TROTTIER INSTITUTE FOR RESEARCH ON EXOPLANETS



ANNUAL REPORT 2021.2022











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ABOUT THE INSTITUTE



1.1. Missions and Objectives

The Trottier Institute for Research on Exoplanets (iREx) was created to find new worlds beyond the Solar System and answer one of the greatest questions facing humanity: Are we alone in the Universe?

This question alone justifies 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 to orbit a star other than the Sun in 1995, astronomers have confirmed the existence of thousands of exoplanets. Thousands more candidates have also been identified, including rocky Earth-like planets, as well as planet types that defy our theories of planetary formation. Over the next decade, the new generation of telescopes and instruments will make it possible for the first time to probe the atmosphere of these Earth-like extrasolar planets for water vapor and, possibly, signatures of biological activity such as oxygen, ozone, or methane.





The Trottier Institute for Research on Exoplanets brings together the best researchers and a dynamic, motivated team of students taking full advantage of the major observational projects underway or planned, and who are promoting this research through their sustained efforts in outreach and science communication, with the ultimate goal of finding life elsewhere in our Universe.

1.2. A Word from our Director



Photo: A. Philibert/UdeN

What an unforgettable year! I'm confident that your reading of this Annual Report, which covers the period from **September 1, 2021 to August 31, 2022**, will leave you as amazed as I am at the exploits and discoveries of iREx members and the entire astronomical community.

Of course, the launch and start of scientific operations of the James Webb Space Telescope made incredible waves internationally, far beyond the scientific community, in popular culture. I'm also incredibly proud that our NIRPS instrument has finally been delivered to Chile. These instruments, and many others, will continue to enable iREx astronomers to make amazing discoveries, such as the ocean planet candidate TOI-1452 b, whose discovery made a huge splash around the world.

I think I speak for the whole iREx team when I express my delight at having been able to meet my colleagues and the public in-person again at several events this year. However, I think we will always carry with us the lessons learned during the pandemic, which I hope will enable us to stay more connected, even remotely, and increase the reach of our activities.

Exceptionally, this report includes a momentous announcement made outside the normal period mentioned: the renewal of the Trottier Family Foundation's donation to iREx. To Lorne and his entire family, I can't thank you enough for enabling the dream and mission of iREx to continue for years to come. Thank you, and thank you to all those who follow iREx from near and far!

René Doγon, Director, iREx Professor, Université de Montréal

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1.3. The Year in Review: 2021-2022

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



These worlds include the **multiplanetary system HD 3167, a brown dwarf around the star TOI-1278,** the extreme exoplanet XO-3 b, the **hot Jupiter WASP-121 b with metallic clouds,** the **ocean planet candidate TOI-1452 b** and the **exoplanet WASP-39 b**, on which CO₂ was detected for the first time outside the Solar System.



Photo: F. Bo

The **SPIRou** instrument continued its observing campaign at the Canada-France-Hawai'i Telescope, and the **NIRPS** instrument finally made its last great journey to ESO's 3.6-meter telescope in La Silla in 2022 to begin its commissioning.



It was an absolutely remarkable year for the **James Webb Space Telescope**, which was finally launched in December 2O21 and commissioned over the next six months. The telescope's first images were unveiled to the public in July 2O22, and scientific operations are now well underway.

Photo: Arianespace/ESA



Photo: NASA/ESA/CSA/J. Olmsted



scientific papers





radio interviews



press interviews

iREx researchers contributed to **99 scientific papers** published in peer-reviewed journals.

iREx members gave a record number of media interviews: **30 for television**, **98 for radio outlets**, **and 96 for print and online media**... for a total of **224 interviews** in 2021-2022!





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The iREx membership remained relatively stable, with **71 members** during the summer peak. This includes a **record number of graduate students**, 36. We welcomed **11 interns in the Summer of 2O22**, returning to in-person internships for the first time since the start of the COVID-19 pandemic.

We reached tens of thousands of people in Quebec and around the world, in person and virtually, via 50 school talks at primary and secondary schools, CEGEPs and universities, 55 public lectures and 7 public events, and through several new content creation initiatives. Our members were delighted to meet the public in person on several occasions!



1.4. Scientific Overview

To carry out their mission, iREx researchers focus their research projects around three main themes: observation, instrumentation, and theory.



Various observational methods are used to detect exoplanets, both directly and indirectly. The observations carried out by iREx researchers exploit different methods: high-contrast direct imaging, high-precision infrared velocimetry, and transit spectroscopy.

In addition to exoplanets, iREx researchers are interested in other celestial bodies such as **stars**, **brown dwarfs, white dwarfs, moons, comets**, and **asteroids**. Several iREx members also specialise in the study of **planet formation and evolution** using theoretical models. Through its collaborations with the Laboratoire d'astrophysique expérimentale (LAE) of the Observatoire du Mont-Mégantic (OMM), iREx has unrivalled access to a wide range of high-performance scientific instruments dedicated to the observation of exoplanets. Its researchers study, develop, and improve data analysis techniques, pushing iREx to the pinnacle of exoplanet research. iREx instrumentation projects include the FGS/NIRISS instrument, Canada's contribution to the James Webb Space Telescope, the SPIRou and NIRPS high-precision infrared spectrographs, installed in Hawai'i and Chile respectively, the GPI imager at the Gemini-North Observatory, and the PESTO optical camera at the OMM.

1.5. Administrative Overview



1.5.1. ORGANISATIONAL

Board of Directors

The iREx is managed by the Board of Directors, which is made up of the **Dean of the Faculty of Arts and Science** of the Université de Montréal (UdeM), who chairs the Board, a representative of the Director of the Department of Physics, the Director of iREx, a Professor who is a member of iREx, a member of the Board of Governors, the iREx Deputy Director, and a representative of the UdeM Office of Development and Alumni Relations as an observer. The duties of the Board of Directors include appointing the Director of iREx, appointing members on the recommendation of the Scientific Committee, approving the iREx scientific program defined by the Scientific Committee, and approving financial reports and budget forecasts.

→ 2021-2022 Membership

Frédéric Bouchard (Chair), Normand Mousseau, René Doγon, Patrick Dufour, Philippe Sureau, Nathalie Ouellette, Marie-Claude Giguère

Scientific Committee

The Scientific Committee advises the Director on the scientific development of iREx and defines its program of activities. It is made up of the Director of iREx, the Vice-Dean for Research and Creation of the UdeM Faculty of Arts and Science, two Professors who are iREx members, the iREx Deputy Director, and a Professor in Astronomy-Astrophysics from an institution other than the UdeM.

→ 2021-2022 Membership

René Doγon, Éric Montpetit, Björn Benneke, David Lafrenière, Nathalie Ouellette, Nicolas Cowan

Board of Governors

The iREx's priority remains its excellence in exoplanetary **research**. A significant portion of iREx funds is also dedicated to **education and public outreach**, an important pillar of the Institute's mission.

1.5.2. FINANCIAL

Our **student scholarships** include bursaries for our undergraduate summer interns, as well as scholarships for our graduate student researchers. Many of our students are also recipients of external iREx scholarships 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 **72%** of the total iREx budget.

Our **outreach program** includes all our activities for the public and for school-age audiences, including public talks and events, workshops, communications and marketing, online content, and the Maunakea Graduate School. This portion of the budget, **21%** on average, also covers part of the salary of our outreach staff. Finally, iREx's operating costs — the purchase of equipment and software, photocopying and telephony costs, other administrative expenses, and a portion of our Deputy Director's salary — make up only 7% of our total budget.



The majority of iREx funding comes from **philanthropic sources** (see next section). In addition, many of our research and science outreach projects are funded by **government grants** (NSERC, CFI, MEIE, FRQ, etc.), and **contracts** with the Canadian Space Agency.

IREX EXPENSES OVER THE LAST SEVEN YEARS



1.6. Our Donors

The iREx could not exist without the precious contribution of its donors. Without their support and vision, it would be impossible for us to continue our research and educational work, which enables us to learn a little more about our Universe every day and to share these discoveries.

We would like to thank the Trottier Family Foundation, Philippe Sureau, Jean-François Bertrand, Sylvain Lumbroso, Stéphanie Codsi, Anne Joli-Cœur, Carole Kleingrib, Hortense Michaud-Lalanne, Isabelle Morin, Marie-Hélène Paquette, and Martin Périard.





1.6.1. A HISTORIC DONATION FROM THE TROTTIER FAMILY FOUNDATION

The excellent relationship between our Director, René Doyon, and the Trottier Family Foundation goes back even further than the inauguration of our Institute. René Doyon and Lorne Trottier have long shared a passion for science and technology, and a deep curiosity about the big questions surrounding the Universe. Since the inception of iREx, the Trottier Family Foundation has been our most significant donor, contributing over \$400k per year between 2017 and 2021.

It is therefore with great pleasure and gratitude that we announce the **renewal of the Trottier Family Foundation's donation in 2022**. This donation of \$10 million over a 10-year period will ensure the long-term viability of iREx's activities. In recognition of this exceptional gift and the support of Lorne Trottier and the Trottier Family Foundation since its inception, the iREx has been **renamed the Trottier Institute for Research** on Exoplanets.

The next ten years will be very busy for iREx researchers, as an avalanche of data from the many different telescopes and instruments they are collaborators on, including the James Webb Space Telescope, is made available to them. The Trottier Family Foundation's generous donation of \$10 million over the next ten years will enable the Institute to pursue many of its ground-breaking initiatives in research, technology development, and educational programs. In concrete terms, this donation will be used to pay the salaries of our research and support staff, to provide grants and scholarships to students to help them pursue their university studies, and to fund our public and educational programs, which we offer free of charge to schools and the community.

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RESEARCH HIGHLIGHTS

2.1. HD 3167: A Surprising Multi-Planetary System

An international team of astrophysicists, including **Romain Allart**, Trottier Postdoctoral Fellow at iREx at the Université de Montréal, has discovered that the **exoplanets of the star HD 3167 in the constellation Pisces orbit in perpendicular planes**.

This configuration is radically different from that of our Solar System, where the planets orbit close to the same plane. The surprising configuration of the HD 3167 system could be due to the influence of a distant companion of the star that remains unknown.

Located 154 light-years away, HD 3167 is slightly smaller than the Sun. Its three exoplanets were discovered in 2016 and 2017. A study published in 2019 revealed a surprising fact: two of the three planets, the mini-Neptunes HD 3167 c and d, are not aligned with their star, i.e., their orbits do not lie in the plane perpendicular to the star's axis of rotation. This came as a surprise, as theories on the origin of planetary systems predict that planets form in this plane and continue their evolution there, unless disturbed by specific events.

> A new study in the journal Astronomy & Astrophysics, led by a team of astronomers including Romain Allart, demonstrates that the third exoplanet, HD 3167 b, has an orbit aligned with its star and is therefore perpendicular to the orbital plane of its two siblings. This discovery was made possible by new data from the ESPRESSO instrument, installed on one of the four 8.2-metre telescopes of the European Southern Observatory's Very Large Telescope (VLT) in Chile.





The use of the CHEOPS satellite was also essential in determining the precise moment at which ESPRESSO had to turn its gaze towards HD 3167 b, which is a super-Earth-type exoplanet orbiting its star in just 23 hours.

These new measurements seem to confirm the prediction made in 2019 of the presence of a fourth body orbiting the star HD 3167, which could be a giant planet or a brown dwarf gravitationally linked to the system. In this scenario, the two mini-Neptunes, more distant than the super-Earth, would have been influenced by this fourth body, which would have contributed to misaligning their orbits.

The Rossiter-McLaughlin Effect Revolutions: an ultra-short period planet and a warm mini-Neptune on perpendicular orbits, V. Bourrier, C. Lovis, M. Cretignier, R. Allart, et al. A&A, 2021.



2.2. TOI-1278 and its Brown Dwarf

An international team led by iREx researchers **has discovered a brown dwarf near a small star called TOI-1278**. Although relatively easy to detect, few such systems have been identified, suggesting that they are particularly rare.

TOI-1278 is a low-mass red dwarf star located around 245 light-years from Earth. The most common type of star, astronomers are particularly interested in red dwarfs, as it is easier to detect companions around these stars than around more massive ones.

In 2019, TOI-1278 was observed by the TESS satellite, which identified dips in the star's brightness on two occasions, possibly due to the presence of a companion periodically passing in front of it. Thanks to follow-up observations at the Wild Boar Remote Observatory and the Catania Astrophysical Observatory, both in Italy, the **presence of a companion very close to the star at just 0.1 astronomical units was confirmed**.



A team led by Étienne Artigau from iREx used the SPIRou instrument to observe the system in 2020 to determine the mass and nature of the companion. The astronomers were then able to determine that the companion's mass was around 18 times that of Jupiter. It would therefore be a brown dwarf, now named TOI-1278 B, and not a planet.

In theory, companions like TOI-1278 B should be easy enough to spot around small stars. Yet we know very little about them. The few very massive planets and brown dwarfs known around red dwarfs are typically much further away from their host.

This rarity is consistent with the predictions of formation models. **The pair formed by the star TOI-1278 and the brown dwarf TOI-1278 B presents a challenge for theorists**, who find it difficult to explain how it could have formed. Indeed, companions are expected to form either as planets, in a protoplanetary disc, or as stars. TOI-1278 B is too massive to have formed like a planet, but not massive enough to have formed like a star.

TOI-1278 B: SPIRou unveils a rare brown dwarf companion in close-in orbit around an M dwarf, É. Artigau, G. Hébrard, C. Cadieux, T. Vandal, N.J. Cook, R. Doyon, J. Gagné, D. Lafrenière, L. Malo, J. Rowe, S. Pelletier, et al. A.J. 2021.

2.3. Extreme Seasons on the Exoplanet XO-3 b

A study led by iREx and McGill University Ph.D. student Lisa Dang and other iREx researchers has revealed much more about the surprising exoplanet XO-3 b. The planet's eccentric orbit results in winds blowing at the speed of sound and seasonal variations hundreds of times more intense than on Earth.

In a recently published paper, the researchers argue that the giant planet XO-3 b's **eccentric orbit**, **extremely high surface temperatures** (2,000°C; enough heat to vaporise rock), and **very low density** are indicative of the planet's history. These discoveries could help advance scientific knowledge on the formation and evolution of exoplanets and provide a better understanding of the planets in our Solar System.

XO-3 b is an example of a hot Jupiter. These planets are gigantic gaseous bodies like Jupiter, but orbit closer to their star than Mercury does to the Sun. Although there are none in our Solar System, they are relatively common in the galaxy. However, **important questions about their formation remain unanswered**. To find out more, the authors of the study used data from the Spitzer Space Telescope to examine the atmosphere of exoplanet XO-3 b. They observed extreme seasons and measured wind speeds on the planet, obtaining the planet's phase curve during a complete orbit around its host star.

This planet is an extremely interesting target for the study of atmospheric dynamics and inner evolution, as its mass falls into an intermediate category where processes normally neglected for less massive hot Jupiters could come into play. **XO-3 b's orbit is oval**, whereas almost all other known hot Jupiters have circular orbits. This indicates that the planet may have recently migrated towards its star and that its orbit may one day become more circular. The planet's eccentric orbit leads to **extreme seasonal variations**, according to the study.



Photo: NASA/JPL-Caltech/R. Hurt/IPAC

Gaia observations also revealed that the planet is **puffier** than expected. Observations made with the Spitzer Telescope indicate that **the planet produces much of its heat**, as the excess thermal emissions from XO-3 b are not seasonal. It is possible that the excess heat comes from within the planet itself via a **tidal heating process**; the gravitational compression exerted by the star on the planet varies significantly as the oblong orbit moves the planet away from and then closer to the star. The resulting variations in internal pressure generate heat.

Thermal phase curves of XO-3 b: An eccentric Hot Jupiter at the deuterium burning limit, L. Dang, T.J. Bell, N.B. Cowan, D. Thorngren, et al. AJ, 2022.

2.4. Metal Clouds Found on WASP-121 b

An international group of astronomers, including iREx postdoctoral researcher **Jake Taylor**, has revealed surprising atmospheric conditions on the hot Jupiterlike exoplanet **WASP-121 b**. These include **metallic clouds and showers of precious stones!**

The study, published in the journal Nature, presents a detailed measurement of WASP-121 b's atmosphere using the Hubble Space Telescope. This exoplanet, discovered in 2015, is located at a distance of 855 light-years from Earth. WASP-121 b's mass is around 20% greater than that of Jupiter, while its diameter is almost twice as large.



Due to tidal effects, this exoplanet always presents the same face to its star. As a result, the side facing the star — the diurnal side — is always subjected to the star's scorching heat. The night side, on the other hand, is constantly exposed to the coldness of space. By **combining data from the day and night sides**, the team obtained a **global view of an exoplanet's atmosphere** for the first time.

Instead of water clouds like those on Earth, WASP-121 b's clouds are **mainly composed of metals** such as iron, magnesium, chromium, and vanadium. Previous observations have revealed the signature of these metals as gas on the day side. The new Hubble data indicate that on the night side, temperatures drop sufficiently for the metals to condense into clouds. Winds blowing eastward carry water vapor from the day side to the night side and push the metal clouds from the night side to the day side, where they evaporate again.

Aluminum and titanium were not among the gases detected in WASP-121 b's atmosphere. Researchers believe that these metals may have condensed and fallen as rain into deeper layers of the atmosphere. This rain would be very special and completely different from the rains observed on the various bodies of the Solar System. Aluminum, for example, condenses with oxygen to form corundum, a species which, when it includes impurities of chromium, iron, titanium, or vanadium, is known on Earth as ruby or sapphire. **Gem showers could therefore be a common sight on the nocturnal side of WASP-121 b**.

Diurnal variations in the stratosphere of the ultra hot giant exoplanet WASP-121 b, T. Mikal-Evans, D.K. Sing, J.K. Barstow, T. Kataria, J. Goyal, N. Lewis, J. Taylor, et al. Nature, 2022.

2.5. TOI-1452 b: an Ocean Planet?

A team of astronomers led by **Charles Cadieux**, a Ph.D. student at iREx and UdeM, has announced the discovery of **TOI-1452 b**, a **potentially water-covered exoplanet** revealed thanks to various ground- and space-based instruments designed in part in Canada.

TOI-1452 b is an exoplanet orbiting one of two small stars in a binary system 100 light-years away. It is slightly larger and more massive than the Earth, and lies in its star's habitable zone, which enables it to **maintain the right temperature for liquid water to exist on its surface**. Astronomers believe it could be an "**ocean planet**", a type of planet entirely covered by a thick layer of water — a composition reminiscent of some of the moons of Jupiter and Saturn.



In the study published in the Astronomical Journal, the researchers detail the various observations that have been gathered to clarify the nature and characteristics of this exoplanet. An observation of the system by the TESS satellite was the first to put the research team on the trail of this strange exoplanet. **The exoplanet's existence was then confirmed using the PESTO camera at the Observatoire du Mont-Mégantic** (OMM). The OMM observation also confirmed TOI-1452 b's radius.

To determine the planet's mass, the team then observed the system with the **SPIRou** instrument, installed on the Canada-France-Hawai'i telescope. Nearly 50 hours of observation were required to obtain **an estimate of the planet's mass, which is almost five times that of the Earth**. iREx researchers played a key role in analysing the data. Thanks to a highly innovative analysis method they devised, it was possible to reveal the existence of the exoplanet in the SPIRou data.



Photo: G.Hüdepohl/ESO

The exoplanet TOI-1452 b is undoubtedly rocky like the Earth, but its radius, mass, and density suggest that it is a world very different from our own. Among exoplanets, there could be worlds where water is much more abundant, even than on Earth. In recent years, astronomers have spotted several such planets of intermediate size between Earth and Neptune, for which both radius and mass are known. Some of these planets have a density that can only be explained if a large fraction of the mass is composed of materials lighter than those that make up the Earth's internal structure, such as water. These hypothetical worlds have been dubbed "ocean planets", and TOI-1452 b is one of the best candidates according to the models of exoplanet internal structure presented in the study.

N.B.: This paper was the most downloaded of all American Astronomical Society journal articles in 2022.

TOI-1452 b: SPIRou and TESS reveal a super-Earth in a temperate orbit transiting an M4 dwarf, C. Cadieux, R. Doyon, M. Plotnykov, G. Hébrard, F. Jahandar, É. Artigau, D. Valencia, N.J. Cook, E. Martioli, T. Vandal, N.B. Cowan, B. Benneke, D. Lafrenière, S. Pelletier, A. Darveau-Bernier, et al. AJ, 2022.

2.6. Signs of CO_2 on WASP-39 b



Photo: NASA/ESA/CSA/J. Olmsted

In a remarkable demonstration of its precision and accuracy, the James Webb Space Telescope **has detected for the first time definitive evidence of carbon dioxide beyond the Solar System in the atmosphere of WASP-39 b**, a gas giant planet 700 light-years away. **iREx researchers** were part of the discovery team.

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The result, published in the journal Nature, provides important information on the composition and formation of the exoplanet, and demonstrates Webb's ability to detect and measure carbon dioxide in the thinner atmospheres of small, rocky planets.

The team behind the discovery secured time on the telescope as part of an **Early Release Science program**, which has been chosen to collect some of Webb's first data after it began science operations at the end of June 2022. Led by Natalie Batalha of the University of California Santa Cruz, the team includes astronomers from around the world, including iREx members Björn Benneke, Louis-Philippe Coulombe, Caroline Piaulet, Michael Radica, Pierre-Alexis Roy, and Jake Taylor.



The target of the observing program, **WASP-39 b**, is a hot gas giant planet with a mass similar to that of Saturn, and a diameter 1.3 times that of Jupiter. The exoplanet's proximity to its star — one-eighth the distance between the Sun and Mercury — inflates WASP-39 b's atmosphere, raising its temperature to 900°C. With its combination of an inflated atmosphere and frequent transits, **WASP-39 b** is an ideal target for transmission spectroscopy. The team used JWST's near-infrared spectrograph, NIRSpec, to carry out this detection.

Among the new data, the researchers found a significant signal — an absorption line — 26 times stronger than the background at wavelengths between 4.1 and 4.6 microns in the infrared. This is the first clear, detailed, and indisputable evidence of the presence of carbon dioxide ever detected on a planet outside the Solar System.

No observatory has ever before measured such subtle differences in the brightness of so many individual infrared colors in the transmission spectrum of an exoplanet. Access to this part of the spectrum, from 3 to 5.5 microns, is crucial for measuring the abundances of gases such as **water** and **methane**, as well as carbon dioxide, thought to exist in many types of exoplanets. The detection of such a clear carbon dioxide signal on WASP-39 b bodes well for the **detection of atmospheres on smaller, Earth-sized planets**.

Identification of carbon dioxide in an exoplanet atmosphere, The JWST Transiting Exoplanet Community Early Release Science Team, incl. E.-M. Ahrer, T.J. Bell, B. Benneke, C. Plaulet, M. Radica, P.-A. Roy, J. Taylor, L.-P. Coulombe, et al. Nature, 2022.

2.7. The Webb Telescope

After more than twenty years full of twists and turns, challenges and successes, the year 2021-2022 saw the **launch, commissioning, start of science operations, and unveiling of the first images** of the **James Webb Space Telescope** (JWST). Nothing less! Several iREx members are part of the international JWST team and were involved in all these milestones.

By Autumn 2021, the JWST had finally completed the battery of tests designed to ensure that it would survive its journey into space. It was packed up and put aboard a ship bound for the Guiana Space Center in Kourou, French Guiana. Webb's journey at sea lasted 16 days, during which it traveled over 9,000 kilometers. The trip was carried out in complete secrecy, to prevent pirates from interfering with the transport of the impressive observatory.

After Webb's arrival in Kourou, a team of engineers and scientists went there to carrγ out final checks and prepare the telescope for launch. The JWST was finallγ launched at 9:20 AM local time on December 25, 2021. Astronomers from around the world followed the launch live online, but iREx Director and Principal Investigator of the Canadian NIRISS instrument on Webb, René Doγon, was on site in Kourou to experience the launch in person.







Photo: Agence spatiale canadienne

The launch of the telescope was flawless, and the observatory was even able to save fuel given the nominal trajectory of the Ariane 5 rocket. Fuel being one of the limiting factors in the mission's lifespan, the team was pleased to learn that the telescope now has over 25 years' worth of fuel, rather than the 10 years estimated before launch. Deployment of the telescope also went perfectly over 14 days, during which more than 300 single points of failure had to be overcome. Thirty days after launch, the JWST arrived at its final destination in orbit around the Lagrange 2 point (L2), 1.5 million kilometers from Earth.

Over the next five months, engineers and researchers **commissioned the observatory**. This included aligning Webb's segmented mirror and calibrating its instruments. iREx's **Loïc Albert** and **René Doyon**, along with several other Canadian members of the Webb team, went to Baltimore, Maryland to the telescope's operations centre at the Space Telescope Science Institute to commission the Canadian dual instrument FGS/NIRISS. **Webb was declared ready for science in July 2022, with NIRISS being the first instrument declared ready on June 27.**

Webb's first high-resolution colour images were finally unveiled to the public on July 11 and 12. Four images and a spectrum representing several of the mission's prime celestial targets — exoplanets, nebulae, stars, galaxies — were presented by United States' President Joe Biden and several astronomers on the Webb team. The contribution of the Canadian instrument NIRISS was the atmospheric transmission spectrum of the exoplanet WASP-96 b. This spectrum was presented by Nathalie Ouellette, iREx Deputy Director and JWST Outreach Scientist in Canada, and Sarah Gallagher, Science Advisor to the President of the Canadian Space Agency (CSA), live to the media and CSA employees, and rebroadcast on the web. In a first demonstration of Webb's power, the NIRISS instrument was able to detect water vapor in the atmosphere of the gas-giant exoplanet.



In July 2022, the JWST began its scientific observations, including several programs led by iREx researchers during the telescope's first year of operation:



Throughout all these important milestones, **iREx researchers were omnipresent in the Canadian and international media**, commenting on and analysing the mission's milestones and anticipated discoveries.

2.8. OMM

The Observatoire du Mont-Mégantic is a unique research facilitγ for training future astronomers in the use of telescopes. Its Laboratoire d'astrophysique expérimentale (LAE) is a unique design facilitγ for instruments such as SPIRou and NIRPS, in use at worldleading telescopes around the globe.

After having to restrict access to the telescope in the heart of the Mont-Mégantic National Park during the COVID-19 pandemic, the OMM team was finally able to **resume its training activities for students**. Summer interns from iREx and graduate students from the Université de Montréal and the Université Laval spent time at the observatory, learning how to operate the telescope and its instruments, accompanied by our observing technicians and support astronomer.

In January 2022, the NIRPS spectrograph made its long journey from the laboratories of the Université Laval to the La Silla Observatory in Chile. From March to June, it was installed and tested in Chile by members of the OMM's LAE, as well as other members of the collaboration. NIRPS saw its first light in June 2022, and scientific operations are scheduled to begin in April 2023. This is when the instrument will be made available to the entire astronomical community, and the scientific team that helped build the instrument will be able to start benefiting from 740 nights of guaranteed observing time over 5 years.

The **SPIP** camera, a copy of the SPIRou instrument, that will be installed at the Bernard-Lyot Telescope in France is currently being assembled at the LAE. The mechanical part of the project is being carried out at the Université de Montréal, while the optical part is being carried out in the laboratories of the Université Laval. **Tests on the camera will take place at the Université de Montréal in Autumn 2022**, for delivery to France by Christmas 2022.



The **SPIRou** instrument continued its observations at the **Canada-France-Hawai'i Telescope**. Several scientific papers have resulted from the last few years of observations. These include the discovery of a rare brown dwarf companion in a tight orbit around an M-type star.





The iREx team is made up of undergraduate and graduate students, postdoctoral and senior researchers (which include staff), and professors. Our members are based at the **Université de Montréal**, **McGill University**, **Bishop's University**, **the Université Laval**, and the **Planétarium de Montréal**.

Together, we form the largest exoplanet research centre in Canada, and one of the most competitive in the world.





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3.1. Our Team's Growth



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At its inception in 2014, the iREx had barelγ a dozen members. Since then, the iREx team has undergone **impressive growth** thanks to its active recruitment of new students and researchers.

Several new students and a few new postdoctoral researchers joined our team in 2021-2022. Despite our smaller cohort of summer interns this year, we were delighted to be able to **welcome these 11 students**

from across Canada in person for the first time since the start of the COVID-19 pandemic. We also reached a record number of graduate students, 36.

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

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3.2. Changes in our Team

The iREx team includes some of the world's leading researchers who have made significant contributions to many aspects of exoplanetary science. In 2021-2022, we welcomed several new members.



Arrival of Lisa Dang

Lisa Dang completed her Ph.D. at McGill University, within iREx, in **Summer 2O22**. She then joined **the Université de Montréal as a Banting Postdoctoral Fellow**. She will therefore remain at our Institute, where she will pursue her multiple research projects, notably on the study of exoplanets very close to their star, such as hot Jupiters and lava planets. In particular, she will be studying one of these planets with the JWST.



Arrival of Clémence Fontanive

Clémence Fontanive joined the iREx in September 2022 as a Trottier Postdoctoral Fellow at the Université de Montréal. Previously, she completed a Ph.D. at the University of Edinburgh in Scotland, and a three-year postdoctoral fellowship at the University of Bern in Switzerland. Her goal is to constrain the demography of giant exoplanets and brown dwarfs, which she studies using direct imaging and astrometry. At the Université de Montréal, she is concentrating on the study of Y dwarfs, the coolest and dimmest brown dwarfs.



Arrival of Yayaati Chachan

Yayaati Chachan obtained his Ph.D. in planetary science at Caltech, after studying at the University of Cambridge. Since **September 2022**, he has been a **CITA/TSI Postdoctoral Fellow at McGill University** and is actively involved in iREx activities. A specialist in planet formation and atmospheres, he is working to understand, through observations and modeling, how the dust and gas of protoplanetary discs can influence the atmospheres of exoplanets that form there.





Geert Jan Talens, a **JWST postdoctoral researcher at the Université de Montréal between 2018 and 2021**, joined Princeton University in the United States as a postdoctoral researcher in January 2022. He previously completed a Ph.D. in Ignas Snellen's team at Leiden University in the Netherlands. He is a specialist in programs allowing the analysis of exoplanet observations. At the Université de Montréal, he contributed to the simulation and development of data reduction tools for NIRISS, the Canadian JWST instrument.

Departure of Daniel Thorngren

Daniel Thorngren, a Trottier Postdoctoral Fellow at the Université de Montréal between 2019 and 2022, joined the Department of Physics and Astronomy at Johns Hopkins University in the United States as a Davis Postdoctoral Fellow in September 2022. During his time in Montreal, he was particularly interested in understanding the composition and atmosphere of hot Jupiters. At iREx, he was able to develop collaborations with several North American researchers, notably within his new institution and thanks to a sustained collaboration with Prof. Björn Benneke, to apply his theoretical work to real observations.

Departure of James Sikora

James Sikora, a postdoctoral researcher at Bishop's University between 2019 and 2022, left iREx last September to pursue his career at the Anton Pannekoek Institute for Astronomy at the University of Amsterdam in the Netherlands. In recent years, he has led an observing program with the JWST to study an anomalously hot Jupiter-like planet, and another at the Gemini-North Observatory in Hawai'i to collect high-precision radial velocity measurements to study a very young planetary system. He feels that his time at iREx has taught him much about data analysis and has opened up new avenues for his future research projects.



Promotion of Nathalie Ouellette

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In August 2022, Nathalie Ouellette became the Deputy Director of iREx and the OMM. This position was created given the close ties between the activities of the two organisations, particularly in terms of instrumental development and scientific communication. Nathalie, who holds a Ph.D. in astrophysics from Queen's University, was previously iREx Coordinator, and retains her title of Outreach Scientist for JWST in Canada.


Congratulations to our new Masters and Doctors!

Congratulations to McGill's **Timothy Hallatt** and **Mahesh Herath**, who moved on to their Ph.D.s this year under the same supervisor (Eve Lee for the former and Nicolas Cowan for the latter), and to **Déreck-Alexandre Lizotte**, who completed his M.Sc. at Bishop's University with Jason Rowe and is now completing his Ph.D. at UdeM with Prof. Rowe, co-supervised with David Lafrenière. Congratulations also to **Benjamin Leblanc**, **Mélissa Marquette**, and **Myriam Prasow-Émond**, who completed their M.Sc. degrees respectively under the supervision of Jason Rowe (Bishop's), Nicolas Cowan (McGill), and Julie Hlavacek-Larondo (UdeM). Finally, we congratulate three of our members who completed their Ph.D.s in 2021-2022: **Dylan Keating** (supervised by Nicolas Cowan at McGill and René Doyon at UdeM), **Lisa Dang** (supervised by Nicolas Cowan, McGill), and **Rafael Fuentes** (supervised by Andrew Cumming, McGill).

Welcome to our new graduate students!

Welcome to our new M.Sc. student members: **Amalia Karalis** (Eve Lee, McGill), **Marylou Fournier Tondreau** (David Lafrenière, UdeM), **Noah Goldman** (Eve Lee, McGill), **Michael Matesic** (Jason Rowe, Bishop's), **Jared Splinter** (Nicolas Cowan, McGill), **Cheryl Wang** (Eve Lee, McGill), **Katherine Thibault** (David Lafrenière, UdeM), **Alexandrine L'Heureux** (René Doyon, UdeM), and **Leslie Moranta** (Jonathan Gagné, Space for Life and UdeM).



3.3. Awards and Grants



\$1M for POET, Jason Rowe

The Canadian Space Agency has awarded a contract worth \$1.1 million in 2021 for the development of a prototype of a small space telescope dedicated to the study of exoplanets. Jason Rowe, Canada Research Chair, Professor at Bishop's University and iREx member, is the researcher in charge of the project named POET, for Photometric **Observations of Exoplanet** Transits. This mission, identified by the Canadian Astronomical Society's Long Range Plan as their priority recommendation in the category of modest investments in space astronomy, calls for an all-Canadian telescope in orbit as early as 2026 to study and detect exoplanets.



Relève scientifique du Québec Prize, Nicolas Cowan

Nicolas Cowan, Professor at McGill University and member of iREx and the McGill Space Institute, is one of the **finalists for the Prix** Relève scientifique du Québec 2021, an award that recognises the commitment and research excellence of a person aged 40 or under. The Quebec government has thus recognised the excellence of Nicolas Cowan's research on exoplanets, as well as his numerous community services, notably on NASA and Canadian Space Agency committees, which have enabled him to establish links with the research community. It is with great pride that iREx congratulates Nicolas on this award.

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Departmental Centennial Poster Award, Mγriam Prasow-Émond

Myriam Prasow-Émond, an M.Sc. student at iREx, won a **poster award during the celebrations surrounding the centennial of the Department of Physics at the Université de Montréal**. The poster she created to present her research project at the "100 Years of Physics" Day was declared the best by a graduate student and earned her a cash prize of \$250.

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New NSERC Discovery Grant, Jonathan Gagné

Jonathan Gagné, Scientific Advisor at Space for Life's Planétarium de Montréal and Adjunct Professor at the Université de Montréal, has been awarded a Discovery Grant from the Natural Sciences and **Engineering Research Council** (NSERC) of Canada in the 'Early Career Researcher' category. This grant of \$220,000 over 5 years (2021-2026) was awarded to him for the project "Disentangling the Kinematics of the Solar Neighborhood to Calibrate the Ages of Stars and Exoplanets". Among other things, it will enable him to hire interns and graduate students.



Annie Jump Cannon Award, Eve Lee

McGill University Professor and iREx member Eve Lee has received the 2022 Annie Jump Cannon Award from the American Astronomical **Society** (AAS). The award, named in honor of astronomy pioneer Annie Jump Cannon, is given annually to a North American astrophysicist in the early stages of their career. The Cannon Award includes a \$1,500 honorarium and an invitation to speak at a AAS meeting. The selection committee recognised Eve Lee's great qualities as a researcher, which have enabled her to make significant progress in her field of research: the formation of planetary systems.



NovaScience Grant, Caroline Piaulet and the InitiaSciences team

InitiaSciences is an initiative led by iREx Ph.D. student Caroline Piaulet and involves several members of our Institute, including founding member Thomas Vandal and advisor Marie-Eve Naud. In 2022-2023, this initiative, unique in Quebec, will enable a first cohort of young students from groups under-represented in the sciences to acquire genuine research experience, accompanied by young researchers. In 2022, the initiative received a major NovaScience grant from the Ministère de l'Économie et de l'Innovation. iREx is a proud partner of the initiative.

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Teaching Awards, David Lafrenière, Patrick Dufour, and Mγriam Prasow-Émond

Each year, the Petit Nobel competition organised within the Department of Physics at the Université de Montréal recognises excellence in teaching. This year, four members of our Institute were honoured. David Lafrenière won 3rd place for the three courses he taught at the undergraduate level, and Patrick Dufour took 4th place for his 1st-year Introduction to Waves and Vibrations course and his 3rd-year Astrophysics course. As for teaching assistants, M.Sc. student Myriam Prasow-Émond won the FemtoNobel, awarded by the first-year cohort, and Ph.D. student Thomas Vandal the NanoNobel, awarded by the thirdyear cohort. It is a real source of pride for iREx to count scientists who have distinguished themselves in this way through the quality of their teaching among its members!



Excelle Science Prizes, Érika Le Bourdais and Leslie Moranta

In June 2022, two iREx students were awarded prizes in the Chapeau, les filles! competition as part of its Excelle Science component. Érika Le Bourdais, who is starting her M.Sc. degree in astrophysics in Patrick Dufour's group at UdeM, won an Excelle Science – Perseverance Award presented by the Centrale des syndicats du Québec. Leslie Moranta, who has already been doing research for two years in Jonathan Gagné's team at Space for Life and at the UdeM, and who is starting her M.Sc. degree this year, won an *Excelle Science* Award presented by the Ministère de l'Enseignement supérieur. The members of iREx are proud to count these two women, who through their hard work have carved out a place for themselves in the still maledominated field of astrophysics, among their ranks.

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Lumbroso Grant, Marylou Fournier Tondreau and Thomas Vandal

Marylou Fournier Tondreau and Thomas Vandal, both graduate students at iREx, are the first recipients of the Lumbroso Grant for iREx Ambassadors. This scholarship, awarded for the first time in 2022, recognises the leadership, community involvement, and efforts to promote scientific culture to a wide audience of a Université de Montréal iREx graduate student. This scholarship is made possible through a generous donation from Sylvain Lumbroso, a long-time supporter of iREx.



In 2O21-2O22, 9 of our summer interns, 3 of our M.Sc. students and 6 of our Ph.D. students benefited from government or institutional scholarships. For a complete list of recipients, please consult our Directorγ at the end of this report.

OUTREACH



4.1. Public Events



Public and School Talks

Several iREx members are invited to give public and school talks every year. In addition to being researchers, our members are also in-demand science communicators across Quebec and Canada. We give public talks at amateur astronomy clubs, science centres, planetaria, and even bars and pubs. Our astronomers are also invited to meet with primary, secondary, college, and university students in the Montreal area and beyond to talk about exoplanets, space, and the career path of an astronomer.

For a more complete list of our public and school talks, please consult the Appendix at the end of this report.

An Evening with Webb:

ladian Astronomers Using the Next Great Space Telescope



Webb MSI/iREx Panel

A few months before the launch of the James Webb Space Telescope in October 2021, iREx and the McGill Space Institute (MSI) organised a virtual panel discussion about the mission and various scientific programs led by Canadian astronomers who have been selected for the telescope's first year of operations. The panel was moderated by our Deputy Director, Nathalie Ouellette. Astronomers invited to present their research projects were iREx Ph.D. students Lisa Dang and Olivia Lim, and University of Toronto Dunlap Institute Professor Maria Drout. About 100 people joined the live event, and the video has already racked up over 1,300 views on the iREx and MSI YouTube channels.

Science Literacy Week 2021

The iREx participated in Science Literacy Week for the second time in September 2021. During this edition, whose theme was "C for Climate", astrophysicists Frédérique Baron, Marie-Eve Naud, and Nathalie Ouellette presented a virtual talk on the habitability of planets in our Solar System and beyond for primary school children. A lesson to remember: our Earth is fragile and unique, and we must take care of it! Students from 60 classrooms across Quebec and Canada joined the live session and were able to ask their questions to our astrophysicists. The presentation is still available on our YouTube channel and has already accumulated nearly 2,000 views.

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La nuit des chercheuses et des chercheurs 2021

For the second time (the first edition being in 2019 before the pandemic), **Space for Life** organised *La nuit des chercheuses et des chercheurs* in November 2021. The aim of this event is to bring the public closer to the everyday reality of researchers and to chat face-to-face with scientists. The evening kicked off with a talk show called *En terrain inconnu* featuring scientists and their anecdotes from working in the field. Our Deputy Director, Nathalie Ouellette, was one of the guests and talked about her daily life and the observing missions she has taken part in. Later in the evening, the public had the chance to chat with several scientists in a speed dating format, including iREx members Jonathan Gagné and Anne Boucher.

Grande conférence de l'iREx 2021

The Grandes conferences de l'iREx allow a worldclass researcher to visit iREx to interact with its members and present their research and story to the public. Since 2016, we have notably welcomed David Charbonneau (Harvard) and Vicky Meadows (U of Washington).

Exceptionally, for the 2O21 edition, to circumvent the difficulties of inviting an international researcher during the pandemic and to celebrate the imminent launch of the JWST, the Grand conférencier de l'iREx was none other than our Director, **René Doyon**. On **November 17, 2O21**, in front of an **in-person audience of 100 attendees and another 100 online**, Prof. Doyon expressed his enthusiasm for the JWST with his presentation entitled "**Webb: The Countdown is On!**". He was able to share his journey on the project as Principal Investigator of the mission's Canadian instrument for over 20 years and offer a glimpse of some of the telescope's anticipated discoveries.



Webb Launch Campaign

After years of anticipation for the **launch of the James Webb Space Telescope**, the entire iREx team wanted to share their excitement with the world! To mark the **start of the mission in December 2O21**, and Canada and iREx's contributions to the project, the Université de Montréal organised a **promotional campaign for the launch of Webb**. Several **news articles highlighting different aspects of the mission and the involvement of UdeM astronomers** were published in **UdeM Nouvelles**. A **special program** in English and French featuring **René Doyon**, **Olivier Hernandez**, and **Nathalie Ouellette**, all members of iREx and involved at some point in the JWST team, was also shot at the Planétarium de Montréal. Finally, a special edition of *La petite école de l'espace*, hosted by **Frédérique Baron** and **Marie-Eve Naud** with special guests **Olivia Lim** and **Nathalie Ouellette**, was also filmed at the Planétarium and presented to children and their families online in **December 2O21**.



Photo: Université de Montréal

astroMIL 2021

Every year iREx, in collaboration with the UdeM, organises astroMIL, a popular astronomy day on the MIL campus. The 5th edition took place on December 10, 2021, with the theme L'exploration spatiale: le futur est à nos portes. It was the first time that this celebration took place in the winter rather than the summer. Rather than the Perseids meteor shower in August, the Geminids were in the spotlight. For this edition, a panel discussion moderated by science journalist Marianne Desautels-Marissal was the main event. Our guests, Université de Sherbrooke geomatician Myriam Lemelin, astrophysicist and our Deputy Director Nathalie Ouellette, and Canadian Space Agency astronaut David Saint-Jacques, spoke about all facets of space exploration to an audience of around **100 people** at the MIL campus. Following the panel, several amateur astronomers from Montreal discussed and shared their educational resources with members of the public.







SIRA 2022

On February 16, 2022, a new edition of the Soirée d'initiation à la recherche en astrophysique was held at the Université de Montréal, in collaboration with the UdeM Department of Physics and the Centre for Research in Astrophysics of Quebec (CRAQ). This virtual information session attracted 160 students from dozens of different CEGEPs. Several of our members helped to make this new edition a memorable one, including astrophysicists Marie-Eve Naud, Frédérique Baron, and Nathalie Ouellette, as well as two of our M.Sc. students, Marylou Fournier Tondreau and Myriam Prasow-Émond. The students thoroughly enjoyed the various presentations and noted that the session helped them with their reflections on their choice of university program or career orientation.

AstroFest 2022

On May 7, 2022, Space for Life held the AstroFest at the Planétarium de Montréal. At our booth named À l'aventure dans ton système planétaire, run jointly by iREx, Discover the Universe and the CRAQ, young and old had fun imagining and drawing imaginary exoplanets all day. Over 3,000 people turned up for this festive day. During the afternoon, the "Canadian Science with the Webb Telescope" panel, organised by iREx, the Observatoire du Mont-Mégantic and the Canadian Space Agency, showcased several of our members involved in this colossal scientific project. Our Ph.D. students Olivia Lim and Thomas Vandal and our postdoctoral researcher Romain Allart presented their research projects that will be using data from the first year of JWST operations. The panel discussion was moderated by our Deputy Director and Webb's Canadian Outreach Scientist, Nathalie Ouellette, before an audience of **70 people**.





24 Hours of Science 2022

As part of the 24 heures de science event in May 2022, iREx, in collaboration with the CRAQ and the Observatoire du Mont-Mégantic, presented the virtual talk À la découverte de mondes extraterrestres to about 30 classrooms across Quebec. During this activity, students learned more about the multitude of planets that exist in the Solar System and beyond. They were able to take a virtual tour of these worlds, discovering what their environments are like and whether they could support life. They were also able to ask their questions directly to our astrophysicists and hosts, Frédérique Baron, Marie-Eve Naud, and Nathalie Ouellette. The presentation is still available on our YouTube channel and has already accumulated over 600 views.



Photo: N. Ouellette

Eurêka! Festival 2022

At the Eureka! Festival, held from June 10 to 12, 2022 at the Parc Jean-Drapeau, iREx astronomers hosted the UdeM Faculty of Arts and Sciences *Scientifiques de demain* booth. Érika Le Bourdais, our science communication intern, created attractive material for the booth and was joined by Myriam Prasow-Émond, Thomas Vandal, Marie-Eve Naud, Frédérique Baron, and Nathalie Ouellette to host it. Youngsters and families were able to learn more about planetary systems. In front of the booth, our team also helped visitors learn how to safely observe the Sun, in anticipation of the total eclipse that will occur in North America on April 8, 2024.



Mont-Mégantic Popular Astronomy Festival 2022

The **Popular Astronomy Festival** is a unique opportunity for astronomy enthusiasts to enjoy Mont-Mégantic's magnificent starry skies and the ASTROLab's captivating program. The public can even access the OMM dome during the event and look through its telescope! The 2O22 edition took place on **July 13, 14 and 15**, with the theme **The James Webb Space Telescope**. Festival speakers were iREx researcher **Loïc Albert** and **Pierrot Lamontagne**, an iREx Trottier summer intern working with David Lafrenière. Both were able to give a summary of the mission as well as their own contributions to the project and their research programs.

4.2. Content Creation





In 2021-2022, iREx astrophysicists **Frédérique Baron** and **Nathalie Ouellette** continued their podcast, *Les astrophysiciennes*, a project carried out thanks to the support of the Bibliothèque des sciences on UdeM's MIL campus. In each episode, which lasts between 20 minutes and 1 hour, they explore different facets of astrophysics research, in an informal and entertaining setting with their guests. The two latest episodes in this series were about the **Perseids meteor shower** and the James Webb Space Telescope, with special guest **René Doyon**.

ExoBites Video Series

In the Winter of 2020, iREx was awarded a **DIALOGUE** – Volet Chercheur grant from the Fonds de recherche du Québec. The iREx team, led by our Deputy Director Nathalie Ouellette, Outreach Officer Frédérique Baron, and Communications Intern and Ph.D. student Caroline Piaulet, created the ExoBites: a series of short videos in French with English subtitles featuring our researchers talking about exoplanets and astronomy.

In 2021-2022, three new ExoBites were published: 1) The Stars That Dance, 2) Telescopes of the Future, and 3) The Modern Astronomer. The featured astronomers were Anne Boucher, Antoine Darveau-Bernier, René Doyon, Nathalie Ouellette, Loïc Albert, and Lison Malo. These three episodes, available on our YouTube channel and shared by many of our partners, have already accumulated over 51,000 views and many very positive comments. They will also serve as excellent resources for our members' presentations in classrooms and to the public.



Exoplanets in the Classroom

Since February 2021, our team has been hard at work on the project *Des exoplanètes à l'école – des nouveaux mondes à découvrir, au primaire et au secondaire*, which aims to create educational resources on exoplanets and the search for life elsewhere in the Universe for school staff in Quebec. This project is led by iREx at the UdeM with numerous partners, thanks to a grant from the NovaScience program of the Ministère de l'Économie, de *l'Innovation et de l'Énergie*.

In the Fall of 2021, our team continued to work on the design of activities for primary and secondary schools, guided by feedback obtained earlier from teachers. During and after the holidays, we tested four of our primary school activities with nearly fifty classrooms across Quebec. Over the summer, we worked with a dozen high school teachers to finalise the activities and resources for older students. We also began designing a seventh ExoBite video on the transit method with our Sureau science communication intern, as well as a three-part video series named *Des exoplanètes et nous*, featuring our members. We started designing the website that will host all our resources: exoplanetsintheclassroom.ca.

All resources will be on the website by Spring 2023.



Eclipse Quebec

To prepare for the **total solar eclipse** that will take place in **southern Quebec on April 8**, 2024, our outreach team has joined forces with a number of partners to create the **Eclipse Quebec group**. With the CRAQ, Observatoire du Mont-Mégantic, ASTROLab du Mont-Mégantic, Space for Life's Planetarium de Montréal, Discover the Universe, and the Fédération des astronomes amateurs du Québec, we have pooled our efforts and resources together to inform the public and various decisionmakers who will make this event a success. A **website**, <u>eclipsequebec.ca</u>, and an **application** are currently under development. Activities and initiatives will also be organised before and during this unique astronomical event, within our members' institutions..



Our New Website

In the Fall of 2022, iREx unveiled its new website to coincide with the announcement of the renewal of its funding by the Trottier Family Foundation. This version of the website is designed to be more attractive to the public and more accessible to all those who would like to know more about the Institute, our members, events, and projects. A new section called *Exo 101* also provides an overview of several basic concepts in the field of exoplanets, for those who are just beginning to learn about the subject or simply want to know more. Several iREx members have made this impressive update possible: Nathalie Ouellette, Marie-Eve Naud, Frédérique Baron, Chris Mann, and Érika Le Bourdais.

4.3. In the News

A4 | NEWS | CANADA

Peering back through time

Canadian astronomer will be among the first to use the James Webb Space Telescope. Set to launch this month, it will orbit the sun 1.5 million kilometres from Earth

STEVE MCKINLEY

As she woke on a clear, cold March morning in Montreal, Lisa Dang felt the weight of the pandemic bearing down on her.

It had been a long, hard year since the first lockdowns began, there was no end in sight, and she was deeply troubled by the news a few days earlier of six Asian women being shot to death in Atlanta, a symptom of rising anti-Asian sentiment during the pandemic.

during the pandemic. Dang, a 28-year-old PhD candidate at McGill University, is an astronomer. She studies exoplanets –







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MONDAY, DECEMBER 13, 2021 TORONTO STAR

iREx members were more in demand than ever in the media, thanks in part to the manγ milestones of the James Webb Space Telescope mission that took place in 2021-2022 and the public and media's incredible enthusiasm for this ground-breaking mission, from local to international scales.

In 2021-2022, iREx members participated in **30 television interviews**, **98 radio interviews** and **96 print and online interviews**, for a total of **224 media interviews**.

For a more complete list of our media interviews, please see the Appendix to this report.

4.4. Social Media

The **number of subscribers on all iREx social networking platforms continued to grow** in 2021-2022. In the Summer of 2022, iREx created a **new account on the professional networking platform LinkedIn** to reach a new audience and diversify its communication and recruitment strategies.

The **iREx website** saw an **impressive gain of about 300%** in the **number of visits** during the γear, rising from around 110k visitors since its creation in August 2021 to over **400k individual visits in August 2022**.

As of August 31, 2022, iREx had



Facebook subscribers

<u>@iRExoplanetes</u>

1305 Twitter Followers <u>@iExoplanets</u>





<u>exoplanets.ca</u>

@exoplanetes



newsletter subscribers

<u>irex@astro.umontreal.ca</u>





5.1. Cafés iREx

The iREx Cafés are weekly get-togethers that enable iREx members to exchange on news in the field of exoplanets, present their latest results or chat with special iREx guests or each other. The cafés remained in a virtual format in 2021-2022 until May 2022. At that point, the evolution of the COVID-19 pandemic made hybrid Cafés possible.



Our iREx Cafés take several formats depending on our needs: presentations with visual aids, open discussions, or question-and-answer periods. We also often welcome internationally renowned researchers during these meetings. These also enable our members, especially our students, to interact with experienced researchers in a more informal setting.

In 2021-2022, in addition to presentations by iREx members, we continued to use the Cafés as a setting for **discussions** and **mini-training sessions on research-adjacent topics such as equity, inclusion, and diversity and science communication**.

Since most of our summer interns were with us in person from May to August 2022, they were also incorporated into our Cafés. To better meet their needs, as well as those of many of our students, our summer Cafés focused on **presenting and** reviewing fundamental concepts in exoplanetary research, as well as useful resources for researchers.

5.2. Summer Internships

We have welcomed **summer interns** since the iREx was founded. The effervescence and dynamism of the Institute, as well as our prestigious T**rottier Excellence Grants** competition, attract undergraduate students from across the country to work with our researchers.

For the first time, the iREx also offered the **Sureau Grant in Science Communication**, enabling an undergraduate student to work with our outreach team on several of our educational projects. The first recipient of this scholarship in 2022 was **Érika Le Bourdais**.



In the Summer of 2022, we welcomed 11 summer interns, including six Trottier Fellows and one Sureau Fellow! For the first time since the pandemic and the first time since the UdeM Department of Physics moved to the new MIL campus, we were able to welcome our interns in person. Among other things, trainees were able to interact with other iREx members during their Orientation Day in May, their Final Presentations Day in August, the weekly iREx Cafés, and several other professional and social events.

They also had the chance to take part in many of our **educational and outreach activities**, such as our booths at the Planétarium de Montréal's AstroFest and the Eurêka! Festival, the Mont-Mégantic Popular Astronomy Festival, and presentations for high school students. Many of them also **spent time at the Observatoire du Mont-Mégantic**, where they were **trained to use the telescope and its instruments**, and to collect astronomical data.

5.3. InitiaSciences Program



InitiaSciences is a unique program in Quebec that gives **secondary school and CEGEP students from groups under-represented in science their first research experience**, supported by young mentors who are university researchers. This program exists thanks to the volunteer work of a great team of young researchers led by **Caroline Piaulet**, one of our Ph.D. students and the **President of InitiaSciences**. The team also includes several of our members, including **Thomas Vandal**, another of our Ph.D. students, and **Marie-Eve Naud**, our Education and Public Outreach Coordinator, as an advisor.

> In preparation for its first cohort of students in the 2022-2023 school year, the InitiaSciences team has been seeking partnerships and funding. The iREx is proud to be counted among InitiaSciences' first partners and to support this initiative through several in-kind contributions. For the coming school year, two of the InitiaSciences mentors who will be supervising young students are iREx members: André Beaudoin, an M.Sc. student, and Caroline Piaulet. An added bonus of this initiative is that all InitiaSciences mentors receive training in science communication, student supervision, equity and diversity concepts, and other professional development skills.



5.4. EDI Committee

The mission of the **iREx Equity**, **Diversity**, **and Inclusion (EDI) Committee** is to promote the professional integration within our Institute of people from groups traditionally under-represented in physics. This mission is intended to help increase the scientific prosperity of an Institute that is inclusive and proud of its diversity.



The iREx EDI Committee was created to:

- → increase recruitment efforts for people from under-represented groups, at all levels of study and employment,
- \rightarrow promote the integration and retention of these individuals within iREx,
- \rightarrow and to promote diversity in science through iREx.



Members of our Institute continue to learn about issues related to equity, diversity and inclusion through training, presentations, and discussions, which has a significant impact on all our activities.

In 2021-2022, a discussion was organised to promote a **harmonious return to work** for our team in hybrid mode. Our **self-identification form** was presented to our members and used in our recruitment campaigns and to gain a clearer picture of our Institute's membership. The information gathered shows us that a majority of our members are not from under-represented groups, and that we need to continue our recruitment and retention efforts. In particular, the Institute hopes to **better reflect the demographics of Quebec and Canada in the applications it receives for its positions and fellowships**, as well as among its membership at all levels.



The Committee's next major project is to **establish a real action plan** and to continue **working in collaboration with other committees with similar missions**, including those of the physics departments at the UdeM and McGill University and that of the CRAQ, to achieve change on a larger scale.

A big thank you to Nathalie Ouellette and Michael Radica, who have completed their terms on this committee this year, and a warm welcome to new student members Caroline Piaulet and Leslie Moranta, as well as postdoctoral researchers Clémence Fontanive and Romain Allart. Étienne Artigau, Frédérique Baron, David Lafrenière, and Marie-Eve Naud remain on the committee.

APPENDIX



1. Public Events

1.1. SCHOOL AND LIBRARY TALKS

- 1. Vénus, Terre et Mars : une seule planète parfaite pour nous ?, Frédérique Baron, Marie-Eve Naud and Nathalie Ouellette, Science Literacy Week, September 22 2021.
- 2. Ma vie de chercheur en astronomie, Thomas Vandal, Cégep Marie-Victorin, Fall 2021.
- 3. Ma vie de chercheur en astronomie, Thomas Vandal, Cégep du Vieux Montréal, Fall 2021.
- 4. *Ma vie de chercheur en astronomie,* **Thomas Vandal**, Cégep de la Gaspésie et Îles-de-la-Madeleine, Fall 2021.
- 5. *Ma vie de chercheur en astronomie*, **Thomas Vandal**, Cégep de Shawinigan, Fall 2021.
- 6. Un astronome dans votre classe, Thomas Vandal, École primaire Saint-Joseph, Fall 2021.
- 7. *Mieux se comprendre à travers le cosmos*, Nathalie Ouellette, Collège André-Grasset, October 21 2021.
- 8. Exoplanets and the James Webb Space Telescope, Nathalie Ouellette, Skype a Scientist, October 22 2021.
- 9. Une journée dans ma vie de chercheuse, Olivia Lim, Cégep de Saint-Laurent, October 22 2021.
- 10. Presentation, Nicolas Cowan, Marianopolis Physics Society, October 26 2021.
- 11. Exoplanets and the James Webb Space Telescope, Nathalie Ouellette, Exploring by the Seat of your Pants, October 27 2021.
- 12. Une journée dans ma vie de chercheuse, Olivia Lim, Collège de Bois-de-Boulogne, November 2 2021.
- 13. Space Talk, Frédérique Baron, Kingscourt School, November 16 2021.
- 14. Une astronome dans votre classe, Marie-Eve Naud, École primaire Au Millénaire, November 23 2021.
- Unveiling the Cosmos with the James Webb Space Telescope, Nathalie Ouellette, Universitγ of Windsor, 23 novembre 2O21.
- 16. Career Panel, Frédérique Baron, Let's Talk Science, November 23 2021.
- 17. Une astronome dans votre classe, Marie-Eve Naud, École primaire St-André, November 29 2021.
- 18. Exoplanets and the James Webb Space Telescope, Nathalie Ouellette, Skype a Scientist, December 8 2021.
- 19. *Cher.ère.s futur.e.s scientifique | Dear Future Scientists,* Lisa Dang and Nathalie Ouellette, Projet Neptune (Fondation Bleu Métropolis), December 15 2021.

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- 20. Planètes et exoplanètes, Frédérique Baron, Central French Immersion Public School, January 27 2022.
- 21. Exoplanets and the James Webb Space Telescope, Nathalie Ouellette, Skype a Scientist, February 3 2022.
- 22. *Exoplanets and the James Webb Space Telescope*, Nathalie Ouellette, Exploring by the Seat of your Pants, February 9 2022.
- 23. *L'exploration de la planète Mars,* **Nathalie Ouellette**, Café des sciences (Cégep de St-Jérôme), February 11 2022.
- 24. Une astronome dans votre classe, Marie-Eve Naud, École Plein-Soleil, February 16 2021.
- 25. Le télescope spatial James Webb, Nathalie Ouellette, Collège Français, February 22 2022.
- 26. Une journée dans ma vie de chercheuse en astronomie, Marylou Fournier-Tondreau, Collège Ahuntsic, February 17 2022.
- 27. Sommes-nous seuls dans l'Univers, René Doyon, Club de mathématique (Université de Montréal), March 2022.
- 28. Exoplanets and the James Webb Space Telescope, Nathalie Ouellette, Skype a Scientist, March 17 2021.
- 29. Exoplanets and the James Webb Space Telescope, Nathalie Ouellette, Skype a Scientist, March 22 2021.
- 30. Une astronome dans votre classe, Marie-Eve Naud, École Plein-Soleil, March 24 2022.
- 31. Analyse spectroscopique d'étoiles naines blanches, Alexandrine L'Heureux, Collège Bois-de-Boulogne (CapCampus), March 24 2022.
- 32. Le métier d'astrophysicienne, Nathalie Ouellette, Collège Regina Assumpta, March 25 2022.
- 33. Une astronome dans votre classe, Marie-Eve Naud, École Lajoie, March 28 2022.
- 34. Le télescope spatial James Webb, Nathalie Ouellette, Collège Bois-de-Boulogne, March 31 2022.
- 35. Analyse spectroscopique d'étoiles naines blanches, Alexandrine L'Heureux, École secondaire Louis-Riel (CapCampus), March 31 2022.
- 36. *Le télescope Webb et les mondes extraterrestres,* **Nathalie Ouellette**, Deux écoles primaires de Québec, April 8 2022.
- 37. The James Webb Space Telescope, Nathalie Ouellette, Peterborough Science Fair, April 13 2022.
- 38. Une astronome en maternelle, Marie-Eve Naud, École Gadbois, April 11 2022.
- 39. *Le télescope spatial James Webb*, **Nathalie Ouellette**, École secondaire Pincourt, April 2O 2O22.
- 40. Une astronome en maternelle, Marie-Eve Naud, École Eymard, April 28 2022.
- 41. *Finding my Place in the Cosmos,* **Nathalie Ouellette**, Operation Minerva (TELUS Spark Science Centre), May 14 2022.

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- 42. À la découverte des mondes extraterrestres, Marie-Eve Naud and Nathalie Ouellette, 24h de science (Science pour tous), May 16 2022.
- 43. Dessine ton système planétaire, Marie-Eve Naud, Les Scientifines, May 17 2022.
- 44. The James Webb Space Telescope, Nathalie Ouellette, Exploring by the Seat of your Pants, May 18 2022.
- 45. Rencontre avec une astrophysicienne, Nathalie Ouellette, Collège Ville-Marie, May 3O 2O22.
- 46. Une astronome dans votre classe, Marie-Eve Naud, École François-Perrot, June 16 2022.
- 47. Du système solaire aux exoplanètes, Érika Le Bourdais and Pierrot Lamontagne, CanYES, June 16 2022.
- Y a-t-il de la vie ailleurs dans l'univers, Marie-Eve Naud, Camp de mathématiques de l'AMQ (Polγtechnique de Montréal), June 29 2022.
- Les exoplanètes : à la recherche de nouveaux mondes, Érika Le Bourdais, Université de Montréal (CapCampus), Julγ 11 2022.
- 50. Les premières images du télescope spatial James Webb, Nathalie Ouellette, Cap Campus (Université de Montréal), July 15 2022.

1.2. PUBLIC TALKS

- 1. À l'aube d'une révolution cosmique : le télescope spatial James Webb, Nathalie Ouellette, Société d'astronomie du Planétarium de Montréal, September 17 2021.
- 2. De la vie sur Vénus ?, Frédérique Baron, Club des astronomes amateurs de Boucherville, September 22 2021.
- 3. À la recherche de nouveaux mondes, Frédérique Baron, Mensa Québec, September 28 2021.
- 4. An Evening with Webb, Lisa Dang, Olivia Lim and Nathalie Ouellette, Astro McGill and iREx, October 5 2021.
- 5. Les radiotélescope, Pierre Bastien, Club d'astronomie de Dorval, October 21 2021.
- 6. *Le télescope spatial James Webb*, **Nathalie Ouellette**, Fédération d'astronomes amateurs du Québec, October 27 2021.
- 7. The James Webb Space Telescope the countdown is on, **René Doyon**, McLennan Public Lecture (Saint-Mary's University), October 2021.
- 8. La spectroscopie sur le télescope JWST, Loïc Albert, Astropoly, November 4 2021.
- 9. Unveiling the Universe with the James Webb Space Telescope, Nathalie Ouellette, Canadian Undergraduate Physics Conference, November 6 2021.
- 10. The James Webb Space Telescope, Nathalie Ouellette, Royal Astronomical Society of Canada, November 9 2021.

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- 11. *Modélisation et observation des exoplanètes,* **Stefan Pelletier**, Société d'astronomie de Montréal, November 9 2021.
- 12. À la recherche de nouveaux mondes, Frédérique Baron, Musée de la nature et des sciences de Sherbrooke, November 12 2021.
- 13. *The James Webb Space Telescope*, **Nathalie Ouellette**, Canadian Association of Science Centres, November 19 2021.
- 14. James Webb: 3, 2, I... décollage!, Nathalie Ouellette, Coeur des sciences (UQAM), December 1 2021.
- 15. Le télescope spatial James Webb, Nathalie Ouellette, À la découverte de l'Univers, January 27 2022.
- 16. The James Webb Space Telescope, Nathalie Ouellette, Discover the Universe, February 2 2022.
- 17. Presentation, **Eve Lee**, *Queen's Space Conference*, February 4 2022.
- 18. Parlons lunaire : Pourquoi la Lune ?, Lisa Dang, Parlons sciences, February 8 2022.
- 19. Presentation *Girls and Women in Astronomy Event*, **Eve Lee**, Cronyn Observatory, February 11 2022.
- 20. *Explorer l'espace avec Lisa Dang,* Lisa Dang, Exploring by the Seat of your Pants, February 11 2022.
- 21. Les radiotélescopes, Pierre Bastien, Société d'astronomie de Montréal, February 15 2022.
- 22. Le télescope spatial James Webb, Nathalie Ouellette, Club d'astronomie Sorel-Tracy, February 15 2022.
- 23. Presentation, Nicolas Cowan, Montreal Field Naturalists Club, February 16 2022.
- 24. Les dernières nouvelles du télescope spatial James Webb, **René Doγon**, Club d'astronomes amateurs de Boisbriand, March 2022.
- 25. Vers l'infini et l'au-delà, Marie-Eve Naud, Série Ce soir, on jase, April 6 2022.
- 26. Le télescope spatial James Webb, Nathalie Ouellette, Les sciences et les femmes (Quantino), April 7 2022.
- 27. TRAPPIST-I through the eyes of JWST, Olivia Lim, RASC Montreal Centre, April 9 2022.
- 28. De la vie sur Vénus ?, Frédérique Baron, Société d'astronomie du Planétarium de Montréal, April 22 2022.
- 29. *Les astroparticules et le télescope spatial James Webb*, **Nathalie Ouellette**, Club d'astronomie de Mont-Tremblant, April 26 2022.
- 30. Exoplanet Educational Programs, Nathalie Ouellette, Falling Walls Conference, May 2 2022.
- 31. Planètes et exoplanètes, Frédérique Baron, Club d'astronomie Véga (section jeunesse), May 4 2022.
- 32. The James Webb Space Telescope, René Doyon, McGill Space Conference (McGill Bicentennial), May 5 2022.
- 33. *La science canadienne avec le JWST*, **Romain Allart**, Olivia Lim, Nathalie Ouellette and Thomas Vandal, Planétarium de Montréal, Maγ 7 2022.

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- 34. Presentation, Pembroke Private Wealth Management: Lunch and Learn, Lisa Dang, May 15 2022.
- 35. Panel, *Comment financier les organismes de culture scientifique*, **Marie-Eve Naud**, Congrès de l'Association de communicateurs scientifiques du Québec, Maγ 26 2022.
- 36. The James Webb Space Telescope, Nathalie Ouellette, Okanagan RASC, May 26 2022.
- 37. Panel, On se dit tout!, Marie-Eve Naud, Congrès de l'Association de communicateurs scientifiques du Québec, May 27 2022.
- 38. *Nature vs Nurture: How to Build a Galaxy*, **Nathalie Ouellette**, RASC Ottawa, June 3 2022.
- 39. *Exoplanètes à l'êre JWST*, **Pierre-Alexis Roy**, Club des astronomes amateurs de Rosemère, June 6 2022.
- 40. À la recherche de nouveaux mondes, Frédérique Baron, Bibliothèque du Vieux-Saint-Laurent, June 17 2022.
- 41. Le système planétaire TRAPPIST-I, Olivia Lim, Société d'astronomie du Planétarium de Montréal, June 17 2022.
- 42. Unveiling the Cosmos with the James Webb Space Telescope, Nathalie Ouellette, Helen Sawγer Hogg Public Lecture (RASC Annual Meeting, June 25 2022.
- 43. Presentation, Eve Lee, Northern Virginia Astronomy Club, July 10 2022.
- 44. *Les premières images du télescope spatial James Webb*, **Nathalie Ouellette**, Livestream de l'ASTROLab du Mont-Mégantic, Julγ 12 2022.
- 45. *First Images from the James Webb Space Telescope*, **Nathalie Ouellette**, Ask an Astronomer (H.R. MacMillan Space Centre), July 14 2022.
- 46. Les premières lumières de JWST, Loïc Albert, Festival d'astronomie populaire du Mont-Mégantic, July 14 2022.
- 47. *Le télescope spatial James Webb,* **Pierrot Lamontagne**, Festival d'astronomie populaire du Mont-Mégantic, July 15-16 2O22.
- 48. What to see in the sky, Marie-Eve Naud, Life Science Ontario's Breakfast Series: Summer of Science, July 18 2022.
- 49. *First Images from the James Webb Space Telescope*, **Nathalie Ouellette**, Livestream de RASC/Guelph University, July 25 2022.
- 50. Discussion avec une astrophysicienne, Marie-Eve Naud, Bibliothèque d'Amqui, August 8 2022.
- 51. Infrared Space Telescopes, Lisa Dang, The Physics Hours (Canadian Association of Physicists), August 16 2022.
- 52. Unfolding the Universe with the James Webb Space Telescope, Nathalie Ouellette, Global Hands-On Universe Conference, August 23 2022.
- 53. Unfolding the Universe with the James Webb Space Telescope, Nathalie Ouellette, StarFest 2022, August 25 2022.

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- 54. *Nature vs Nurture: How to build a galaxy*, **Nathalie Ouellette**, StarFest 2022, August 26 2022.
- 55. *Exploring the Cosmos with the James Webb Space Telescope*, **Nathalie Ouellette**, Ontario Science Centre, August 27 2022

1.3. PUBLIC EVENTS

- 1. *La nuit des chercheuses et des chercheurs,* **Anne Boucher, Jonathan Gagné and Nathalie Ouellette**, Planétarium de Montréal, November 12 2021.
- Webb : le compte à rebours est lancé!, René Doγon and the iREx Team, La grande conférence de l'iREx (Université de Montréal), November 17 2O21.
- 3. *Le futur de l'exploration spatiale*, **Nathalie Ouellette and the iREx Team**, astroMIL 2O21, (Université de Montréal), December 10 2O21.
- 4. La petite école de l'espace : édition spécial James Webb, Frédérique Baron, Olivia Lim, Marie-Eve Naud and Nathalie Ouellette, YouTube de l'iREx, December 21 2021.
- Soirée d'initiation à la recherche en astrophysique 2022, Frédérique Baron, Marylou Fournier-Tondreau, Marie-Eve Naud, Nathalie Ouellette and Myriam Prasow-Émond, Université de Montréal, February 16 2022.
- 6. *AstroFest 2022,* Érika Le Bourdais, Marie-Eve Naud and Nathalie Ouellette, Planétarium de Montréal, May 7 2022.
- Les chercheuses et chercheurs du futur, Érika Le Bourdais, Marie-Eve Naud, Nathalie Ouellette, Mγriam Prasow-Émond and Thomas Vandal, Eurêka! Festival, June 10-11-12 2022.

2. Media Interviews

2.1. TELEVISION INTERVIEWS

- 1. Particule fantôme, Nathalie Ouellette, Savoir Média, September 24 2021.
- 2. World's Most Powerful Telescope, René Doyon, CTV News, November 22 2021.
- 3. À la découverte du télescope spatial James Webb, Nathalie Ouellette, Salut Bonjour, November 27 2021.
- Webb Space Telescope: Building the Next Discovery Machine, René Doyon, NASA TV, November 3O 2O21.
- 5. Spécial Questions : Quel âge a-t-on sur les autres planètes ?, Nathalie Ouellette, Infoman (Radio-Canada), December 2 2021.
- 6. *Exploration spatiale : la révolution du télescope James Webb,* **René Doγon**, Le téléjournal 18h (Radio-Canada), December 15 2O21.
- 7. Les nébuleuses sombres et les trous noirs, Frédérique Baron, Chasseurs d'étoiles (ICI Explora), December 15 2021.
- 8. Entrevue, *Le télescope spatial James Webb*, **Loïc Albert**, Étienne Artigau and Olivia Lim, YouTube du Cosmodôme, December 22 2021.
- 9. Two key contributions to the James Webb space telescope, Loïc Albert and Lisa Dang, December 23 2021.
- 10. A giant telescope is about to launch into space to explore the origins of the universe, **René Doγon and Olivia Lim**, The National (CBC), December 23 2021.
- Un jour historique pour l'exploration spatiale : le télescope spatial James Webb, René Doγon, Le téléjournal 18h (Radio-Canada), December 25 2021.
- 12. Canada's crucial role in the creation of the James Webb telescope, Lisa Dang, Global News, December 24 2021.
- 13. Un astéroïde potentiellement dangereux passera près de la Terre, Nathalie Ouellette, TVA Nouvelles, January 7 2022.
- 14. James Webb Telescope, Nathalie Ouellette, BBC World, January 8 2022.
- 15. René Doyon et le télescope spatial James Webb, René Doyon, Découverte (Radio-Canada), January 23 2022.
- 16. *Research offers new insights into planets outside our solar system, Lisa Dang, Global News, February 5 2022.*
- 17. Dossiers Ovnis, Frédérique Baron, DocHumanité (Radio-Canada), March 12 2022.

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- 18. Première image du trou noir Sagittaire A, Nathalie Ouellette, Noovo Info, May 12 2022.
- 19. First Images from the JWST, Loïc Albert, CTV News, July 12 2022.
- 20. First Images from the JWST, Loïc Albert, The National (CBC), July 12 2022.
- 21. NASA telescope captures spectacular images from deep in the cosmos, René Doyon, CBC News, July 12 2022.
- 22. *Exploration spatiale : Un télescope d'une puissance jamais vue*, **Nathalie Ouellette**, Le téléjournal 18h (Radio-Ganada), Julγ 12 2022.
- 23. Aux confins de l'Univers, Nathalie Ouellette, Le téléjournal (Radio-Canada), July 12 2022.
- 24. Les Canadiens pourront utiliser James Webb 5% du temps, Nathalie Ouellette, TVA Nouvelles, July 12 2022.
- 25. Les débuts du télescope James Webb épate les experts, Nathalie Ouellette, TVA Nouvelles, July 12 2022.
- 26. Key parts of James Webb telescope built in B.C., René Doyon, Global News B.C., July 14 2022.
- 27. Entrevue avec l'astrophysicienne Nathalie Ouellette, **Nathalie Ouellette**, Y'a du monde à messe (Télé-Québec), July 22 2022.
- 28. New visuals of Jupiter from James Webb Space Telescope, Loïc Albert, The National (CBC), August 23 2022.
- 29. La découverte de l'exoplanète TOI-1452, potentiellement recouverte d'eau, **Charles Gadieux**, Salut Bonjour, August 25 2022.
- 30. La découverte de l'exoplanète TOI-1452, potentiellement recouverte d'eau, Charles Cadieux, TVA Nouvelles, August 27 2022.

2.2. RADIO INTERVIEWS

- 1. *La naissance de la vie dans l'univers,* **Nathalie Ouellette**, Fascinant! (Radio-Canada), September 14 2021.
- 2. Les exoplanètes, à portée d'oeil avec le futur télescope James Webb, Nathalie Ouellette, Fascinant! (Radio-Canada), September 14 2021.
- 3. Dans combien de temps les sondes Voyager atteindront-elles un astre?, Nathalie Ouellette, Moteur de recherche (Radio-Canada), September 15 2021.
- Le film Particule fantôme : Entrevue avec l'astrophysicienne Nathalie Ouellette, Nathalie Ouellette, Du côté de chez Gatherine (Radio-Ganada), September 19 2021
- 5. *Au sujet des sciences humaines et sociale...,* **Frédérique Baron and René Doγon**, Balado UQAM, September 24 2O21.
- 6. Cool Stuff: The James Webb Space Telescope with Prof. René Doγon, René Doγon, The Rational View, September 25 2O21.

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- 7. Infiniment petit ou grand, Nathalie Ouellette, Spécialiste en la matière, (Musée d'art de Joliette), September 28 2021.
- 8. Une nouvelle théorie pour la formation des planètes comme la Terre et Vénus, **Frédérique Baron**, Les années lumière (Radio-Canada), October 3 2021.
- 9. *Mise à jour sur le lancement du télescope James Webb*, **Nathalie Ouellette**, Sur le vif (Radio-Canada), October 8 2021.
- 10. *Existe-t-il de la matière peu ou pas sujette à la gravité ?*, **Nathalie Ouellette**, Moteur de recherche (Radio-Canada), October 19 2021.
- 11. Jasette à SpaceCast, Marie-Eve Naud, SpaceCast (Radio X), October 25 2021.
- 12. La mission DART de la NASA, Nathalie Ouellette, Mario Dumont (QUB Radio), November 7 2021.
- 13. *Est-ce qu'il existe une limite au nombre de planètes qu'une étoile peut avoir ?*, **Nathalie Ouellette**, Moteur de recherche (Radio-Canada), November 16 2021.
- 14. Une nouvelle mission de la NASA qui va décoller le 23 novembre est digne du film Armageddon, Nathalie Ouellette, 98.5 FM, November 7 2021.
- 15. The James Webb Space Telescope, Nathalie Ouellette, Reach out and Touch Space (AstroRadio), November 11 2021.
- 16. Décrocher les étoiles, Nathalie Ouellette, Kaleido Balado, November 26 2021.
- 17. Webb Space Telescope: Building the Next Discovery Machine, René Doyon, Curious Universe (NASA), November 30 2021.
- 18. *Le télescope spatial James Webb*, **Frédérique Baron**, **René Doyon and Nathalie Ouellette**, Les astrophysiciennes (balado de l'iREx), December 2 2021.
- Émission spéciale sur le télescope spatial James Webb, Lisa Dang, René Doγon, David Lafrenière and Nathalie Ouellette, Les années lumière (Radio-Canada), December 12 2021.
- 20. JWST is Ready for Launch and Amazing Science, René Doyon, The Planetary Society, December 15 2021.
- 21. Pourquoi le télescope James Webb sera-t-il situé au point Lagrange L2?, Nathalie Ouellette, Moteur de recherche (Radio-Canada), December 15 2021.
- 22. Le long voγage du télescope spatial James-Webb, René Doγon and Nathalie Ouellette, Agence Science Presse, December 15 2021.
- 23. Le télescope spatial James Webb, Nathalie Ouellette, L'heure du monde (Radio-Canada), December 17 2021.
- 24. Le Cancre Pédagogue reçoit Marie-Eve Naud de l'Institut de recherche sur les exoplanètes, Marie-Eve Naud, Le Cancre Pédagogue, December 20 2021.
- 25. La petite école de l'espace : entrevue avec Marie-Eve Naud, Marie-Eve Naud, Par ici l'info (Radio-Canada), December 21 2021.

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- 26. Quels risques avec les astéroïdes, Nathalie Ouellette, Le midi (98.5 FM), December 23 2021
- 27. Lancement du télescope James Webb, Nathalie Ouellette, Tout un matin (Radio-Canada), December 24 2021.
- 28. Lancement du télescope James Webb, Nathalie Ouellette, Toujours le matin (Radio-Canada), December 24 2021.
- 29. *Le télescope James Webb sera lancé demain*, **Nathalie Ouellette**, Les matins d'ici (Radio-Canada), December 24 2021.
- 30. Lancement du télescope James Webb, René Doyon, 15-18 (Radio-Canada), December 25 2021.
- 31. Le télescope spatial James Webb avec René Doyon, astrophysicien, René Doyon, Pénélope (Radio-Canada), December 28 2021.
- 32. La fusée qui transporte le télescope James Webb a été lancée le matin de Noël, **Nathalie Ouellette**, Le midi (98.5 FM), December 28 2021.
- 33. *Ailleurs dans l'univers avec Nathalie Ouellette, astrophysicienne,* **Nathalie Ouellette**, 2021 Dernier rappel (Radio-Canada), December 28 2021.
- 34. Des dizaines de planètes errantes, Loïc Albert, Les années lumière (Radio-Canada), January 9 2022.
- 35. The James Webb Space Telescope will map the atmosphere of exoplanets, Louis-Philippe Coulombe, Mid-morning with Shane Ganam (CHED), January 10 2022.
- 36. The James Webb Space Telescope, Lisa Dang, Today Explained (Vox Media), January 15 2022.
- 37. Les nouvelles du télescope spatial James Webb, **René Doyon**, Les années lumière (Radio-Canada), January 16 2022.
- 38. In which direction will the James Webb Space Telescope be looking?, **René Doγon**, Quirks & Quarks (CBC), January 2O 2O22.
- 39. La stratégie canadienne de l'observation de la Terre par satellite, **Nathalie Ouellette**, Sur le vif (Radio-Ganada), Januarγ 2O 2O22.
- 40. La stratégie canadienne de l'observation de la Terre par satellite, Nathalie Ouellette, La croisée (Radio-Ganada), Januarγ 20 2022.
- 41. La stratégie canadienne de l'observation de la Terre par satellite, Nathalie Ouellette, Panorama (Radio-Canada), January 2O 2O22.
- 42. La pollution lumineuse à Montréal, Jonathan Gagné, Midi Info (Radio-Canada), January 21 2022.
- James Webb nous aidera-t-il à voir de la vie ailleurs que sur la Terre ?, Nathalie Ouellette, Moteur de recherche (Radio-Ganada), January 25 2022.
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