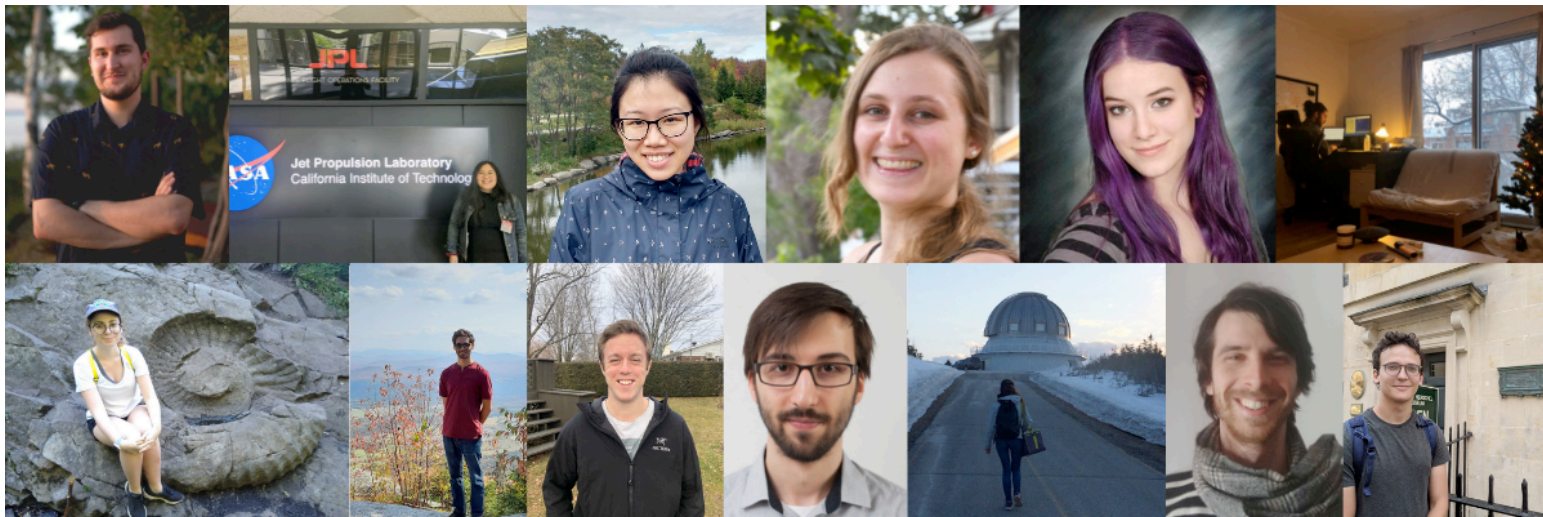


**Nathalie Ouellette**, astrophysicist and Coordinator of the iREx, is the winner of the **2021 Rector's Prize at the Université de Montréal**, in the **Initiative** category. This award recognises the **imagination, dynamism and creativity** of a member of the UdeM community. Nathalie has distinguished herself since she took up her position in 2018 by her passion, dedication and leadership within the iREx team, and has since positioned herself as one of UdeM's great ambassadors.



## [...] Awards and Grants

An educational initiative of the iREx outreach team led by **Marie-Eve Naud**, our Education and Public Outreach Coordinator, was a **\$63,000 NovaScience grant from the ministère de l'Économie et de l'Innovation** for 2 years. Thanks to this grant, the iREx and its partners are developing new educational resources as part of the project ***Les exoplanètes: des nouveaux mondes à découvrir, au primaire et au secondaire***. iREx's partners for this venture are Discover the Universe, École en réseau, the Association pour l'enseignement de la science de la technologie au Québec and several Quebec schools that will allow the team to develop and test educational resources on exoplanets in their classrooms.



In 2020-2021, **9 of our summer interns, 4 of our M.Sc. students and 10 of our Ph.D. students benefited from government or institutional scholarships.** For a full list of recipients, please see our directory at the end of this report.



## Public Events

**HEALTH MEASURES IN PLACE CONTINUED TO LIMIT GATHERINGS, BUT SEVERAL iREx MEMBERS STILL MANAGED TO ORGANISE ACTIVITIES TO ENCOURAGE THE PUBLIC TO LOOK AT THE SKY THIS YEAR.**

In **December 2020**, the iREx took part in one of the Discover the Universe program's initiatives, the **Look Up Challenge**. Throughout the challenge, which took place over the holiday season, children and their families were invited to make **a dozen astronomical observations**. The proposed observations included phases of the Moon, constellations, and the planets of our Solar System. **Nathalie Ouellette, Marie-Eve Naud and Frédérique Baron recorded short video clips in English and French, discussing each observation**. Many astronomy enthusiasts of all ages expressed their appreciation for the activity, which allowed them to spend quality time with their families and reconnect with the beauty of the sky and nature.



A **solar eclipse** (which was partial in the South of Quebec) took place on the morning of **June 10<sup>th</sup> 2021** in North America. iREx members found several creative ways to publicise this event, and to ensure that young and old alike could enjoy this unique spectacle. The iREx participated in the **distribution of over 4000 free sun filters through Montréal's municipal libraries and the UdeM's libraries**, thanks to a partnership with the Rio Tinto Alcan Planetarium, the CRAQ, and the Société d'astronomie du Planétarium de Montréal. The iREx also participated in the **Eclipse Challenge**, an initiative of Discover the Universe, which invited several players of the scientific communication community to propose safe ways to observe the eclipse indirectly. To this end, our **summer interns Maude Larivière and Sarah Thiele** recorded short educational videos.

# Virtual Events

THROUGHOUT THE YEAR 2020-2021, iREx CONTINUED TO ORGANISE AND PARTICIPATE IN NUMEROUS **VIRTUAL EVENTS** TO REACH ITS TARGET AUDIENCES ALL OVER QUEBEC AND CANADA.



**La petite école de l'espace** is a series of live YouTube shows for children aged 3 to 8. This initiative was born out of a desire to reach families during the COVID-19 pandemic. Between July 2020 and May 2021, five editions took place, accumulating nearly **50,000 views** in total. Each edition lasts about 30 minutes and features astrophysicists **Frédérique Baron** and **Marie-Eve Naud** and their guests, who tell stories related to astronomy, play space games and answer children's questions about the Universe, sent ahead of time by families. Children are also invited to take part in observational challenges and send in artwork that shows what they have learned. More than **a hundred entries were received for each show!**



The concept of **La petite école de l'espace** and the elements that contributed to its success were presented by the astrophysicists to their colleagues at the **Astronomical Society of the Pacific's annual meeting** which had the theme of "Embracing the Future: Astronomy Teaching and Public Engagement", as well as at **Canadian Astronomical Society's annual meeting**.

For slightly older children, the iREx also hosted three episodes of a **bilingual series** called the **Cosmic Club**. This online program for 8 to 12 year olds and their families is hosted by **Nathalie Ouellette** in collaboration with Plateau Astro. The hosts discussed astronomical topics and then invited young people to participate in **observation challenges in the form of a celestial scavenger hunt**. More than **a hundred families participated in these activities** during the first half of 2021.





## [...] Virtual Events

The **Grandes conférences de l'iREx** allow a **world-class researcher to visit the iREx** to interact with its members and present their research **and their story to the general public**. Since 2016, we have hosted, among others, David Charbonneau (Harvard) and Vicky Meadows (U of Washington).

For this year's edition, the Institute was pleased to welcome (virtually) **Clara Sousa-Silva** on **November 10<sup>th</sup> 2020**. On that evening, nearly **200 people tuned in live** to hear her presentation entitled "**Finding an Alien Biosphere... on Venus?**". The lecture is still available on the iREx YouTube channel. Clara Sousa-Silva, a postdoctoral researcher at Harvard University, is a quantum astrochemist interested in the habitability and biosignatures of planets. She is part of the team that discovered a possible phosphine signal in the atmosphere of Venus.



On **February 10<sup>th</sup> 2021**, the **Soirée d'initiation à la recherche en astrophysique** at the Université de Montréal, organised by iREx in collaboration with the UdeM Physics Department and the CRAQ, was held. The objective of this virtual evening was to introduce cégep students to the career path and reality of astrophysics researchers. **Marie-Eve Naud** and **Frédérique Baron**, two iREx astrophysicists, hosted the event. iREx graduate students **Olivia Lim** and **Myriam Prasow-Émond** were among the students who spoke about their research projects, their daily lives and their career paths to over **230 cégep students who attended the event**.



# [...] Virtual Events



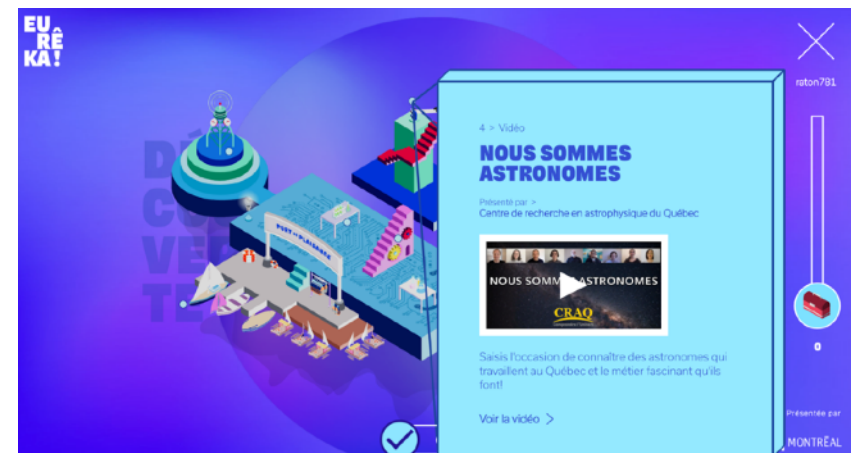
As part of the **24 heures de science**, the iREx, in collaboration with the Centre de recherche en astrophysique du Québec (CRAQ) and the Observatoire du Mont-Mégantic, proposed the activity "**Astronomer in your virtual classroom**".

During the week of **May 3<sup>rd</sup> 2021**, 11 astronomers, including **Frédérique Baron, Nathalie Ouellette, Marie-Eve Naud** and **Charles Cadieux** from iREx, visited **50 primary school classes** in Quebec, from grade 1 to grade 6, via videoconference, meeting with close to **1300 students!**

As the theme of this year's 24 heures de science was "Unusual Science", they talked about all the strange, bizarre and surprising aspects of our Universe, and answered the children's many questions about space.

In 2021, the **Eurêka! Festival**, which attracted over 100,000 people to the Old Port of Montreal before the pandemic, moved online. Several iREx astronomers participated in an initiative of the Centre de recherche en astrophysique du Québec, which led to the creation of the **video "Nous sommes astronomes"** (We are astronomers), to **raise awareness of the profession among youth**.

**Loïc Albert, Marie-Eve Naud, Caroline Piaulet** and **Thomas Vandal** answered questions such as "What do astronomers study?", "What do you like most about your job?", and "What got you interested in astronomy? This video is available on the digital platform "The Eurêka Virtual Archipelago", where several other players in the education and outreach community have shared resources suited for the whole family.





# Content Creation

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WITH THE GROWTH OF ITS EDUCATIONAL PROGRAM, THE iREx EMBARKED IN SEVERAL **CONTENT CREATION** INITIATIVES IN 2020 TO PRODUCE ENDURING RESOURCES THAT CAN BE USED BY STUDENTS, EDUCATORS AND THE GENERAL PUBLIC TO LEARN MORE ABOUT EXOPLANETS.

## Des exoplanètes à l'école



The "**Des exoplanètes à l'école – des nouveaux mondes à découvrir, au primaire et au secondaire**" project was launched in February 2021. This project, led by iREx at the UdeM, in collaboration with numerous partners and key players from the education community, is financed by the ministère de l'Économie et de l'Innovation's **NovaScience program**. It consists of the **creation of educational resources on exoplanets and the search for life for school personnel working at the primary and secondary levels** (teachers, pedagogical advisors, technicians in practical work), **in Quebec schools**.

Starting in spring 2021, several **co-creation workshops were held with some thirty school staff members** to better identify their needs and constraints. An **educator community was created on Facebook** to allow regular exchanges on different topics. During the summer, **activities and materials were drafted for the primary and secondary levels**. At the end of the summer, a **second round of co-creation workshops** were held with eight teachers from primary and secondary schools, to work more concretely on these drafts.

The activities we are working on include a night sky observation challenge, a scale model of our Solar System and other planetary systems, an invitation to invent a planetary system, an interactive activity on types of exoplanets and another on the possibility of extraterrestrial life. The next steps will be to test these activities with teachers and their students.

# [...] Content Creation



In the winter of 2020, the iREx was awarded a **DIALOGUE - Volet Chercheur** grant by the Fonds de recherche du Québec. The iREx team, led by our coordinator **Nathalie Ouellette**, science communicator **Frédérique Baron** and communications intern and doctoral student **Caroline Piaulet**, created the **ExoBites videos**: a series of short videos in French with English subtitles that feature our researchers talking about exoplanets and astronomy.

In 2020-2021, three ExoBouchées were released: 1) **An Exoplanet Zoo**, 2) **Earth 2.0**, and 3) **Alien Life**. These three episodes, available on our YouTube channel and shared by several of our partners, have already accumulated more than **61,000 views** and many very positive comments. They will also serve as excellent resources for our members to use in classrooms and with the general public.

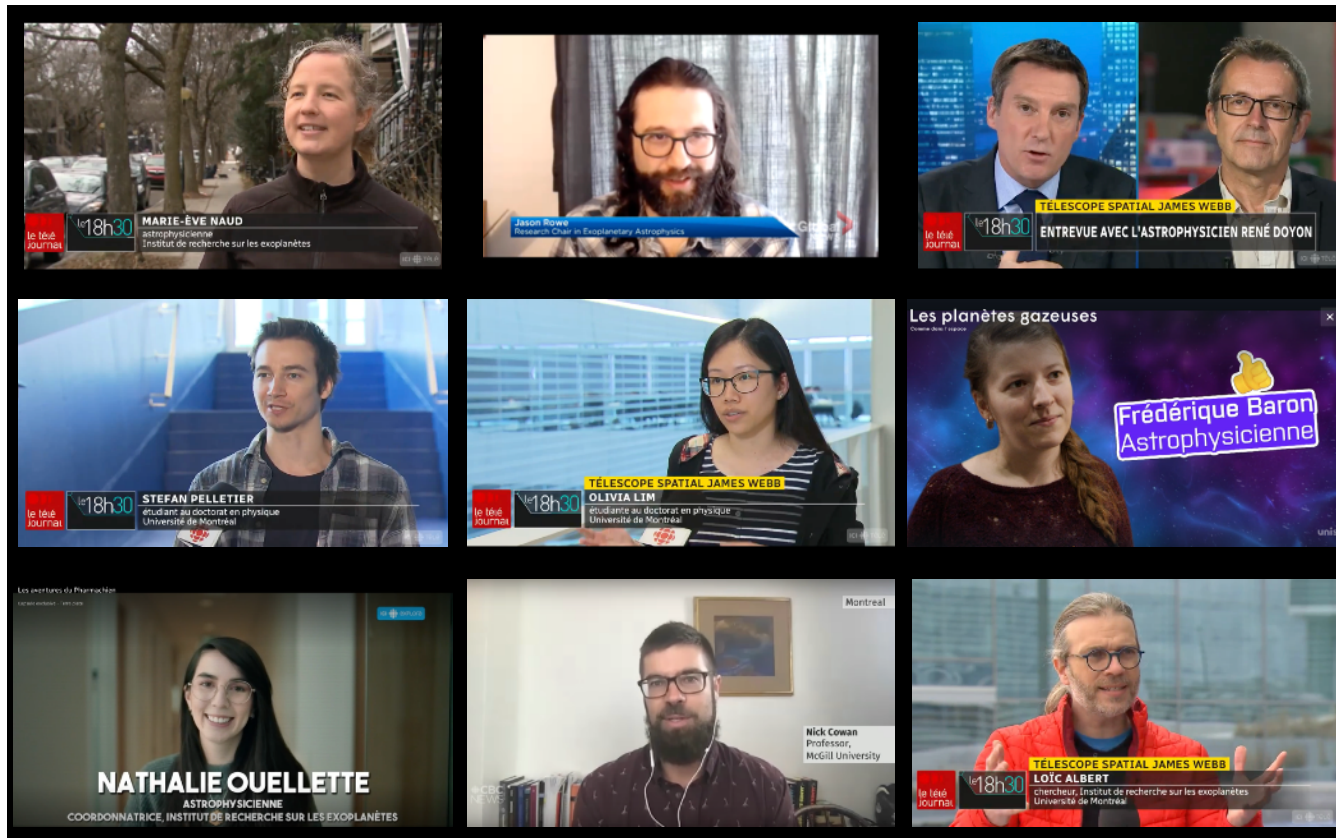


In March 2021, **Frédérique Baron** and **Nathalie Ouellette**, two iREx astrophysicists, broadcast the very first episode of their **podcast "Les astrophysiciennes"**, a project carried out thanks to the support of the Bibliothèque des sciences of the campus MIL's Complexe des sciences at the UdeM. During each episode, which lasts between 20 minutes and 1 hour, they explore different facets of astrophysics research in an informal and entertaining way with their guests. They discuss the past, present and future of astronomy, stargazing with UdeM and iREx astronomer **Lison Malo**, eclipses with Rio Tinto Alcan Planetarium eclipse chaser Marc Jobin, and the Perseids meteor shower.



# In the News

iREx MEMBERS HAVE SEEN A RENEWED INTEREST IN THEIR RESEARCH AND ASTRONOMY **IN THE NEWS** DUE TO, AMONG OTHER THINGS, THE INCREASED POSSIBILITY OF DOING REMOTE INTERVIEWS AND THE ACHIEVEMENT OF MAJOR MILESTONES FOR SEVERAL LARGE PROJECTS INVOLVING THE INSTITUTE SUCH AS THE WEBB SPACE TELESCOPE.



In 2020-2021, iREx members participated in **17 television interviews, 77 radio interviews and 34 print and online interviews.**

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

# Social Media

THE iREx's **ONLINE PRESENCE** CONTINUED TO EXPLODE IN 2020-2021, PARTICULARLY ON OUR YOUTUBE CHANNEL WHERE MUCH NEW CONTENT WAS PUBLISHED.

Our subscribers on all our online platforms are more numerous than ever, and we relaunched our YouTube channel. **Our number of Facebook followers, website visits and newsletter subscribers have all nearly doubled** since last year. Moreover, **with the addition of several series of shows, videos and live events on our YouTube channel, our subscriber base on that platform has increased by more than a factor of 10!**

## As of August 31<sup>st</sup> 2021, the iREx had

4334 followers  
Facebook



@iRExoplanetes

1103 followers  
Twitter



@iExoplanets

110 478 hits  
Website



[www.exoplanetes.ca](http://www.exoplanetes.ca)

2017 subscribers  
Newsletter



[irex@astro.umontreal.ca](mailto:irex@astro.umontreal.ca)

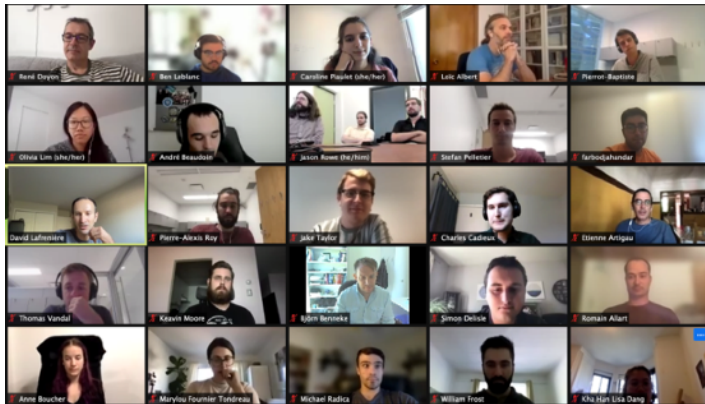
2090 subscribers  
YouTube



[/exoplanetes](https://www.youtube.com/exoplanetes)

## Cafés iREx

**THE CAFÉS iREx ARE WEEKLY MEETINGS THAT ALLOW iREx MEMBERS TO DISCUSS NEWS IN THE FIELD OF EXOPLANETS OR TO PRESENT THEIR LATEST SCIENTIFIC RESULTS. THE CAFÉS REMAINED VIRTUAL IN 2020-2021.**



Each week, iREx members meet to **discuss the latest news from the world of exoplanets**, astronomical instrumentation and more broadly astronomy. Given the health measures in place for the COVID-19 pandemic in 2020-2021, **our meetings continued in a virtual format.**

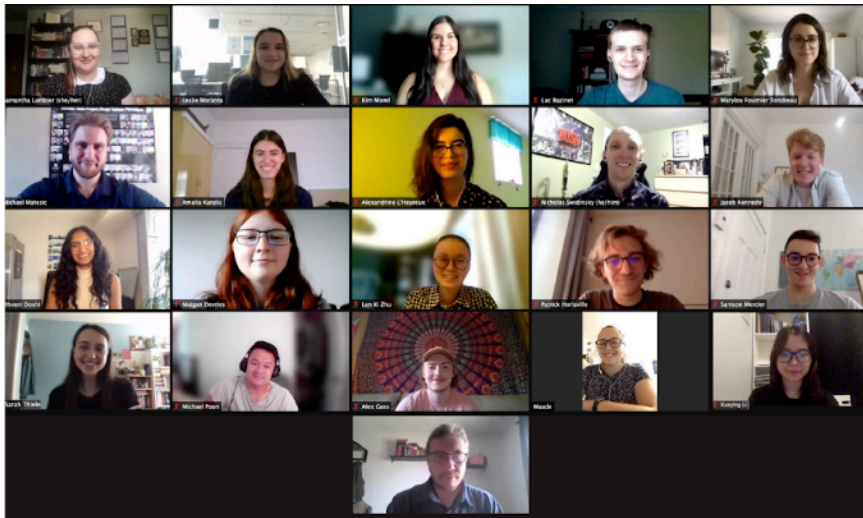
Our **Cafés iREx** take several formats depending on our needs: presentations with visual aids, round table discussions or question and answer sessions. We also often welcome internationally renowned researchers. These meetings allow our members, especially our students, to interact with experienced researchers in a more informal setting.

In 2020-2021, in addition to presentations by iREx members, some Cafés were dedicated to **seminars or online conferences organised by other institutes** elsewhere in the world on exoplanet-related topics. We also organised a few **sessions on equity, diversity and inclusion**, featuring invited experts or group video viewing, as well as **mini-workshops** on topics such as science communication.



# Summer Internships

WE HAVE WELCOMED **SUMMER INTERNS** SINCE THE iREx WAS FOUNDED. THE EXCITEMENT AND DYNAMISM OF THE INSTITUTE, AS WELL AS OUR PRESTIGIOUS TROTTIER EXCELLENCE GRANTS COMPETITION, ATTRACT UNDERGRADUATE STUDENTS FROM ACROSS THE COUNTRY TO COME WORK WITH OUR RESEARCHER



In the **summer of 2021**, a **record number of interns joined our team: 21!** Of these, **eight were Trottier Fellows**. Once again this year, most of the work had to be done remotely, due to the constraints of the COVID-19 pandemic. However, our trainees were able to take advantage of an orientation day at the beginning of the summer, weekly intern meetings and weekly Cafés iREx, and they presented their results during the final virtual presentation in August.

They also had many opportunities to **participate in our education and public outreach initiatives**, including **creating educational videos about the June 10<sup>th</sup> eclipse** or **giving presentations to high school students** during the Séjours d'immersion organised by our partner Cap Campus of the Université de Montréal.

# EDI Committee

THE MISSION OF THE **iREx EQUITY, DIVERSITY AND INCLUSION (EDI) COMMITTEE** IS TO PROMOTE THE PROFESSIONAL INTEGRATION WITHIN iREx OF PEOPLE FROM GROUPS THAT ARE TRADITIONALLY UNDER-REPRESENTED IN PHYSICS, TO HELP INCREASE THE SCIENTIFIC PROSPERITY OF AN INCLUSIVE iREx THAT IS PROUD OF ITS DIVERSITY.



The iREx **EDI Committee** was created to:

- increase efforts to recruit people from under-represented groups at all levels of education and employment,
- to promote the integration and retention of these people within the iREx,
- and to promote diversity in science through the iREx.

Since its creation in February 2018, the committee members and all iREx members have learned a lot about EDI issues through various **trainings, presentations and discussions**. This has significantly affecting our recruitment strategies, our interactions with each other and with our partners, as well as our youth education and public outreach activities.

One of the issues we worked on in 2020-2021 is the **creation of a self-identification form** for our members and for applicants for summer intern and postdoctoral positions. We are also working in **collaboration with other committees with similar objectives**, within the Physics Department at the UdeM, at McGill University and at the CRAQ, in order to achieve change on a larger scale.

**2020-2021 Membership:** Étienne Artigau, Frédérique Baron, David Lafrenière, Marie-Eve Naud, Nathalie Ouellette, Michael Radica.

### School & Library Presentations

- *Being an Astronomer*, Nathalie Ouellette, Exploring by the Seat of your Pants, 1 September 2020.
- *Build your own Galaxy*, Nathalie Ouellette, Morrin Culturel Centre, 8 September 2020.
- *Exploring the Universe*, Nathalie Ouellette, Skype a Scientist, 1 October 2020, 14 October 2020, 29 October 2020, 30 October 2020, 20 January 2021, 21 January 2021, 8 February 2021, 11 February 2021, 22 February 2021, 11 March 2021, 16 March 2021, 30 March 2021.
- *Dévoiler l'Univers avec le télescope Webb*, Nathalie Ouellette, Exploring by the Seat of your Pants, 8 October 2020.
- *Profession: astronome*, Lison Malo, École secondaire Saint-Stanislas, 12 October 2020.
- *Les exoplanètes et l'astronomie*, David Lafrenière, École St-Jean-de-la-Lande, 20 October 2020.
- *Les exoplanètes*, Marie-Eve Naud, École Ahuntsic Annexe, 22 October 2020.
- *Planets and exoplanets*, Frédérique Baron, CanYES, 26 October 2020, 3 February 2021, 11 June 2021.
- *Planets and exoplanets*, Frédérique Baron, Exploring by the Seat of your Pants, 28 October 2020.
- *Exoplanets and Beyond*, Nathalie Ouellette, CanYES, 28 October 2020, 9 February 2021, 27 April 2021, 31 May 2021.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Collège Jean-de-Brébeuf, 29 October 2020.
- *Exploring the Universe*, Nathalie Ouellette, Virtual Researcher on Call, 11 novembre 2020, 7 June 2021.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Cégep de Saint-Laurent, 13 November 2020.
- *Je réponds à tes questions sur l'astronomie et l'espace*, Marie-Eve Naud, École Ahuntsic Annexe, 16 November 2020.
- *À la recherche de nouveaux mondes*, Frédérique Baron, Cégep du Mont-Tremblant, 18 November 2020.
- *Je réponds à tes questions sur l'astronomie et l'espace*, Marie-Eve Naud, École les Colibris, 25 November 2020.
- *WR-124: explosion imminente?* (9 présentations), Caroline Piaulet, Sprint des sciences (UQAM), December 2020 to February 2021.
- *Les exoplanètes*, Anne Boucher, Université de Montréal, 2 December 2020.
- *An astronomer in your classroom*, Marie-Eve Naud, CanYES, 10 December 2020.
- *WR-124: explosion imminente?* (9 présentations), Thomas Vandal, Sprint des sciences (UQAM), January to April 2021.
- *Planètes et exoplanètes*, Frédérique Baron, Central French Immersion Public School, 12 January 2021.
- *Les constellations*, Marie-Eve Naud, Académie Yéchiva Yavné, 14 January 2021.
- *À quoi ressemble une carrière en astrophysique?*, Caroline Piaulet, Volet Douance du projet SEUR (UdeM), 15 January 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Lajoie, 20 January 2021, 28 January 2021.



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

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## **[...] School & Library Presentations**

- *Planètes et exoplanètes*, Frédérique Baron, Exploring by the Seat of your Pants, 25 January 2021.
- *The Gaia Mission*, Jonathan Gagné, Canadian Undergraduate Physics Conference, 26 January 2021.
- *La vie extraterrestre*, Nathalie Ouellette, École Joseph-Hermas-Leclerc, 29 January 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, Collège de l'Horizon, 1 February 2021.
- *Les trous noirs*, Nathalie Ouellette, Cégep du Vieux-Montréal, 2 February 2021.
- *Les exoplanètes*, Marie-Eve Naud, École des Saules Rieurs, 9 February 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Ahuntsic Annexe, 18 February 2021.
- *Let's Talk Astrophysics*, Nathalie Ouellette, Let's Talk Science, 20-21 February 2021.
- *Les naines brunes*, Frédérique Baron, École de la Montée, 22 February 2021.
- *Faire de la recherche... c'est quoi?*, Caroline Piaulet, Volet Découverte du projet SEUR (UdeM), 15 March 2021.
- *Les exoplanètes*, Marie-Eve Naud, École de l'Envolée, 15 March 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Lajoie, 23 March 2021.
- *Are we alone in the Universe?*, Frédérique Baron, Vanier College, 25 March 2021.
- *Développement instrumental en lien avec la recherche sur les exoplanètes*, Lison Malo, Projet SEUR (UdeM), 30 March 2021.
- *Chasseurs d'exoplanètes* (18 présentations), Thomas Vandal, Sprint des sciences (UQAM), April to June 2021.
- *Chasseurs d'exoplanètes* (17 présentations), Caroline Piaulet, Sprint des sciences (UQAM), April to June 2021.
- *Space Explorers*, Nathalie Ouellette, TELUS Spark Spring Camps, 31 March 2021, 6 April 2021.
- *Les exoplanètes: à la recherche de nouveaux mondes*, Myriam-Prasow Émond, Marie-Eve Naud and Thomas Vandal, École secondaire Calixa Lavallée, 31 March 2021, 6 April 2021.
- *Canada In Space*, Nathalie Ouellette, Collège Bois-de-Boulogne, 7 April 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Alphonse Desjardins, 19 April 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École élémentaire catholique virtuelle, 20 April 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Lajoie, 21 April 2021.
- *The Wonders of Space*, Nathalie Ouellette, TELUS Spark Operation Minerva, 26 April 2021.
- *Astronome dans votre classe* (20 présentations), Frédérique Baron, Charles Cadieux, Ariane Deslières, Marie-Eve Naud, Nathalie Ouellette, Stefan Pelletier, Michael Radica and Thomas Vandal, 3 to 7 May 2021.
- *L'astrophysique et l'immensité de l'Univers*, Myriam Prasow-Émond, École en réseau, 5 May 2021.
- *Les exoplanètes*, Anne Boucher, Cégep de Maisonneuve, 14 May 2021.

## **[...] School & Library Presentations**

- *Une astronome dans votre classe*, Marie-Eve Naud, École Au Millénaire CSS des Rives-du-Saguenay, 25 May 2021.
- *Unveiling the Universe with the Webb Telescope*, Nathalie Ouellette, Exploring by the Seat of your Pants, 27 May 2021.
- *The Search for Earth 2.0*, Michael Radica, Villa Maria High School, 28 May 2021.
- *Une astronome dans votre classe*, Marie-Eve Naud, École Les Saules Rieurs, 28 May 2021.
- *L'éclipse solaire du 10 juin 2021*, Marie-Eve Naud, École Gadbois, 1 June 2021.
- *Les exoplanètes et l'équation de Drake*, Patrick Horlaville, Maude Larivière and Thomas Vandal, Projet SEUR (UdeM), 14 July 2021.
- *Asteroids! Friend or Foe?*, Nathalie Ouellette, TELUS Spark Summer Camp, 20 July 2021.
- *Les exoplanètes*, Frédérique Baron and Nathalie Ouellette, École de langues de l'UdeM, 27 July 2021, 29 July 2021.
- *Venus and the other planets*, Frédérique Baron, TELUS Spark Summer Camp, 3 August 2021.
- *Space Explorers*, Nathalie Ouellette, TELUS Spark Summer Camp, 17 August 2021.

## **Public Talks**

- *L'Univers multicolore*, Nathalie Ouellette, Club d'astronomie de Boucherville, 4 November 2020.
- *Discussion avec un astronome*, Nathalie Ouellette, Société d'astronomie du Planétarium de Montréal, 5 November 2020.
- *Sommes-nous seuls dans l'Univers?*, Frédérique Baron, *Direct 3 de la FAS* (UdeM), 5 November 2020.
- *Ask an Astronomer*, Nathalie Ouellette, H.R. MacMillan Space Centre, 26 November 2020.
- *De la vie sur Vénus?*, Frédérique Baron, Club d'astronomes amateurs de Rosemère, 30 November 2020.
- *Exoplanètes ou naines brunes déguisées*, Frédérique Baron, Club d'astronomes amateurs de Lévis, 20 January 2021.
- *An Evening of Exoplanets*, Nicolas Cowan, Jonathan Gagné and Nathalie Ouellette, Guelph Physics Livestream, 26 January 2021.
- *Le satellite Gaia et ses découvertes*, Jonathan Gagné, Club d'astronomie du Mont-Tremblant, 9 February 2021.
- *Les exoplanètes dans les environnements extrêmes*, Myriam Prasow-Émond, Club d'astronomie Cassiopée, 8 March 2021.
- *Table ronde sur les carrières*, Nathalie Ouellette, Parlons sciences, 1 April 2021.
- *Les exoplanètes dans les environnements extrêmes*, Myriam Prasow-Émond, Club d'astronomie Io de Val-Bélair, 12 April 2021.
- *The James Webb Space Telescope*, Nathalie Ouellette, *Yuri's Night* (Plateau Astro), 12 April 2021.
- *Our Galactic Neighborhood*, Tim Hallatt, AstroMcGill Public Talks, 22 April 2021.

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

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

- *Au-delà de la découverte de petites planètes: Caractériser la nature et la formation des super-Terres et des mini-Neptunes*, Caroline Piaulet, Club d'astronomie Io de Val-Bélair, 1 May 2021.
- *De la vie sur Vénus*, Frédérique Baron, Société d'astronomie de Montréal, 4 May 2021.
- *Galaxies fracassantes*, Nathalie Ouellette, Parlons science, 8 May 2021.
- *Exoplanets in the most extreme environments*, Myriam Prasow-Émond, International Day of Light (UNESCO), 21 May 2021.
- *La mission Gaia et la cinématique stellaire*, Jonathan Gagné, Société d'astronomie du Planétarium de Montréal, 28 May 2021.
- *Comme jour et nuit: les phases exoplanétaires*, Nicolas Cowan, Club d'astronomie Mont-Tremblant, 1 June 2021.

## **Public Events**

- *La petite école de l'espace #2*, online, 26 September 2020.
- *Concours "Astrophysicienne en herbe"*, online, 26 October 2020.
- *La grande conférence de l'iREx 2020*, online, 10 November 2020.
- *La petite école de l'espace #3*, online, 12 December 2020.
- *"Look Up" Challenge*, across Canada, 16 December 2020 to 6 January 2021.
- *Cosmic Club #1*, en ligne, 23 January 2021.
- *Soirée d'initiation à la recherche en astrophysique 2021*, en ligne, 17 January 2020.
- *La petite école de l'espace #4*, en ligne, 20 March 2021.
- *Cosmic Club #2*, en ligne, 27 March 2021.
- *La petite école de l'espace #5*, en ligne, 22 May 2021.
- *Cosmic Club #3*, en ligne, 5 June 2021.
- *Éclipse solaire*, across Québec, 10 June 2021.
- *AstroComm 2021*, en ligne, 16 June 2021.



# Media Interviews

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## Television Interviews

- *Possible signs of life discovered on Venus*, Nathalie Ouellette, *Global News*, 14 September 2020.
- *Astronomers find signs of life on Venus*, Nicolas Cowan, *The National* (CBC), 14 September 2020.
- *Un enjeu de pollution lumineuse*, Marie-Eve Naud, *Le Téléjournal* (Radio-Canada), 13 November 2020.
- *Les galaxies*, Nathalie Ouellette, *Chasseurs d'étoiles* (ICI Explora), 17 March 2021.
- *L'exploration spatiale et la vie extraterrestre*, Nathalie Ouellette, *On va se le dire* (Radio-Canada), 17 November 2020.
- *La quête de l'espace*, Marie-Eve Naud, *Le Téléjournal* (Radio-Canada), 12 January 2021.
- *La Terre tourne de quel sens?*, Nathalie Ouellette, *Infoman* (Radio-Canada), 18 February 2021.
- *Perseverance sur Mars*, Nathalie Ouellette, *TVA Nouvelles* (LCN), 18 February 2021.
- *Perseverance sur Mars*, Nathalie Ouellette, *Nouvelles* (RDI), 18 February 2021.
- *Perseverance sur Mars*, Nathalie Ouellette, *24/60* (RDI), 18 February 2021.
- *Mission réussie pour l'hélicoptère Ingenuity*, Nathalie Ouellette, *Le Téléjournal* (Radio-Canada), 19 April 2021.
- *James Webb: le plus grand télescope jamais mis en orbite*, Loïc Albert, René Doyon, Olivia Lim and Stefan Pelletier, *Le Téléjournal* (Radio-Canada), 11 May 2021.
- *La Terre plate*, Nathalie Ouellette, *Le Pharmacien* (ICI Explora), 14 May 2021.
- *Les planètes gazeuses*, Frédérique Baron, *Comme dans l'espace* (TV5 Unis), 18 May 2021.
- *Une éclipse solaire à 5h du matin jeudi*, Marie-Eve Naud, *Salut Bonjour* (TVA), 9 June 2021.
- *Exploration spatiale: mission Vénus*, Frédérique Baron, *Le Téléjournal* (Radio-Canada), 29 July 2021.
- *Canadian-made space telescope to search for distant planets, explorer 'origins of life'*, Jason Rowe, *Global News*, 7 August 2021.

## Radio Interviews

- *Chroniques d'astronomie* (35 chroniques), Nathalie Ouellette, *Dutrizac* (QUB Radio), 11 September 2020, 18 September 2020, 25 September 2020, 2 October 2020, 9 October 2020, 16 October 2020, 23 October 2020, 30 October 2020, 6 November 2020, 13 November 2020, 20 November 2020, 27 November 2020, 4 December 2020, 11 December 2020, 18 December 2020, 15 January 2021, 29 January 2021, 12 February 2021, 19 February 2021, 26 February 2021, 5 March 2021, 12 March 2021, 19 March 2021, 26 March 2021, 9 April 2021, 16 April 2021, 23 April 2021, 30 April 2021, 7 May 2021, 14 May 2021, 21 May 2021, 28 May 2021, 4 June 2021, 11 June 2021, 18 June 2021.

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

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

- *Détection possible de phosphine sur Vénus*, Nathalie Ouellette and Caroline Piaulet, *Les années lumière* (ICI Première), 20 September 2020.
- *Est-ce qu'il y a des gaz ou d'autres éléments inconnus ailleurs dans l'univers?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 23 September 2020.
- *Le pourquoi du pourquoi*, Marie-Eve Naud, *Les malins* (ICI Première), 7 November 2020.
- *Y a-t-il des changements climatiques sur Mars?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 9 November 2020.
- *Qu'ont-elles à nous dire?*, Marie-Eve Naud, *Plus on est de fous, plus on lit* (ICI Première), 12 November 2020.
- *Une nouvelle carte de la Voie lactée*, Nathalie Ouellette, *La croisée* (ICI Première), 3 December 2020.
- *Retour sur Terre des échantillons de l'astéroïde Ryugu*, Nathalie Ouellette, *Les années lumière* (ICI Première), 6 December 2020.
- *Les changements climatiques affectent-ils l'espace?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 16 December 2020.
- *Est-ce que les couleurs sur les images de l'espace sont réelles?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 12 January 2021.
- *Virgin Orbit*, Nathalie Ouellette, *As It Happens* (CBC Radio), 19 January 2021.
- *Quelques nouvelles scientifiques de la semaine*, Caroline Piaulet, *Les années lumière* (ICI Première), 24 January 2021.
- *La vie extraterrestre*, Marie-Eve Naud, *Un phare dans la nuit* (ICI Première), 30 January 2021.
- *Pourrons-nous éviter les rayons cosmiques quand nous voyagerons dans l'espace?*, Nathalie Ouellette, *Moteur de recherche* (Radio-Canada), 10 February 2021.
- *Mars, cette planète qui fascine*, Nathalie Ouellette, *Pénélope* (ICI Première), 18 February 2021.
- *Vidéo spectaculaire de l'atterrissage du rover Perseverance*, Nathalie Ouellette, *Le Québec maintenant* (98.5 FM), 22 February 2021.
- *Vie extraterrestre*, Marie-Eve Naud, *Sans Filtre* (podcast), 2 March 2021.
- *L'effet d'un renversement des pôles sur les écosystèmes*, Nathalie Ouellette, *Les années lumière* (ICI Première), 7 March 2021.
- *Finding exoplanets in Montréal*, Lisa Dang, *Splashdown* (Plateau Astro podcast), 22 March 2021.
- *Comment utilisons-nous les ondes radio dans l'exploration spatiale?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 6 April 2021.

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

- *L'astrophysicien Loïc Albert sélectionné pour utiliser le prochain télescope spatial James Webb dans le cadre de ses recherches*, Loïc Albert, *Le Québec maintenant* (98.5 FM), 13 April 2021.
- *Lune et Mars*, Marie-Eve Naud, *Bien entendu* (ICI Première), 2 May 2021.
- *Certains événements peuvent-ils ralentir la rotation de la Terre?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 4 May 2021.
- *Investissement de 1,1M\$ pour développer un nouveau télescope spatial à l'Université Bishop's*, Déreck-Alexandre Lizotte, *Midi Actualité* (107.7 FM), 14 May 2021.
- *Les origines cosmiques de métaux lourds*, Nathalie Ouellette, *Les années lumière* (ICI Première), 30 May 2021.
- *L'éclipse solaire au Québec*, Nathalie Ouellette, *Dutrizac* (QUB Radio), 9 June 2021.
- *L'éclipse solaire de demain*, Marie-Eve Naud, *Bien entendu* (ICI Première), 9 June 2021.
- *Une éclipse annulaire partielle du Soleil se déroulait à l'aube ce matin*, Nathalie Ouellette, *Que la Mauricie se lève* (106.9 FM), 10 June 2021.
- *Exoplanets & Telescopes*, Lisa Dang, *Abstract: The Future of Science* (podcast), 14 June 2021.
- *La Terre plate*, Nathalie Ouellette, *Ce n'est qu'une théorie* (podcast), 14 June 2021.
- *Des étoiles clignotantes mystérieuses*, Nathalie Ouellette, *Bien entendu* (ICI Première), 23 June 2021.
- *Apprécier le ciel nocturne à l'oeil nu*, Nathalie Ouellette, *Dessine-moi un été* (ICI Première), 3 July 2021.
- *Fusions de trous noirs avec une étoile à neutrons*, Frédérique Baron, *Les années lumière* (ICI Première), 4 July 2021.
- *De Hubble à James Webb, les grands télescopes*, Frédérique Baron, *Bien entendu* (ICI Première), 7 July 2021.
- *Des mondes à explorer et la recherche appliquée*, *Dessine-moi un été* (ICI Première), 17 July 2021.
- *L'expérience L'Infini à la Station spatiale internationale*, Frédérique Baron, *Bien entendu* (ICI Première), 21 July 2021.
- *Les astronomes peuvent-ils percevoir les débuts de notre Univers?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 27 July 2021.
- *Il n'y a pas de planète B*, Nathalie Ouellette, *Dessine-moi un été* (ICI Première), 31 July 2021.
- *Un ballon stratosphérique pour observer les étoiles et la matière noire*, Nathalie Ouellette, *Les années lumière* (ICI Première), 1 August 2021.
- *Les Perséides*, Frédérique Baron, *Bien entendu* (ICI Première), 11 August 2021.
- *Les Perséides*, Nathalie Ouellette, *Dessine-moi un été* (ICI Première), 14 August 2021.



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

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

- *Est-ce que le satellite naturel Europe deviendra un gigantesque océan?*, Nathalie Ouellette, *Moteur de recherche* (ICI Première), 24 August 2021.
- *“Une brève histoire du temps” de Stephen Hawking*, Marie-Eve aux, *Plus on est fous plus on lit* (ICI Première), 31 August 2021.

## **Print & Online Interviews**

- *Astronomers may have found hints of life in clouds of Venus*, Nicolas Cowan, *CBC News*, 14 September 2020.
- *Un biomarqueur découvert dans l’atmosphère de Vénus: un signe de vie?*, Nicolas Cowan, *Québec Science*, 14 September 2020.
- *Nathalie Ouellette: une passionnée des galaxies*, Nathalie Ouellette, *blogue du Planétarium Rio Tinto Alcan*, 30 September 2020.
- *If The Readings Are Right, There’s Something Very Strange About This Exoplanet*, Nicolas Cowan, *Futurism*, 23 October 2020.
- *Study portrays the atmosphere of exoplanet ‘hot Neptune’*, Björn Benneke et Nicolas Cowan, *Tech Explorist*, 24 October 2020.
- *GU Piscium b: A very large world that twinkles*, Marie-Eve Naud, *ScienceLine*, 26 October 2020.
- *Astronomers look into atmosphere of ‘planet that shouldn’t exist’*, Nicolas Cowan, *Yahoo! Sports*, 27 October 2020.
- *Data reveals evidence of molecular absorption in the atmosphere of a hot Neptune*, Björn Benneke, *Space Daily*, 28 October 2020.
- *Une lune bleue pour l’Halloween*, Nathalie Ouellette, *Quartier Libre*, 30 October 2020.
- *Astronomers discover extreme planet which rains rocks, has lava seas and 3,000 mph winds*, Nicolas Cowan, *The Telegraph*, 3 November 2020.
- *Astronomers discovered the most inhospitable planet ever*, Nicolas Cowan, *Daily Mail*, 3 November 2020.
- *Scientists discover bizarre hell planet where it rains rocks and oceans are made of lava*, Nicolas Cowan, *CBS News*, 5 November 2020.
- *This lava planet has ‘rocky’ weather and winds many times the speed of sound*, Nicolas Cowan, *CNN*, 6 November 2020.
- *Un défi d’observation du ciel à faire en famille durant le temps des Fêtes*, Frédérique Baron, Marie-Eve Naud and Nathalie Ouellette, *Zone des parents* (Radio-Canada), 16 December 2020.
- *Spacey ‘super puffs’ are changing our understanding of how planets form*, Björn Benneke and Caroline Piaulet, *PopSci*, 19 January 2021.

## **[...] Print & Online Interviews**

- *Découverte d'une nouvelle planète "barbe à papa" dans la Voie lactée*, Caroline Piaulet, *Sciences et Avenir*, 20 January 2021.
- *Mieux comprendre la formation des planètes gazeuses géantes*, Bjorn Benneke, Eve Lee and Caroline Piaulet, *Radio-Canada International*, 20 January 2021.
- *L'exoplanète "barbe à papa" qui défie les scientifiques*, Caroline Piaulet, *Le Point*, 22 January 2021.
- *Cette exoplanète "barbe à papa" remet en question les conceptions des astronomes*, Caroline Piaulet, *Futura Sciences*, 23 January 2021.
- *Astronomers discover huge exoplanet has the density of cotton candy*, Eve Lee and Caroline Piaulet, *CBC News*, 25 January 2021.
- *James Webb Telescope Targets TRAPPIST-1 for ET Life in Milky Way Galaxy*, David Lafrenière, *The Debrief*, 27 January 2021.
- *The puffiest of planets*, Caroline Piaulet, *Tune!FM*, 12 February 2021.
- *La Terre frôlée par des extraterrestres?*, René Doyon, *Journal de Montréal*, 15 February 2021.
- *Puffy exoplanet challenges traditional notions of planet formation*, Caroline Piaulet, *The McGill Tribune*, 16 February 2021.
- *À la conquête de la planète Mars*, Nathalie Ouellette, *Journal de Montréal*, 18 February 2021.
- *The strange case of the misplaced cotton candy world*, Caroline Piaulet, *SuperCluster*, 3 March 2021.
- *Des étudiants de l'UdeM à la recherche d'exoplanètes*, Louis-Philippe Coulombe, Caroline Piaulet and Thomas Vandal, *Quartier Libre*, 2 April 2021.
- *Des chercheurs de l'UdeM derrière l'élaboration du télescope spatial le plus puissant au monde*, Loïc Albert, René Doyon and Olivia Lim, *Quartier Libre*, 8 April 2021.
- *Trois chercheurs de l'UdeM inaugureront le télescope "James Webb"*, Loïc Albert, Olivia Lim and Stefan Pelletier, *Forum*, 12 April 2021.
- *Bishop's University awarded \$1 million micro satellite technology development contract*, Jason Rowe, *SpaceQ*, 30 April 2021.
- *Une éclipse pour commencer la journée*, Marie-Eve Naud, *La Presse*, 9 June 2021.
- *Astronomers estimate 29 potentially habitable exoplanets may have received signals from Earth*, Nicolas Cowan, *CBC News*, 25 June 2021.
- *Oumuamua: visiteur d'un autre monde*, Nathalie Ouellette, *Québec Science*, 12 July 2021.
- *Overture to Exoplanets*, Lisa Dan, Olivia Lim and Stefan Pelletier, *Eos*, 26 July 2021.

# Publications

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1. "Constraining protoplanetary discs with exoplanetary dynamics: Kepler-419 as an example", **Ali-Dib, M.**; Petrovich, C., *MNRAS*, 2020.
2. "Limits on Protoplanet Growth by Accretion of Small Solids", **Ali-Dib, M.**; Thompson, C., *ApJ*, 2020.
3. "Phase Curves of Hot Neptune LTT 9779b Suggest a High-metallicity Atmosphere", Crossfield, I. J. M.; Dragomir, D.; **Cowan, N. B.**; et d'autres incluant **Benneke, B.**, *ApJ*, 2020.
4. "Neon Cluster Formation and Phase Separation during White Dwarf Cooling", Caplan, M. E.; Horowitz, C. J.; **Cumming, A.**, *ApJ*, 2020.
5. "A Featureless Infrared Transmission Spectrum for the Super-puff Planet Kepler-79d", Chachan, Y.; Jontof-Hutter, D.; Knutson, H. A.; et d'autres incluant **Benneke, B.**, *AJ*, 2020.
6. "Clearing up the clouds on hot gas giants", **Cowan, N. B.**; Rauscher, E., *Nature Astronomy*, 2020.
7. "Pixel level decorrelation in service of the Spitzer microlens parallax survey", **Dang, L.**; Calchi Novati, S.; Carey, S.; **Cowan, N. B.**, *MNRAS*, 2020.
8. "Five New Post-main-sequence Debris Disks with Gaseous Emission", Dennihy, E.; Xu, S.; Lai, S.; et d'autres incluant **Dufour, P.**, *ApJ*, 2020.
9. "Spitzer Reveals Evidence of Molecular Absorption in the Atmosphere of the Hot Neptune LTT 9779b", Dragomir, D.; Crossfield, I. J. M.; **Benneke, B.**; et al., *ApJ*, 2020.
10. "The CARMENES search for exoplanets around M dwarfs. LP 714-47 b (TOI 442.01): populating the Neptune desert", Dreizler, S.; Crossfield, I. J. M.; Kossakowski, D.; et d'autres incluant **Benneke, B.**, *A&A*, 2020.
11. "A Wide Planetary-mass Companion to a Young Low-mass Brown Dwarf in Ophiuchus", Fontanive, C.; Allers, K. N.; Pantoja, B.; Biller, B.; Dubber, S.; Zhang, Z.; Dupuy, T.; Liu, M. C.; **Albert, L.**, *ApJ*, 2020.



12. "Beyond Equilibrium Temperature: How the Atmosphere/Interior Connection Affects the Onset of Methane, Ammonia, and Clouds in Warm Transiting Giant Planets", Fortney, J. J.; Visscher, C.; Marley, M. S.; Hood, C. E.; Line, M. R.; **Thorngren, D. P.**; Freedman, R. S.; Lupu, R., *AJ*, 2020.
13. "The  $\mu$  Tau Association: A 60 Myr Old Coeval Group at 150 pc from the Sun", **Gagné, J.**; David, T. J.; Mamajek, E. E.; Mann, A. W.; Faherty, J. K.; Bédard, A., *ApJ*, 2020.
14. "The First Habitable-zone Earth-sized Planet from TESS. I. Validation of the TOI-700 System", Gilbert, E. A.; Barclay, T.; Schlieder, J. E.; et d'autres incluant **Rowe, J. F.**; **Lee, E. J.**, *AJ*, 2020.
15. "Can Large-scale Migration Explain the Giant Planet Occurrence Rate?", **Hallatt, T.**; **Lee, E. J.**, *ApJ*, 2020.
16. "Revisiting the Magnetic Field of the L183 Starless Core", Karoly, J.; Soam, A.; Andersson, B.-G.; Coudé, S.; **Bastien, P.**; Vaillancourt, J. E.; Lee, C. W., *ApJ*, 2020.
17. "Atmospheric Temperature Inversions and He I 5876 Core Profile Structure in White Dwarfs", Klein, B.; Blouin, S.; Romani, D.; Zuckerman, B.; Melis, C.; Xu, S.; **Dufour, P.**; Genest-Beaulieu, C.; Bédard, A.; Jura, M., *The Astrophysical Journal*, 2020.
18. "Cloud Atlas: Unraveling the Vertical Cloud Structure with the Time-series Spectrophotometry of an Unusually Red Brown Dwarf", Lew, B. W. P.; Apai, D.; Marley, M.; et d'autres incluant **Cowan, N. B.**, *ApJ*, 2020.
19. "Eigenspectra: a framework for identifying spectra from 3D eclipse mapping", Mansfield, M.; Schlawin, E.; Lustig-Yaeger, J.; et d'autres incluant **Keating, D.**, *MNRAS*, 2020.
20. "Spin-orbit alignment and magnetic activity in the young planetary system AU Mic", Martioli, E.; Hébrard, G.; Moutou, C.; et d'autres incluant **Artigau, É.**; **Cook, N. J.**; **Doyon, R.**, *A&A*, 2020.
21. "Reflected Light Observations of the Galilean Satellites from Cassini: A Test Bed for Cold Terrestrial Exoplanets", Mayorga, L. C.; Charbonneau, D.; **Thorngren, D. P.**, *AJ*, 2020.

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22. "Serendipitous Discovery of Nine White Dwarfs with Gaseous Debris Disks", Melis, C.; Klein, B.; Doyle, A. E.; Weinberger, A.; Zuckerman, B.; **Dufour, P.**, *ApJ*, 2020.
23. "Early science with SPIRou: near-infrared radial velocity and spectropolarimetry of the planet-hosting star HD 189733", Moutou, C.; Dalal, S.; Donati, J.-F. et d'autres incluant **Artigau, É.; Cook, N. J.; Doyon, R.**, *A&A*, 2020.
24. "Modelling the atmosphere of lava planet K2-141b: implications for low- and high-resolution spectroscopy", Nguyen, T. G.; **Cowan, N. B.; Banerjee, A.**; Moores, J. E., *MNRAS*, 2020.
25. "Birth sites of young stellar associations and recent star formation in a flocculent corrugated disc", Quillen, A. C.; Pettitt, A. R.; Chakrabarti, S.; Zhang, Y.; **Gagné, J.**; Minchev, I., *MNRAS*, 2020.
26. "A Multiwavelength Study of the Cool Core Cluster MACS J1447.4+0827", **Prasow-Émond, M.**; Hlavacek-Larrondo, J.; Rhea, C. L.; Latulippe, M.; Gendron-Marsolais, M. -L.; Richard-Laferrrière, A.; Sanders, J. S.; Edge, A. C.; Allen, S. W.; Mantz, A.; von der Linden, A., *AJ*, 2020.
27. "On the relation between mini-halos and AGN feedback in clusters of galaxies", Richard-Laferrrière, A.; Hlavacek-Larrondo, J.; Nemmen, R. S.; et d'autres incluant **Prasow-Émond, M.**, *MNRAS*, 2020.
28. "The First Habitable-zone Earth-sized Planet from TESS. II. Spitzer Confirms TOI-700 d", Rodriguez, J. E.; Vanderburg, A.; Zieba, S.; et d'autres incluant **Lee, E. J.**, *AJ*, 2020.
29. "The magnetic early B-type stars - IV. Breakout or leakage? H  $\alpha$  emission as a diagnostic of plasma transport in centrifugal magnetospheres", Shultz, M. E.; Owocki, S.; Rivinius, Th; et d'autres incluant **Sikora, J.**, *MNRAS*, 2020.
30. "Discovery of a Nearby Young Brown Dwarf Disk", Schutte, M. C.; Lawson, K. D.; Wisniewski, J. P.; et d'autres incluant **Gagné, J.**, *AJ*, 2020.
31. "A spectroscopic test of the rotational modulation origin of periodic Kepler photometric variability of A-type stars", **Sikora, J.**; Wade, G. A.; **Rowe, J.**, *MNRAS*, 2020.

32. "An extensive spectroscopic time series of three Wolf-Rayet stars - II. A search for wind asymmetries in the dust-forming WC7 binary WR137", St-Louis, N.; **Piaulet, C.**; Richardson, N. D.; *et al.*, *MNRAS*, 2020.
33. "Dynamical Mass Estimates of the  $\beta$  Pictoris Planetary System through Gaussian Process Stellar Activity Modeling", **Vandal, T.**; Rameau, J.; **Doyon, R.**, *AJ*, 2020.
34. "A giant planet candidate transiting a white dwarf", Vanderburg, A.; Rappaport, S. A.; Xu, S.; et d'autres incluant **Benneke, B.**; **Dufour, P.**, *Nature*, 2020.
35. "Searching for ZZ Ceti White Dwarfs in the Gaia Survey", Vincent, O.; Bergeron, P.; **Lafrenière, D.**, *AJ*, 2020.
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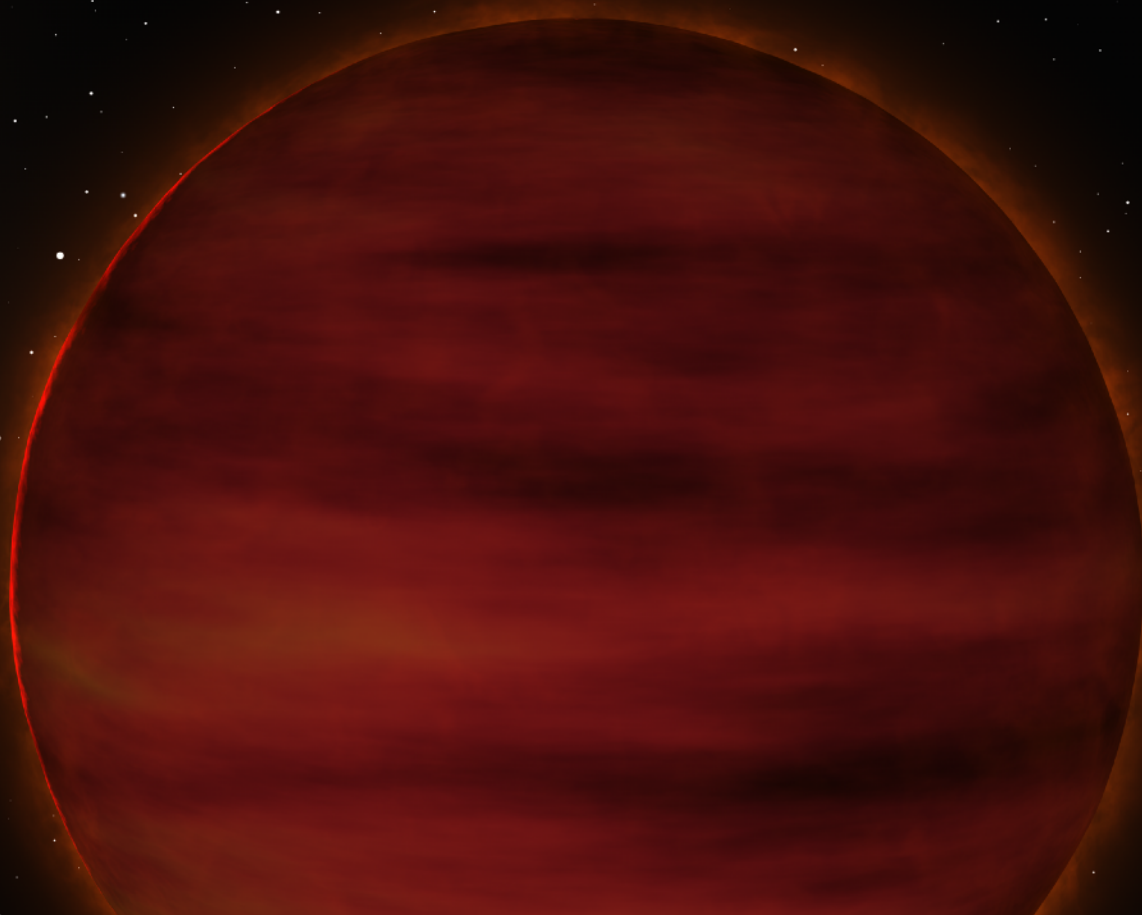
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