Annual Report

Research Institute Leiden Observatory

Onderzoeksinstituut Sterrewacht Leiden

INDEX

FOREWORD

Dear Reader

Corona. This is the one word that describes this year. At the beginning of 2020 we slowly began to realize the seriousness of the situation. The intelligent lockdown started on March 23rd, and had a very large impact on the institute. Education, in particular, had to deal with major challenges. All lectures were stopped for one week to give all the lecturers and their teaching assistants time to completely transform their way of working to online teaching only. On page 18 our director of education, Harold Linnartz, sketches how this was organized and what the impact of Corona was on our education during the rest of the year. I would like to take this opportunity to give my sincerest thanks and gratitude to Harold, all the lecturers, and the education office for their hard work in ensuring that our education program continued.

During pre-Corona times, a normal day at the office would include a variety of small and large meetings, lunch talks, and colloquia, and, at the end of the week, the traditional borrel. This fabric, which is so important for moral and a feeling of belonging, completely disintegrated. Immediately after the lockdown, we started well-attended, institute-wide, weekly zoom sessions where the first two speakers were always our institute manager Evelijn Gerstel informing us about the latest university rules and regulations related to Corona measures, and Harold bringing us the latest news from the education front. After some further announcements, we would then have the pleasure of listening to a Sterrewachter giving a science talk. Possibly most memorable, though, were the musical performances we regularly had at the end. It was amazing to find out what a variety of musical talent we have in the house. Most vividly, I remember our own Helgi Hrodmarsson, who used to play in Carpe Noctem, a famous Icelandic band, explaining to us all the intricacies of extreme metal drumming before showing us the most recent clip of their performance. Yamila Miguel assembled a small team to form a social support committee to see what we could do to help each other. This led to a number of activities including, importantly, the surveys that asked each of us how we were doing. These surveys provided further evidence that life was not easy, especially for foreign master and PhD students and postdocs that had moved to Holland, and for people with young kids that needed some form of home-schooling. One very nice initiative was the establishment of a buddy system, so that people would find it easy to, for example, drink coffee together, all over Zoom.

And what about research? At first sight, things continued as usual, and a number of scientific highlights are given in this yearly report. Most of our science teams were already spread out geographically so for us using video conferencing was not something new. Indeed, if you, for example, count our number of published papers (640, see page 39), this is still an impressive showing. However, this is almost 15% lower than last year, suggesting that Corona is also taking its toll on our publication rate. In addition, a significant number of PhD students had to delay finishing their thesis and only 9 PhD students defended their PhD, which is about a factor of two less than normal. And yes, the PhD defenses were also done remotely and the traditional dinners and parties were dearly missed.

The very sad news of this year was that Jet Katgert passed away at the age of 76. Working in extragalactic radio astronomy she wrote a PhD thesis under the supervision of Oort and was awarded a PhD in 1970. With her organizational skills, pleasant character and sharp mind, she has been an important figure in Dutch astronomy: after several postdoc positions, she worked as an Executive Secretary of ASTRON, published a book, "The manuscripts and correspondence of Jan Hendrik Oort", and was a language editor for A&A. It is very fitting to see that this yearly report contains such a warm in memoriam, so well written by Harm Habing.

The good news is that this year there are also a number of things to be extremely proud of: Emiel Por was awarded a Hubble Fellowship, Jorryt Matthee received the MERAC-prize by the European Astronomical Society for the best PhD Thesis in observational astrophysics in the past three years, and Huib van Langevelde was appointed as the new director of the Event Horizon Telescope and tasked with ensuring new results to follow the amazing 'pictures' of the black hole of M87. Finally, Ewine van Dishoeck was elected Member of the American Philosophical Society, an honour she shares with former members Charles Darwin, Louis Pasteur and Albert Einstein – certainly good company!

Overviewing this year, I am very grateful to all members of the Sterrewacht for their enormous efforts to what we collectively have done: continue to carry out the vast majority of our tasks in these difficult circumstances. Also, I am very thankful for the help and support, in whatever form, Sterrewachters have given to their fellow Sterrewachters. While I am writing this, I have just had my second vaccination and we are all preparing to go back to some form of normal. Due to the climate crisis, less travel seems unavoidable. Furthermore, working at home for a significant fraction of our time will clearly be acceptable. Possibly the greatest challenge is for education: how can we optimally combine the advantages of online teaching with personal contact? Only time will tell.

Huub Röttgering, Director

LEIDEN OBSERVATORY

The mission of Leiden Observatory is to carry out world class astronomical research, provide education at the bachelors, masters, and PhD level, and inform the general public about the most exciting astronomical results and the beauty of the Universe. Our research is wide ranging, with a particular emphasis on observational and theoretical studies of galaxies and the structures in which they are embedded, on exoplanets, and on star and planet formation.

The Observatory and its people

Sterrewacht Leiden was founded by Leiden University in 1633 to house the quadrant of Snellius, making it the oldest operating university observatory in the world. While originally located at the main Faculty Building of the university, a purpose-built observatory was constructed in the university's botanical gardens in 1860. Since the mid-1970s the institute has been located within the campus of the Faculty of Science. A long list of eminent astronomers has populated the Sterrewacht, including Profs. Willem de Sitter, Ejnar Hertzsprung, Jan Oort, Adriaan Blaauw, and Henk van de Hulst. Currently, Leiden Observatory is proud to be one of the largest and top astronomical research institutes in Europe. It has 24 full time scientific staff members, about 55 postdoctoral researchers, 90 PhD students, 118 Masters students and 265 Bachelor students. Among its professors are three Dutch Spinoza Prize winners: van Dishoek, Franx and Tielens. Prof. Tim de Zeeuw was the Director General of the European Southern Observatory – the largest observatory in the world, and Prof. Ewine van Dishoeck is the president of the International Astronomical Union (2018 – 2021).

Research and Technology

Leiden Observatory is part of the Netherlands Research School for Astronomy (NOVA). Scientific research at Leiden Observatory ranges from studying how the Earth and the Solar System have formed and how this compares to other planetary systems, to the origin and evolution of the Milky Way and the Universe as a whole. Observations play a central role in astronomical research, and the state of the art instrumentation is almost exclusively built and operated through international collaborations. Optical and infrared ground-based observations are mostly conducted with telescopes from the European Southern Observatory (ESO) in Northern Chile, and from the Isaac Newton Group (ING) on La Palma (Canary Islands, Spain). Flagship telescopes at other wavelength regimes are the Atacama Large mm/sub-mm Array (ALMA) in Chile and the international Low Frequency Array (LOFAR), which has its core in the north of the Netherlands. Other observations can only be conducted from space, meaning that Leiden astronomers also frequently use the NASA Hubble Space Telescope. A second pillar of astronomical research is theoretical and astrochemistry modeling. Large-scale numerical simulations and big data are key ingredients of astronomical research. Leiden Observatory hosts the Laboratory for Astrophysics, which carries out unique experiments to simulate inter – and circumstellar conditions in a controlled environment.

Leiden Observatory is also focused on driving the development of key technologies that will enable future astronomical discoveries. Close collaborations with Dutch partners are crucial, such as the NOVA optical group at ASTRON, TNO Delft, the Netherlands Institute for Space Research (SRON), and Airbus (Leiden). Ultimately, most instruments are built in international consortia under the umbrella of ESO or the European Space Agency (ESA). In this way, Leiden astronomers play important roles in the development and operation of the ESA's GAIA and EUCLID missions. Leiden professor Bernhard Brandl is the NOVA principal investigator of METIS, one of the first light instruments of the future Extremely Large Telescope (ELT).

Bachelor and Master education

Leiden Observatory is part of the Faculty of Science and hosts both the Bachelor and Master studies in astronomy of Leiden University. By the end of the year the three year bachelor in astronomy is followed by about 265 students, and provides a broad basis in astronomy, with important components in physics, mathematics, and informatic. In the same period the two year masters in astronomy is followed by about 118 students. Since it is fully taught in English it is also very popular among non-Dutch students. The master not only prepares students for a scientific path, but also launches careers in business or industry.

Public Engagement

An important task of Leiden Observatory is to engage the general public with the wonders of the universe, and share the scientific, technological, cultural, and educational aspects of astronomy with society. It operates a modern visitor centre at the historic observatory building in the centre of town, where the astronomy student club L.A.D.F. Kaiser conducts about two hundred guided tours per year of the antique telescopes.

Calendar of Events 2020

JANUARY

New Year's coffee Sterrewacht & Physics [06]

FEBRUARY

Movie night organized by The Netherlands Space Society (NVR) and the International Institute of Air and Space Law (IIASL) [05]

PhD recruitment days [10]

"Pale Blue Dot" Symposium Oude Sterrewacht [14]

Piet van der Kruit presented the Dutch version of his Oort Biography called: "Horizonnen" [21]

Open Day [22]

Leiden astronomers ask the general public to identify LOFAR radio galaxies (Leidsch Dagblad) [27]

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The start of the "Intelligent lockdown" of the University [16]

Emiel Por awarded a NASA Hubble Fellowship as a Sagan Fellow at the Space Telescope Science Institute [30]

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MAY

IAU president Ewine van Dishoeck presents the "IAU 100" Report [26]

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JULY

Astronomer Dr. Jorryt Matthee receives MERAC-prize for PhD Thesis: "Identifying the origins of galaxy formation" (2018)	[02]
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Huib Jan van Langevelde new director Event Horizon Telescope	[21]

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The SpaceEU project, coordinated by Leiden University	[19]

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First direct detection of a brown dwarf with a radio telescope	[09]
YouTube channel for exoplanet researchers opens	[30]

DECEMBER

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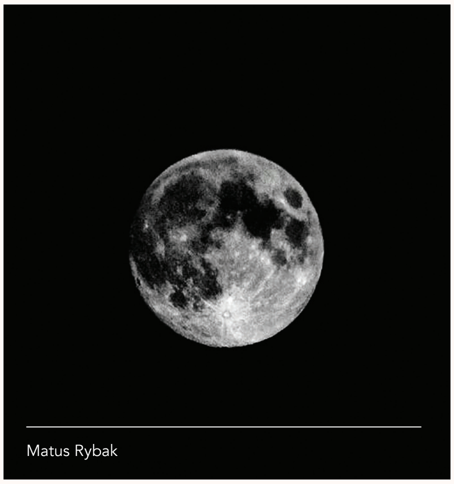
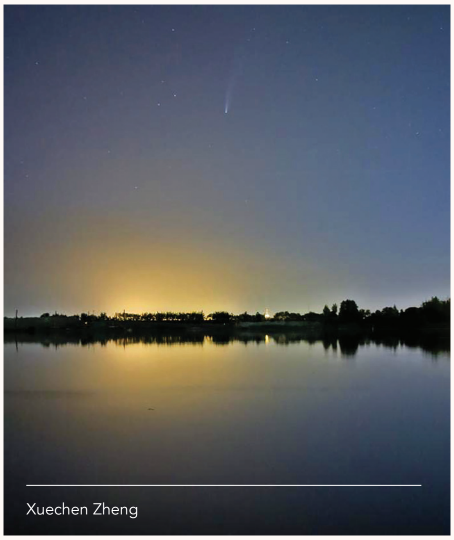
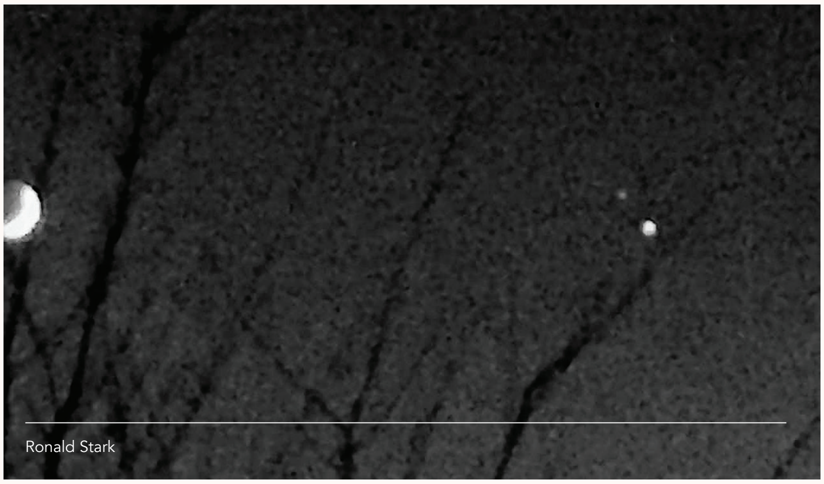
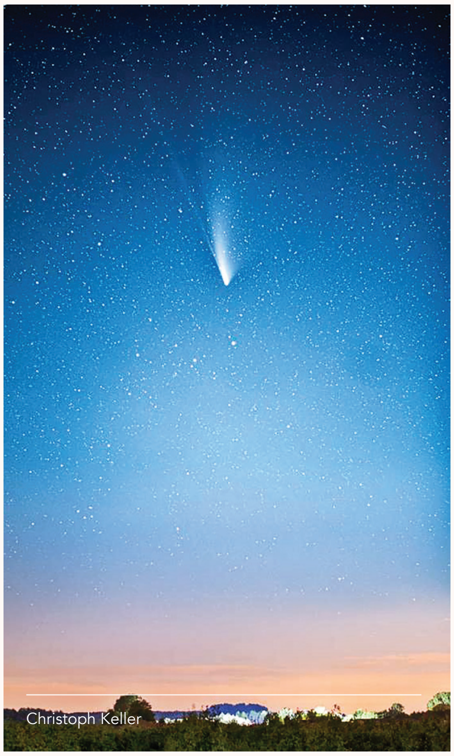
Sinterklaas online visit to Special Observatory Seminar	[04]
Social Distancing Xmas Dinner – cooking together	[17]
Dutch collaboration wins HPC Innovation Excellence Award for the first time	[21]

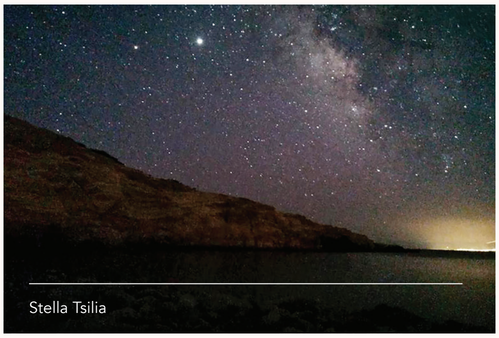

Brent Maas


Matus Rybak


Xuechen Zheng


Ronald Stark


Christoph Keller



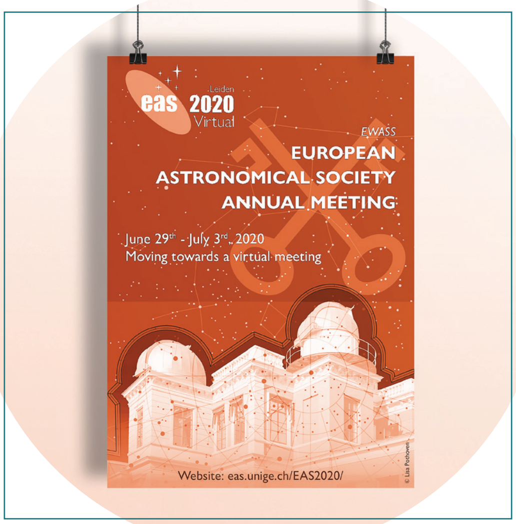
Stella Tsilia

Aleksandar Shulevski

Aleksandar Shulevski

Melissa McClure

A YEAR WITH CORONA +

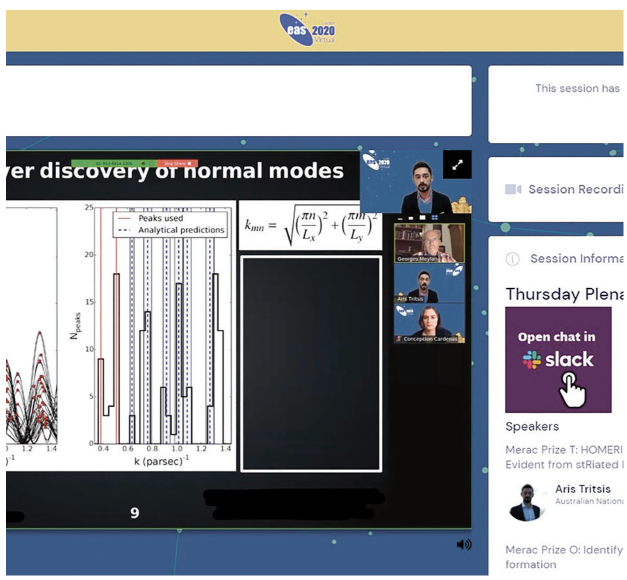


The European Astronomical Society annual meeting 2020 –
the largest virtual conference in astronomy to date

Leo Burtscher
Alexandra Schouten
Joop Schaye
Huub Rottgering

Due to the ongoing Coronavirus pandemic, the European Astronomical Society (EAS) decided at the end of March 2020 to change its annual meeting in June to a virtual format. When these lines were written in early 2021, it is hard to imagine the dramatic shift this represented at the time. Never before had a big astronomical society meeting, or any astronomy meeting of this scale, been organised entirely online.

Despite its online format, the conference was still marketed as a "Leiden" conference since the Sterrewacht provided the head of the SOC (Joop Schaye), the hosting committee (headed by Huub Röttgering), the project manager (Alexandra Schouten-Voskamp), as well as many local volunteers. Together with the "EWASS board", the EAS body in charge of managing the conference, and the conference organisation company KUONI, the conference was set up using the novel OnAir platform, developed by the Australian software company EventsAIR. Participants



EAS website

joined the platform via their web browser and saw an interactive programme that linked to Zoom webinars that were embedded in the browser window. OnAir also provided (video)chat functionality, conference-wide announcements and "speed dating" functionality to get to know a random set of participants for a few minutes during the breaks. In addition to OnAir, a Slack space was installed that offered persistent (offline available) discussions in a number of channels, as well as group chats. Last but not least, an experimental social online session was organised during the conference on the gather.town platform, which allowed participants to move their avatar on a two-dimensional landscape and start video chats with everyone in their neighbourhood.

The conference was a tremendous success. Almost all of the session organisers accepted the shift to an online meeting: Only four out of the 51 EAS sessions were cancelled, and all of the 14 NAC sessions that were organised in parallel, took place. The fee was set at a very low level (80 € for the full conference; 50 € for one day), and allowed widespread participation, also by students or by researchers from lower-income countries. 1777 participants registered for the conference, a plus of more than 40% compared to the 2019 in-person meeting in Lyon. 88% of all participants also registered for the Slack space and almost everyone (95%) who registered read or wrote at least one message there, leading to a total of 40,000 exchanged messages during the week of the conference. Based on our exit survey, participants typically took part in four out of the five days of the conference and then spent on average 5.5 hours on the virtual platform per day. Approximately ⅕ of all participants said that they would not have been able to participate in the meeting if it had not been held online. An analysis of the carbon emissions further showed that the online meeting in 2020 produced at least 3000x lower CO_2 equivalent emissions than the in-person conference in Lyon in 2019 (Burtscher et al. 2020).

While the in-depth analysis of the EAS 2020 exit survey is still to be completed, the general impression from the conference was very positive. There were no major technical glitches, the participation rate was high and the question & answer sessions lively. Obviously, not all was perfect, however. After all, EAS 2020 was a first of its kind. While structured interactions (such as during talks) worked well, informal discussions were less easily facilitated and some participants said they found it hard to make new connections, as compared to reinforcing existing connections. In addition, a good format for social interactions at online conferences is yet to be found. In contrast to traditional conferences, where social interactions happen during the breaks and after the programme, virtual conferences require dedicated time for bonding and networking, in addition to, rather than during, on-screen breaks. There is reason to believe, however, that these hurdles will eventually be overcome. After all, we had only one year of optimizing massive online conferencing so far, but decades, if not centuries, to optimise traditional conferences. The technological, and also societal, progress for efficient online conferences is advancing rapidly, however, and is the subject of major (online) symposia itself (e.g. Moss et al. 2021). Advanced technologies that have the potential to revolutionise online meetings, such as virtual reality goggles or holographic projections have either already arrived or are in advanced stages of development.

In 2021, Leiden will again be the host of the EAS annual meeting. This meeting will again be held virtually using the OnAir platform, which has seen significant development over the last year. Given the immense benefits of online conferences in terms of inclusivity, accessibility, and sustainability, it will be hard to imagine that the astronomy community returns to "business as usual" when the Corona pandemic will have ended.

– Burtscher et al., Nat. Astro, Sep 2020
– Moss et al., Nat. Astro, March 2021

Oort Huygens reception

LEAPS

The (online) Leiden/ESA Astrophysics Program for Summer Students (LEAPS) 2020 has resulted in eight amazing students giving their final presentation via zoom.

Yun-Hsin Hsu	"Dissecting Massive Galaxies with Color Information"
Xiaohan Wang	"Generating maps of properties with an image-to-image Network"
Celia Mulcahey	"Star Formation and AGN Feedback in the Local Universe"
Lucie Scharre	"Protons in the innermost coma of comet 67P/Churyumov Gerasimenko observed by Rosetta"
Rowan Dayton--Oxland	"Impact of using a collisional plume model on detecting Europa's water plumes from a flyby"
Fahim Rajit Hossain	"Detecting TiO in High Resolution Transmission Spectra of the Hot Jupiter WASP 76b"
Fergus Donnan	"Determining the Orientations of Proto-Planetary Disks with VLTI-MATISSE"
Raphaël Meshaka	"Modeling the emission of complex organic molecules around nascent Sun-like stars"

LEAPS students

Teaching & Corona

Prof. dr. Harold Linnartz

Director of Studies Astronomy

On March 13th 2020, it was decided that all regular teaching would halt, effective immediately – corona did not allow campus activities any longer. In a period of only one week, all bachelor and astronomy courses had to be transferred into a full online-only curriculum and from March 23rd remote teaching became the 'new standard'. The educational life of lecturers, educational support staff and students drastically changed overnight. Kaltura, remote teaching both from and at home, prerecorded and/or live lectures, online exams and proctoring, graduation talks and master exam ceremonies, hundreds of online meetings, to coordinate and to stay in touch, this all became daily practice. From March through to the middle of May, access to the Observatory buildings was forbidden. This impacted many and in particular the bachelor and master students who were in the middle of their research projects. Several of our international students decided to go home and to continue their studies even more remotely. In-person contact was reduced to a minimum and despite all these constraints, we managed to keep things running and to realize most of our learning goals. Chapeau ! To our students who adapted quickly to the new situation, to our lecturers who managed to adapt their teaching and way of examining in the most effective and creative ways and the education office staff that helped in providing all the logistical support to keep things running.

At the end of the spring semester 2019 – 2020, after a strict lockdown and people taking care of the Corona measures, the number of infections started to decrease. The buildings opened for research related activities which also involved bachelor and master research projects. We even managed to organize the bachelor graduation ceremony on location; in August nearly 50 astronomy students obtained their degree in the Corpus Congress Centre, and in the presence of family/friends (restricted to a maximum of three).

Summer 2020 started promising, with a minimum in the number of Corona infections, but with the turn in this number, a limited number of test facilities and vaccines still far away, it became clear that the start of the new academic year had to be organized differently, in a Corona-safe way introducing hybrid teaching, with at least one full day on campus at 1.5 meter social distancing, face masks and cleaning hands wherever possible. This came with quite some logistical challenges as the number of students in lecture rooms was reduced to typically 20% of its normal value. We realized that our new first year students, both in bachelor and master, needed extra attention, with the aim to make them familiar with Leiden Observatory and their lecturers and also to inform them on the way teaching is organized. Moreover, we wanted our new students to be able to meet, to talk to each other in real and to support each other in their studies. This was realized by a special biweekly 'Tutoraat' meeting and by providing access to our buildings to meet with TA's during problem sessions of some of our key courses or with master supervisors to discuss research projects. A remote teaching facility was realized for lecturers to further increase the quality of the online lecturing. Considerable effort was also put into improving remote teaching, using quizzes, breakout rooms, having TA's participating in lectures and assisting via chat functions, by inviting 'remote teachers' from all over the world to give a guest lecture.

In Autumn 2020, the Corona numbers further worsened. Higher education was allowed to continue with hybride teaching and with exams largely on location. "Business as usual" we were told. Looking back to 2020 we saw that many of the numbers we use for a quality check stayed quite stable, even improved, but at the same time we realized that both students and staff were suffering from the lack of in-person contact, social isolation in a number of cases, personal concerns and many extra hours of work.

The new year 2021 did not start much better, but there is perspective. With the number of vaccinations increasing, hope exists that the next academic year will improve. Once we see that regular teaching becomes possible again, we will evaluate which elements of remote teaching we should decide to keep and can use to strengthen the way we teach our regular curriculum – hopefully from 2021 – 2022 onwards.

Leiden Observatory Social Support Committee

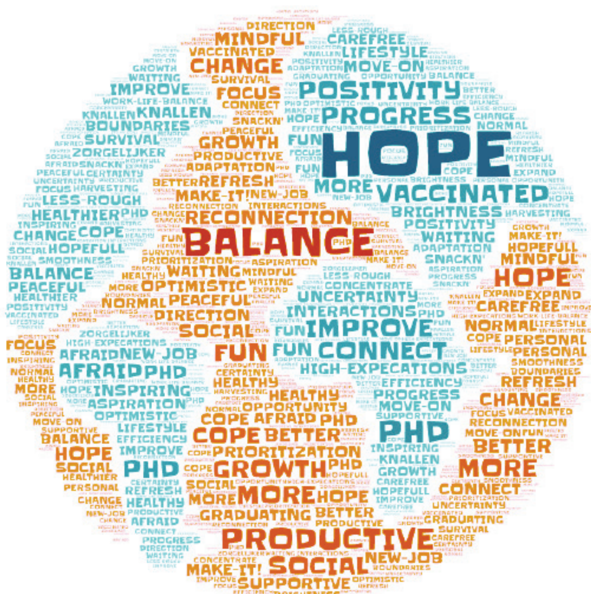
Sarah Leslie
on behalf of the SSC

In March 2020, our lives were turned upside-down as the number of COVID-19 cases grew and lockdowns were announced in the Netherlands and around the world. One year later, it is still not clear what the long-term impacts will be on our academic careers, mental health, and society in general. The Leiden Observatory Social Support Committee was formed in March 2020 in response to the novel COVID-19 pandemic and social distancing measures. We monitored staff and student well being through short confidential surveys sent out to the observatory on a monthly basis. The committee members followed up with those who indicated they had concerns and reported any particular trends or issues raised to the Director.

It was helpful to show (quantitatively) that those adversely affected by the pandemic and the work-from-home conditions in terms of mood and productivity were not (and are still not) alone. General results from the surveys were presented at the weekly department seminar (on zoom) during 2020, at which we would also emphasise the need for compassion for ourselves and others, and advertise any resources or events run by the University.

WORD THAT REFLECTS 2020

INTENTION FOR 2021



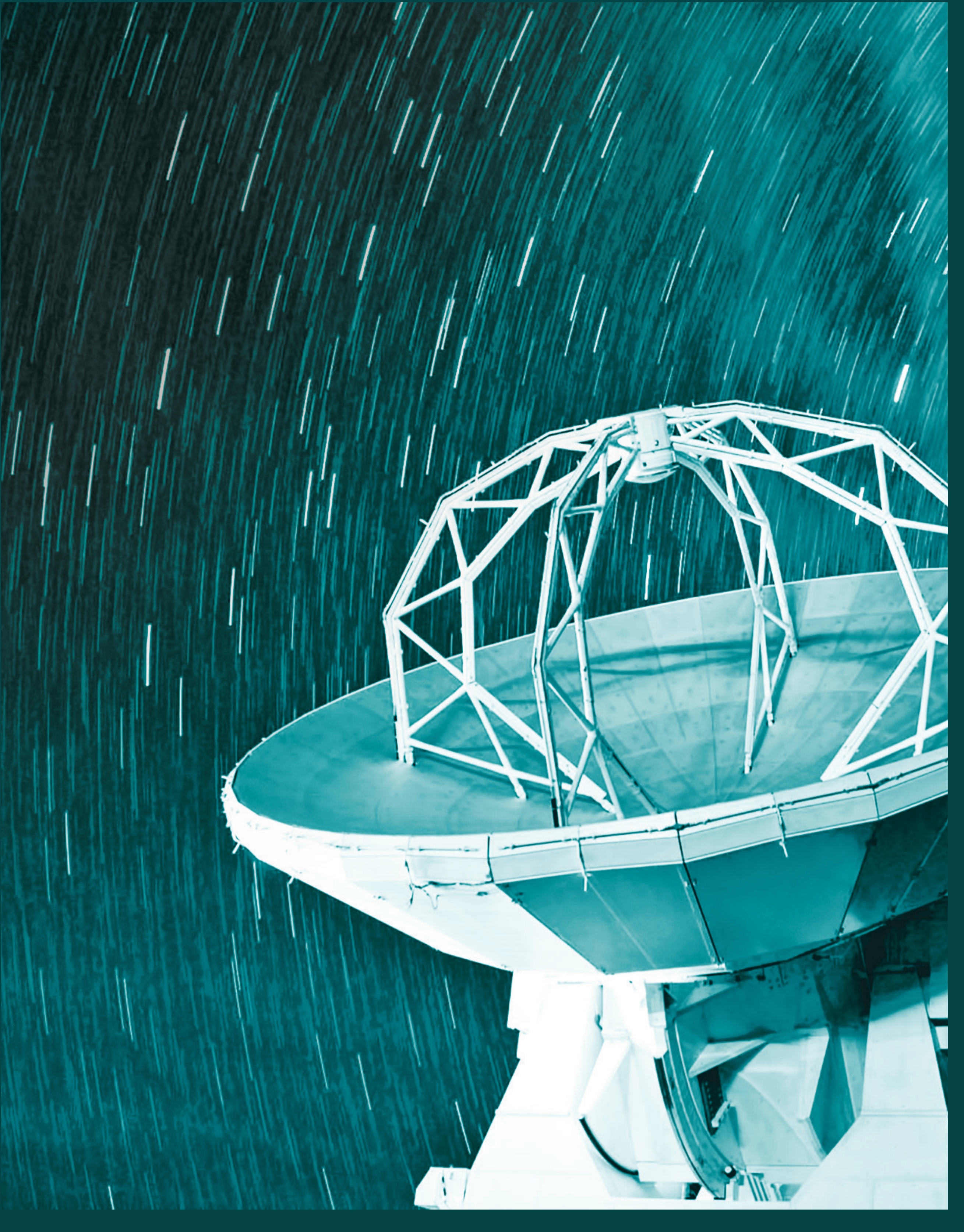
Word cloud summaries of 2020 and 2021 from the people of the STRW

DIVERSITY

Sanjana Panchagnula
on behalf of the EDI committee

2020 brought in tremendous growth for the Observatory's Equity, Diversity, and Inclusion Committee, which now has 15 active members across all levels of faculty and students. The committee produced an official mission statement expressing our strong commitment to equity, diversity, and inclusion (EDI) at Leiden Observatory, coupled with a petition for anti-racism that garnered nearly 200 signatures from members of our department.

One of our key objectives this year was to raise awareness of EDI at all departmental levels. The decision to decorate the walls of the Observatory with posters of astronomers and physicists from underrepresented groups has generated a healthy discussion about the need for diversity in science. With our EDI Journal Club, we now also have an active community that meets twice a month to discuss all matters relating to EDI in academia. EDI seminars, workshops, and networks are regularly shared on our dedicated Slack channel. For our weekly colloquia, the committee has strived to achieve broader representation of speakers and welcomed Dr. Andreas Keil to present a seminar on gender equality in the European Research Council. We have also launched a new training scheme in which the first year PhD students attend a workshop on Implicit Bias, led by inclusion expert Caroline Pickard, as part of their introductory programme. 2021 shall bring a new wave of efforts with increasing representation from newer faculty members and a new chair, as well as the return of the biennial Observatory climate survey.



RESEARCH HIGHLIGHTS +

Evidence for fast magnetic field amplification in distant galaxy clusters

Gabriella di Gennaro

Magnetic fields are ubiquitous in the Universe, from stars to the largest structures, and are thought to regulate a large variety of astrophysical processes. However, the origin and evolution of magnetic fields are still unsolved questions. The main theories involve weak seed field populations, originating eitherin the primordial Universe or during the first structure formation, which gets stronger during cosmic time. This is usually investigated via cosmological simulations. A way to retrieve observational insights on the formation and evolution of magnetic fields is to study them in large-scale structures, namely galaxy clusters.

Galaxy clusters are the largest structures in the Universe held by gravity. They contain thousands of galaxies, but most of the "visible" mass is in the form of extremely hot and dilute intracluster gas, visible at X-ray wavelengths, the so-called intracluster medium (ICM). According to the current accepted Cosmology (ΛCDM, where Λ refers to the cosmological constant and CDM stays for Cold Dark Matter) the Universe is governed by hierarchical growth, with the smallest objects – such as stars – forming at earlier times and the largest ones, such as galaxy clusters, at later times.

During the process of cluster formation, shock waves and turbulence are generated in the ICM, which accelerate electrons to ultra-relativistic energies. When these ultra-relativistic electrons spiral along the magnetic field lines, steep-spectra synchrotron radiation is produced, and diffuse radio emission is spread throughout the cluster volume. These emission sources are called "radio halos" or "radio relics", depending on their morphology (see Figure 1). Since the emitted radio power partly depends on the magnetic field strength, radio halos can be used to study the magnetic field properties in clusters.

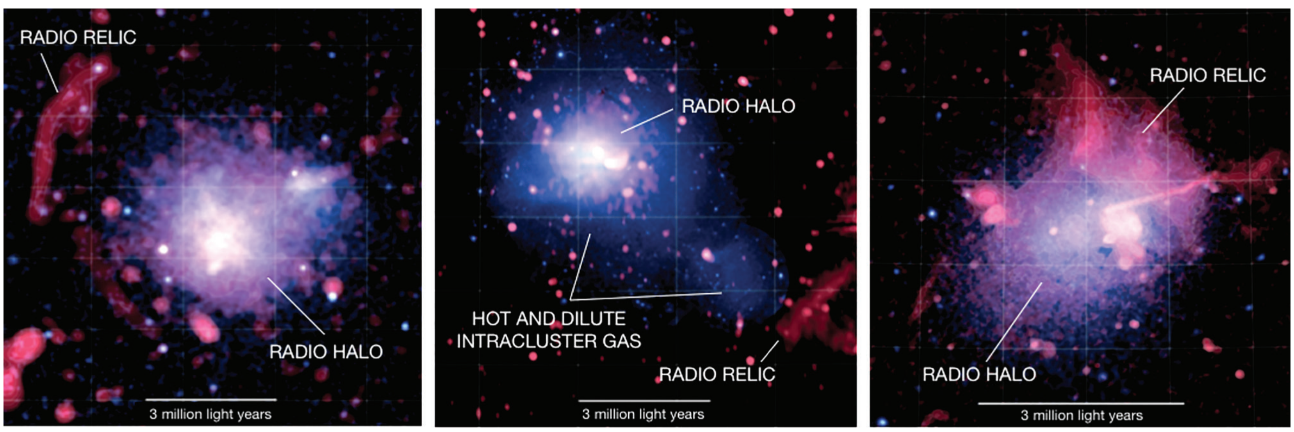


Figure 1: Three examples of local clusters of galaxies observed at radio (red) and X-ray (blue) wavelengths. The radio emission traces accelerated particles and magnetic fields, while the X-ray emission traces the hot and dilute intracluster gas. Images taken and adapted from van Weeren et al. (2019).

LOFAR

Being steep-spectrum sources ($\nu < -1$, with the surface brightness S_ν depending on the frequency ν as $S_\nu \propto \nu^\alpha$), radio halos are better observed at low-frequencies (namely $\nu <$ GHz). LOFAR (an acronym for LOw Frequency ARray, van Haarlem, 2013) is a Dutch-European network of radio receivers with its core of antennas located in the Netherlands.

This radio telescope consists of two sets of antennas in each station, the Low Band Antennas (LBA, 10-90 MHz) and the High Band Antennas (HBA, 110-240 MHz), and therefore is a most suitable instrument to use to search for diffuse cluster-wide radio emission. In the last decades a large number of new radio halos have been observed, especially at low redshifts.

At high redshift the observation of radio halos is challenging, because they are affected by dimming effects and are expected to have steeper spectra than those at low redshift, as the Inverse Compton energy losses get stronger. Therefore, LOFAR observations are even more crucial to search for, and study, cluster-scale diffuse radio emission.

Estimating magnetic field strengths at the moment of cluster formation

Magnetic fields in clusters are usually investigated via Faraday rotation. This technique is based on the fact that when a polarisation wave passes through a magnetised plasma, such as the ICM, it gets altered in a way that is directly dependent on the strength of the magnetic field in the crossed plasma. Therefore, by observing the polarisation properties of several radio galaxies in and behind a cluster we can infer the line-of-sight component of the cluster magnetic field of the ICM.

However, this direct measurement is challenging as it requires a sufficiently large number of polarised sources both in and outside of the cluster region, and has therefore mostly been used in statistical studies. Individual measurements are obtained for only a few tens of nearby clusters, for which an averaged magnetic field level of few microGauss has been estimated.

At high redshift, the Faraday rotation technique is not feasible, as the chances to have several polarised radio galaxies in the cluster angular volume are low. However, since the emitted radio power partly depends on the magnetic field strength, radio halos can be used to

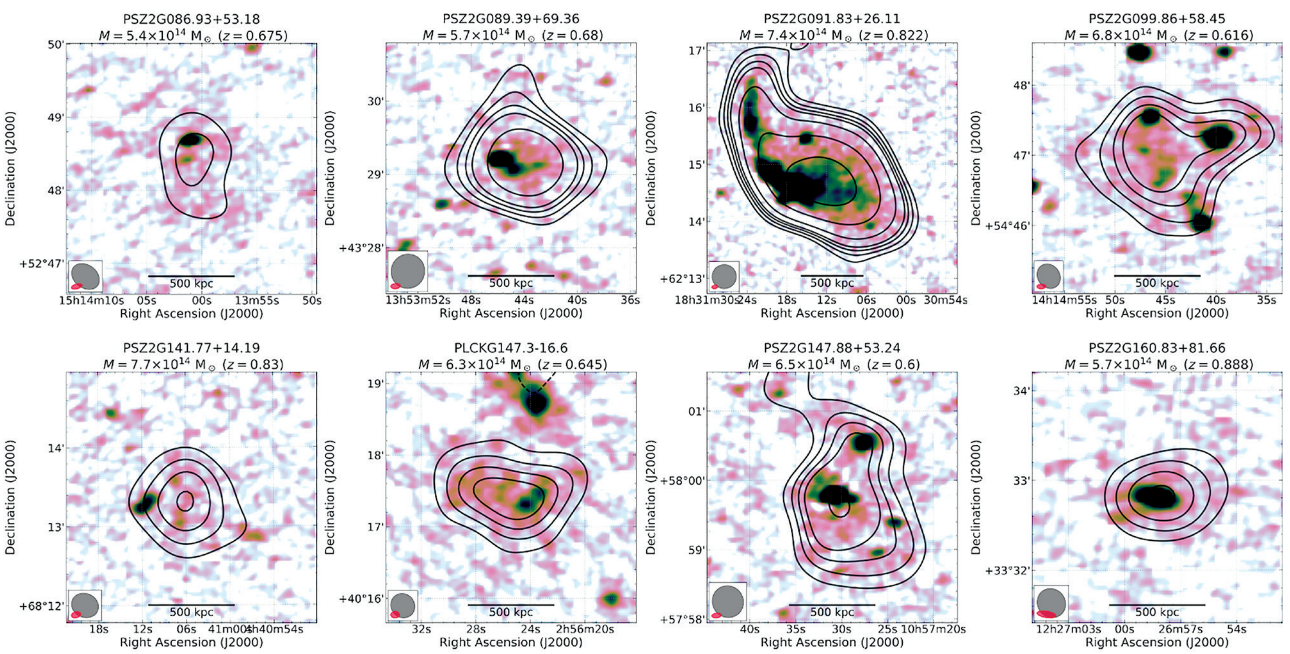


Figure 2: Examples of observed radio emission in the high-z galaxy cluster sample. The black contours highlight the cluster-wide diffuse radio emission, after the subtraction of the cluster radio galaxies. The LOFAR beams are displayed in the bottom left corner (in pink and grey, respectively). In the header of each image, the cluster name, mass and redshift are reported.

estimate the large-scale magnetic field properties over cosmic time.

Di Gennaro et al. (2021) performed the first systematic search for radio halos in distant galaxy clusters, selected from the Planck catalogue, using data from the LOFAR Two-Meters Sky Survey (LoTSS) at 144 MHz. The final sample consists of 19 clusters, nine of which hosting diffuse radio emission regions that were classified as radio halos. These observations showed for the first time that low-frequency observations reveal a common presence of cluster-wide diffuse radio emission at high redshifts (see Figure 2). From the flux densities measured at 144 MHz, the extrapolated radio luminosities at 1.4 GHz are in the range 0.7-13.8x10^{24} W Hz^{-1}. These resulted to be surprisingly similar to those in closer systems, in the same mass range (see Figure 3a).

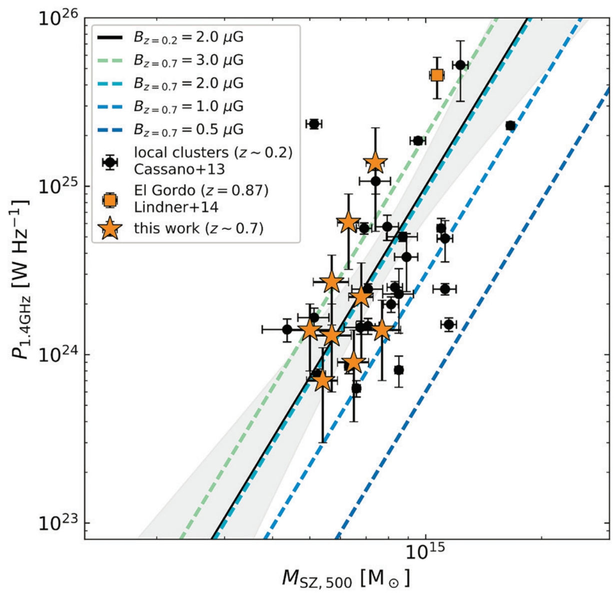
New insights on the magnetised intracluster plasma

According to the popular turbulent re-acceleration model of radio halo formation, the synchrotron radio luminosity mostly depends on the amount of turbulent energy flux injected during the cluster merger and on magnetic field strengths, taking into account the energy losses due to Inverse Compton. At these redshifts, hosting radio halos of similar luminosities than the low-redshift counterparts means that also the cluster magnetic field strengths must be comparable, namely few microGauss. Since these distant clusters have ages of few billion years, this result implies that the magnetic field amplification must happen faster at early times.

The evolution of magnetic fields also provides insights on the properties of the intracluster plasma. It mostly depends on the Reynolds number, which indicates the level of turbulence in a plasma. To have microGauss-level magnetic fields already when the Universe was only about 7 billion years old, and when clusters were few billion years old, the Reynolds number of the ICM has to be extremely high. This is the case for both the primordial (B_0=1 nanoGauss) and astrophysical (B_0=0.1 microGauss) seed field populations (see Figure 3b), and implies that the ICM is an extremely turbulent plasma.

The increasing area covered by LoTSS, together with new surveys that will detect a large number of new distant galaxy clusters, such as eROSITA and Euclid, will improve the statistics of distant clusters hosting diffuse radio emission. This will help to make the cosmological simulations more robust, and to get a better handle on the evolution of cosmic magnetism.

(a)



(b)

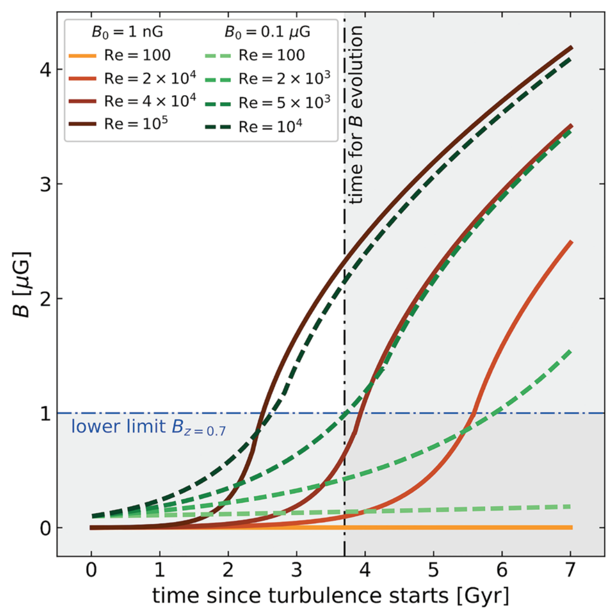


Figure 3: Panel (a): Radio luminosity as function of the cluster mass, for nearby (black) and distant (yellow) radio halos. The black solid line represents the best-fit relation from the low-redshift sample, with the 95% level confidence (grey area). The blue dashed lines represent, from light to darker colors, the relations at high-z for different levels of magnetic fields. Panel (b): Magnetic field growth since the start of the turbulence, assuming different initial values for the seed field population. The horizontal blue dot-dashed line sets the lower limit of the magnetic field strength in distant galaxy clusters (see panel (a)). The vertical black dot-dashed line shows the upper limit on the approximate time available for the magnetic field growth.

Elegast's Mischief – The first radio discovery of a brown dwarf

Joe Callingham

Our Sun is by far the brightest object in the sky across most of the electromagnetic spectrum. If you are observing the sky at optical, X-ray, infrared, or gamma-ray wavelengths, you will find that the Sun outshines all else. However, there is a small window in the electromagnetic spectrum where the Sun loses its blazing hegemony. It is at long wavelengths that Jupiter usurps the Sun's dazzling crown to assume its place as the brightest object in the radio sky.

The bright Jovian radio emission is driven by two unique interactions between the planet and plasma trapped in its magnetic-field. Firstly, as the magnetic field of Jupiter sweeps over its conducting satellites, bright auroral radio emission is produced at the poles of Jupiter. Secondly, plasma trapped in Jupiter's magnetosphere can rotationally decouple since the planet is rotating so rapidly, producing a circuit that can also drive polar auroral emission (as seen by the ring evident in Figure 1). It is because the emission mechanism producing these aurorae is so incredibly efficient that Jupiter outshines the radio Sun.

One obvious extrapolation one can make from the radio brightness of Jupiter is: Could we find Jupiter analogues in other stellar systems by its tell-tale radio aurorae? Unfortunately, even at a modest 5 parsecs we would never detect Jupiter with the most sensitive low-frequency radio telescope LOFAR.

However, there is a way to boost the brightness of the radio emission that suggests it might be possible to detect a Jupiter-analogue. For example, making the emitting body's magnetic field stronger and rotate faster, or interact with a body larger than a Jovian satellite, could make the radio emission detectable with today's low-frequency telescopes.

Armed with this simple idea, my colleagues and I set out to see if we could discover radio emission from a cold brown dwarf – an object more massive than Jupiter but significantly less massive than stars. Previous work at short radio wavelengths suggest some can rotate incredibly quickly and are radio bright but all previous radio discoveries had been targeted based on an infrared detection.

Using the all-sky survey of LOFAR, the most sensitive wide-field low-frequency survey produced to date, we conducted a blind search for a radio-bright brown dwarf. Exploiting the fact that auroral emission is circularly-polarised, we were able to isolate an interesting detection that had no optical or infrared counterpart in the available archival or survey data (Figure 2).

To confirm that the object was indeed a brown dwarf, we followed up the source with a near-infrared spectrograph

Figure 1: Jovian auroral emission (blue) footprints. The ring is produced by the breakdown of co-rotation between the planet and plasma in its magnetosphere, while the "hot-spot and tail" seen on the right is the footprint of the Jupiter-Io auroral emission. Image credit: NASA / ESA / J. Nichols (University of Leicester)

and imager on Gemini North (Figure 3). The data confirmed the radio object is a very cold brown dwarf of ~T7 sub-type, implying an effective temperature as low as ~700 K. Such a temperature is roughly 10 times hotter than Jupiter but an order of magnitude colder than the Sun. This represents the first discovery of a brown dwarf from its radio emission. We nicknamed the detection "Elegast" after the sly and stealthy elf-knight of Dutch folklore, which we thought was a good fit for this tough to find brown dwarf (Figure 4).

So what did we learn that we did not already know about radio bright brown dwarfs? What is particularly unique about our discovery is that we do not have the biases that come with a targeted search. In particular, Elegast appears to be located at ~65 pc, while all previously detected radio-bright brown dwarfs are within 10 pc. This makes Elegast the most luminous radio brown dwarf discovered by over an order of magnitude.

How can Elegast produce such luminous auroral radio emission? One of the most expeditious way to produce such luminous emission is via the interaction of the brown dwarf with an orbiting low-mass companion or exoplanet. The jury is currently still out on what is making Elegast so incredibly bright. However, we are working on followup observations to detect potential periodicities in the radio light curve that might hint at whether the emission is driven by a near-by companion. The sly Elegast still has a few secrets to reveal.

You can read further about the results in Vedantham, Callingham, Shimwell et al. (2021), ApJL: https://arxiv.org/abs/2010.01915

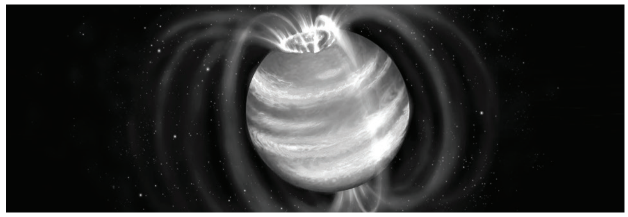


Figure 4: Artist's impression of Elegast. Image credit: ASTRON / Danielle Futselaar.

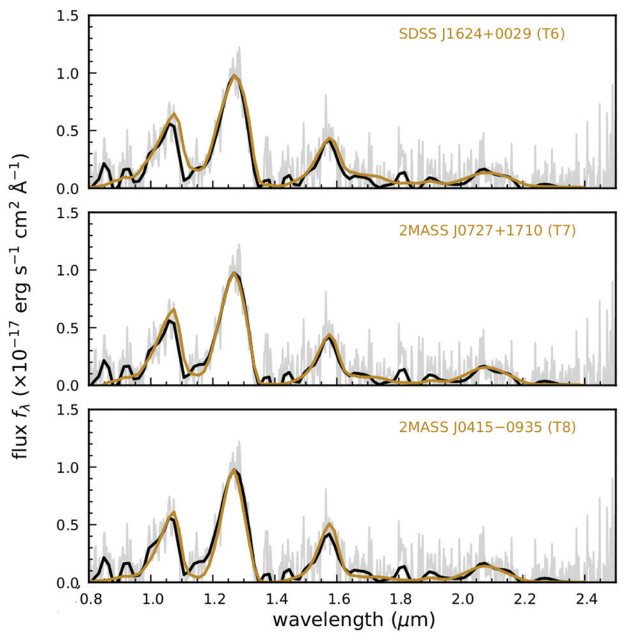


Figure 3: Near-infrared spectrum of Elegast (black is the smoothed raw grey data) compared to T dwarf spectral standards (tan). The standards suggest Elegast is a cold brown dwarf of ~T7 sub-type.

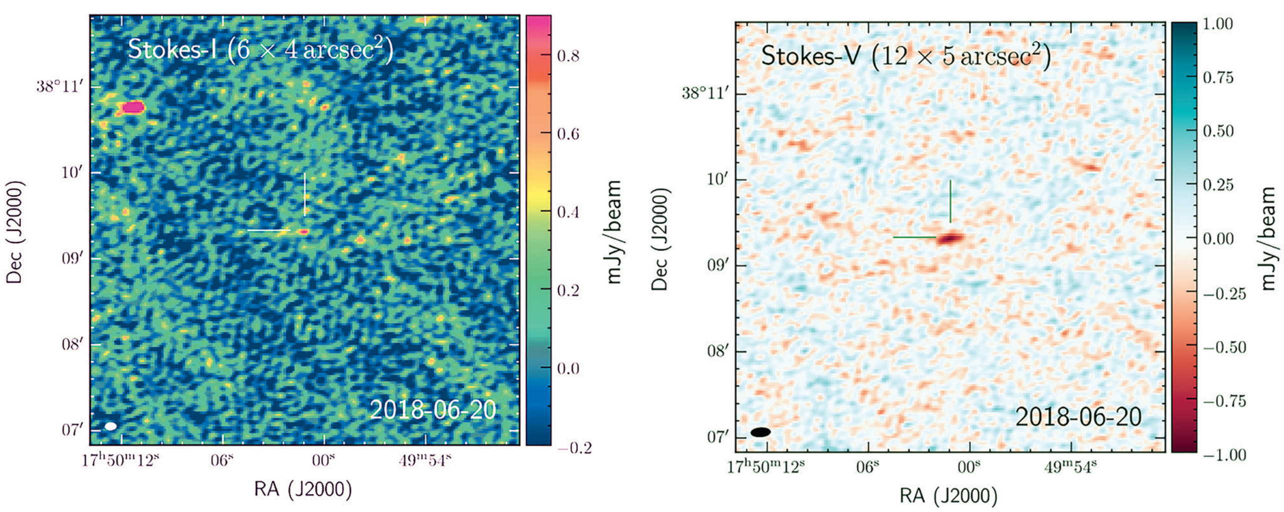


Figure 2: LOFAR detection of Elegast in total-intensity (Stokes I, left panel) and circular polarisation (Stokes V, right panel).

Capturing the first image of two giant planets around a 'Young Sun'

Alexander J Bohn

Even though thousands of exoplanets have been detected in our galaxy during the past decades, only a small fraction of these distant worlds has been imaged. This low number can be attributed to the huge contrast between the bright star and much fainter companion that has to be provided at angular separations that are smaller than 1 arcsecond.

Whereas Earth-sized planets exhibit contrast of more than 10^9 and are thus out of reach for current instrumentation, young, Jovian planet with contrast in between 10^3 to 10^6 can be imaged with state-of-the-art detectors, coupled with powerful adaptive optic systems, and mounted at the largest telescopes of the world.

The majority of directly imaged exoplanets have been found around stars that are markedly different from our Sun. To assess the occurrence rates of wide-orbit giant planets orbiting around solar analogues, we thus launched the Young Suns Exoplanet Survey (YSES). YSES is targeting a homogeneous sample of 70 young, solar-type members of the Lower Centaurus Crux subgroup of the Scorpius-Centaurus association (Sco-Cen). With the Spectro-Polarimetric High-contrast Exoplanet REsearch (SPHERE) instrument mounted at the European Southern Observatory's Very Large Telescope (VLT) in the Chilean Atacama desert, we are looking for Jovian companions around these 'Young Suns'.

The survey is not completed yet. So far, we have observed all 70 'Young Suns' once, which led to the discovery of an intriguing protoplanetary disk (see Figure 1).

We detect the signal of an inner (ring A) and outer arc (ring B) of the disk, with a region of significantly reduced flux in between (gap). Most remarkable, though, is the general appearance of the circumstellar disk. Despite the low inclination, we detect only scattered light signals from approximately half the disk. This might be caused by shadowing effects caused by misaligned structures interior to the inner working angle of our data (i.e. below the masked region in the image center). A giant planet could be responsible for this misalignment, which might be detectable by observations of gas dynamics with the Atacama Large Millimeter/submillimeter Array.

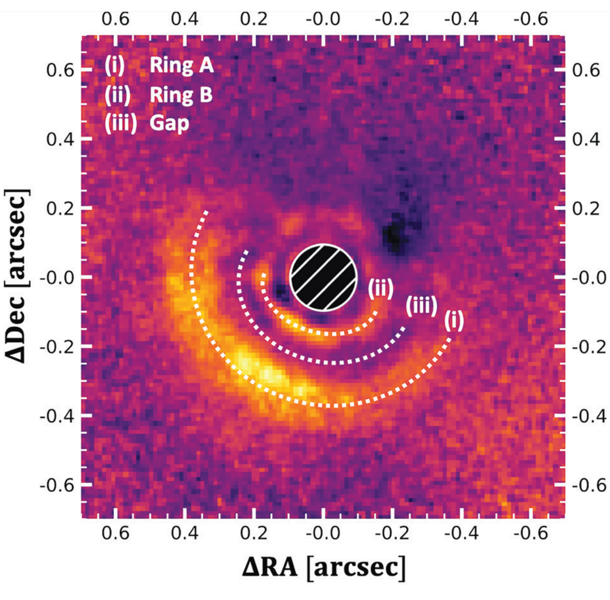


Figure 1: A peculiar, self-shadowed transition disk around Wray 15-788.

The multiplanet system around TYC 8998-760-1

To probe actual companions to our 'Young Suns', a single observation of each target is not sufficient. Two epochs that are separated by a baseline of at least one year are required to confirm companionship via proper-motion analysis: by that means we can distinguish unassociated background contaminants from actual co-moving companions.

So far, for only eight of our systems such a second epoch observation was collected. Among these stars was TYC~8998-760-1, which is a young version of our own Sun with an age of 17 Myr and a mass of 1.00±0.02 solar masses. Our observations first revealed one giant Jovian planet around this solar analog. The detection of this first companion around TYC 8998-760-1 was already remarkable in many ways. TYC 8998-760-1 b is 14 times as heavy as Jupiter and about three times as large in diameter. Furthermore, it is separated by at least 160 Astronomical Units from its host star, placing it more than five times farther away than Neptune from our Sun. For a detailed characterization of this giant exoplanet we took additional photometric measurements at several infrared wavelengths as visualized in Figure 2.

Photometric measurements that were supposed to characterise TYC 8998-760-1 b reveal the presence of a second companion: TYC 8998-760-1 c. The star TYC 8998-760-1 is located in the upper left of the image at the origin of the coordinate system and its intensity is reduced by a coronagraphic mask.

The most remarkable feature of this multi-wavelength sequence was not the discovered planetary-mass companion TYC 8998-760-1 b, but another point source at even larger separation from the primary. This point source was invisible at the shortest wavelengths but became brighter when going towards the red part of the spectrum.

'This looks extremely exciting!' we thought, because this appearance is exactly what is expected from an object with a low effective temperature such as another smaller planet in the system. The source became even more intriguing, as other point sources in the image

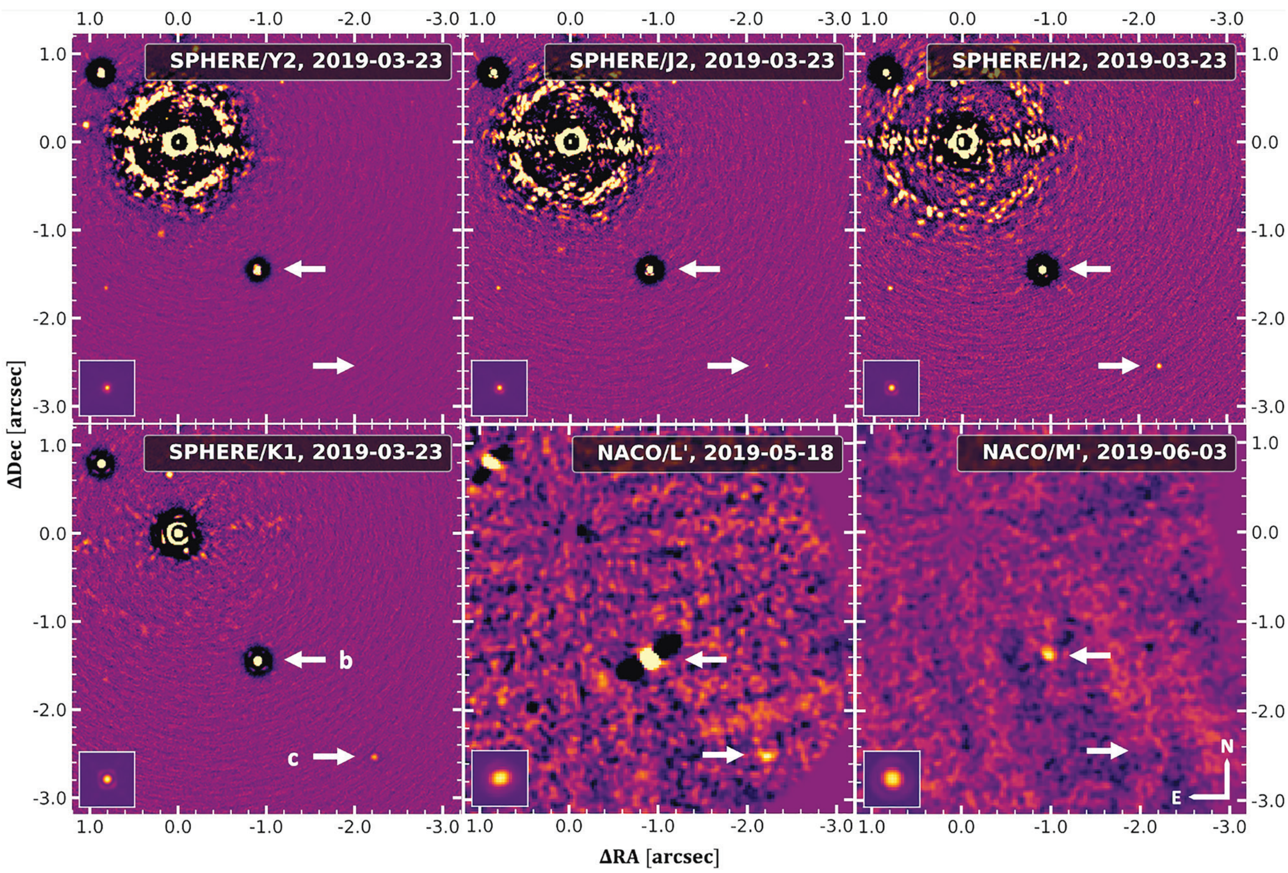


Figure 2: Detection of two planets around TYC 8998-760-1.

showed a completely complementary behavior: these were brightest in the blue part of the spectrum and vanished when going towards longer wavelengths, which resembles a stellar object at much farther distance than TYC 8998-760-1.

But the data we had collected on this system by March 2019 were not sufficient to confirm the companionship of the second planet candidate TYC 8998-760-1 c. Therefore, we applied for additional telescope time on this promising target. Eventually, new data from February 2020 confirmed that TYC 8998-760-1 c is co-moving with its Sun-like primary and thus an additional planet of even lower mass and at even farther separation of at least 320 Astronomical Units. Our latest mass estimate predicted that this new planet TYC 8998-760-1 c weighs about six times the mass of Jupiter.

These two Jovian gas giants make TYC 8998-760-1 the first imaged multi-planet system around a young, Sun-like star. As visualized in the color-magnitude diagram in Figure 3, both companions are redder than the sequence of field brown dwarfs, as often observed for young and inflated objects.

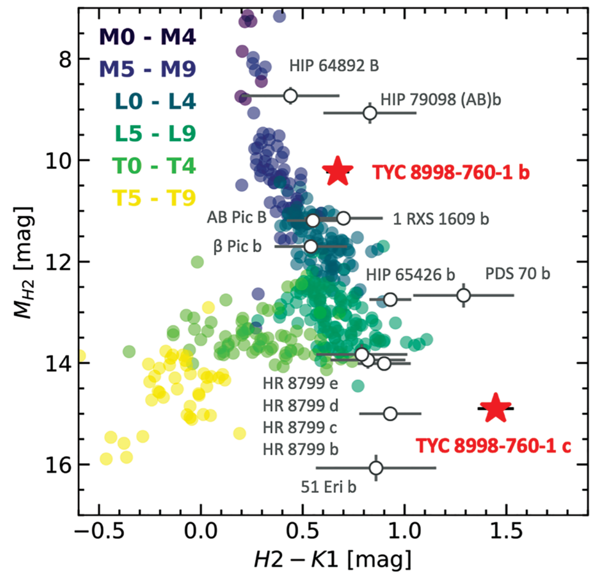


Figure 3: Color-magnitude diagram for the two companions around TYC~8998-760-1. As usually seen for young, planetary companions both objects are redder than the population of evolved field brown dwarfs.

Future outlook

The large separations of both planets trigger exciting follow-up questions that need to be answered: How did this system form and evolve? Did both planets form at the current locations or were they born closer to the star, followed by an outward migration?

The next generation of instruments at observatories such as the James Webb Space Telescope or the Extremely Large Telescope will certainly shed light on the nature of underlying formation mechanisms and may even reveal further planets in this very young solar-like environment.

Forming interstellar methane ice along the road to uncharted territories of carbon atom chemistry

Danna Qasim

The most abundant ices that have been detected in the interstellar medium (ISM) are H_2O, CO_2, CO, CH_3OH, NH_3, and CH_4. The combination of observations, laboratory experiments, astrochemical models, and quantum chemical computational calculations has shown that H_2O is mainly formed starting from O + H, CO_2 from CO + OH, CO from the accretion of gas-phase CO, CH_3OH from CO + H, and NH_3 from N + H. But what about methane (CH_4)?

For decades, it was generally assumed in the astrochemical community that interstellar CH_4 ice is formed by adding H-atoms to a C-atom, just as H_2O and NH_3 are formed by adding H-atoms to O – and N-atoms, respectively. However, unlike that of H_2O and NH_3, the addition of H-atoms to a C-atom to form CH_4 was yet to be experimentally confirmed. Without empirical evidence, not only was the feasibility of this reaction put into question, but quantitative results on CH_4 formation from C – and H-atoms could not be accurately obtained.

So this begged the question, why wasn't the formation of interstellar CH_4 ice starting from C– and H-atoms already confirmed in the laboratory? After all, CH_4 is one of the most abundant interstellar ices to be detected, and with such a simple formation pathway that was generally accepted for decades, one would assume that CH_4 ice formation would have been a prioritized astrochemical laboratory experiment years ago.

The bottleneck came down to the fact that it is technically challenging to develop an atomic carbon source that can be used to simulate the carbon atom reactions that occur in interstellar ices. Such technical challenges include, but are not limited to, 1) atomic carbon will stick to almost anything at room temperature, 2) carbon can short-circuit electronics, 3) the creation of ground state atomic carbon, and 4) the creation of an atomic carbon beam free of contamination.

In the work by Krasnokutski and Huisken (2014), the authors developed an atomic carbon source that specifically addressed challenges 3 and 4. In the work by Qasim et al. (2020; Review of Scientific Instruments), the authors further developed the source so that it could be integrated into the ultrahigh vacuum apparatus, SURFRESIDE (SURFace REaction SImulation DEvice – see Figure 1) an apparatus used to explore the chemical complexity arising from the accretion of

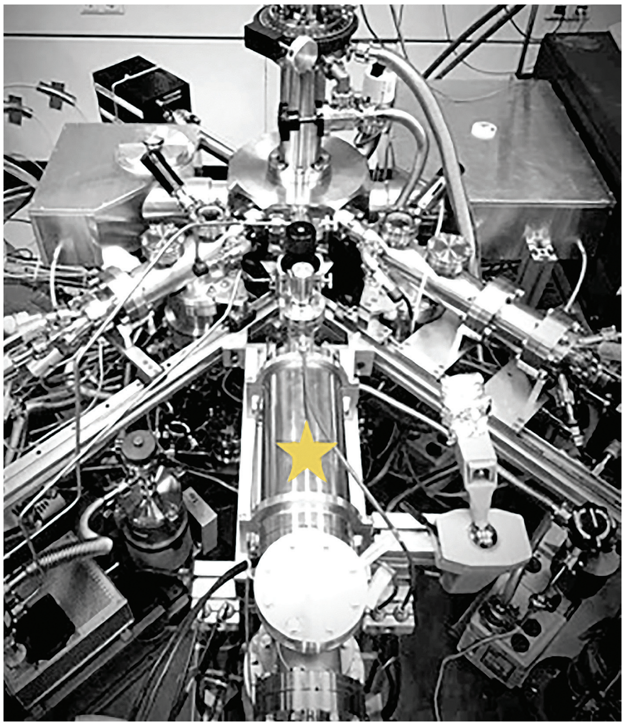


Figure 1: The ultrahigh vacuum setup, SURFRESIDE, in the Leiden Laboratory for Astrophysics, which can study the (simultaneous) accretion of C, H/D, O, N, molecular fragments, and molecules on a 10 K surface. This aims to simulate the initial growth process of ice in interstellar molecular clouds. The gold star marks the atomic carbon source.

small atoms and molecules on interstellar dust grains (Ioppolo et al. 2008, Linnartz et al. 2015, Chuang et al. 2016, Fedoseev et al. 2017).

With the integration of the atomic carbon source into SURFRESIDE, we are as close as it gets to simulating the initial formation of molecules onto dust grains as would be in interstellar molecular clouds – through the accretion of atoms such as C, H/D, N, and O. With this new capability, we were finally able to explore, under controlled laboratory conditions, the formation of interstellar CH_4 ice starting from C + H.

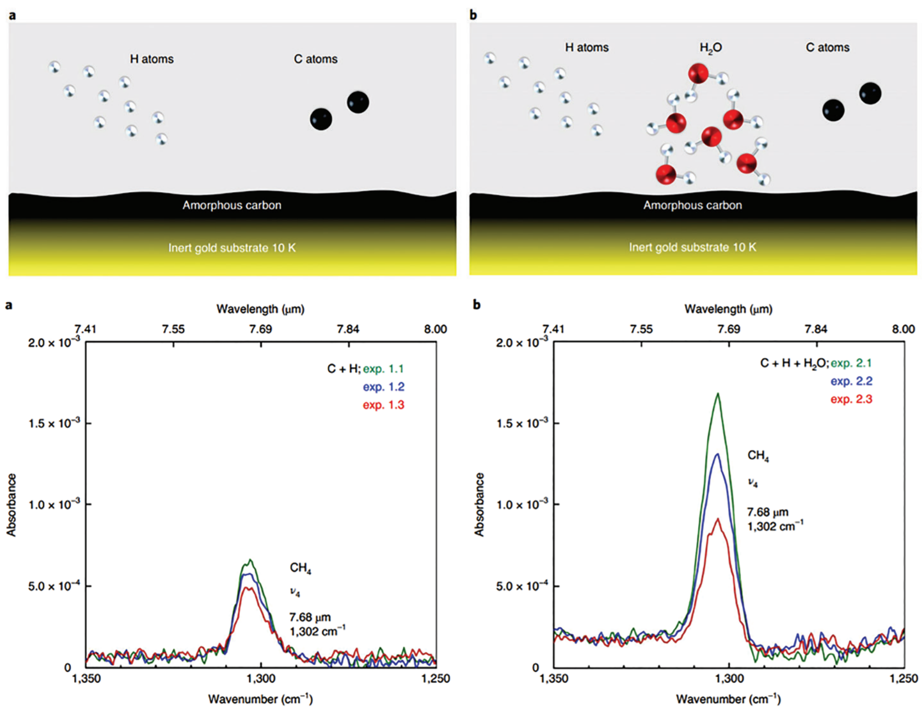


Figure 2: (Top) Visualization of the two experiments, (a) C + H atoms on a 10 K carbonaceous surface and (b) the addition of H_2O molecules. (Bottom) Reflection absorption infrared spectroscopy (RAIRS) of CH_4 formation after (a) C + H atoms on a 10 K carbonaceous surface and (b) the addition of H_2O molecules. It is evident that H_2O enhances the CH_4 formation rate, which supports the conclusions from astronomical observations of CH_4 ice.

In the work by Qasim et al. (2020; Nature Astronomy), two major highlights are shown: 1) CH_4 ice can indeed be formed by the hydrogenation of atomic C, as predicted by observational studies and astrochemical models, 2) CH_4 is successfully formed in a H_2O-rich ice, also predicted by observational and modelling efforts. These findings are important, as the majority of interstellar CH_4 is expected to be formed in H_2O-rich ices starting from the accretion of atoms.

Qualitative and quantitative results are presented, which can now be used in astrochemical models to more accurately trace the formation and abundance of CH_4 ice. As CH_4 is best observed with space-based observatories, the timing of this study falls in line with the timing of the launch of the James Webb Space Telescope – a space telescope with high sensitivity in the mid-IR that will be the most promising facility to date to detect CH_4 ice in quiescent molecular clouds.

The initial accretion of atoms on interstellar dust grains to primarily form water. Methane (CH_4) is also formed simultaneously with water, and is in the top 6 most abundant ices to be detected.

Now that CH_4 has been tackled, we are moving on to bigger molecules – namely complex organic molecules (COMs). These are molecules composed of ≥ 6 atoms and contain C and H. A hot topic in astrochemistry, COMs have been created in numerous laboratory experiments primarily through the recombination of radicals that contain C. Now, we can study COM formation starting from C, H/D, O, and N atoms, which takes us into a whole new dimension into how the first complex organics are formed.

Supermassive Black Holes & The Torus

Violette Impellizzeri

Supermassive black holes (SMBHs) are now thought to play a critical role in the formation and evolution of galaxies. Understanding the interplay between black holes and their surroundings requires a detailed understanding of how black holes grow and feed energy back into the galaxy. Active galactic nuclei (AGN) are powered by those SMBHs that are particularly efficient at accreting. According to AGN unifying schemes, all AGN possess a broad and narrow line region, an accretion disk and a torus, and in some cases jets (e.g. Antonucci 1993; Urry & Padovani 1995). The torus remains a very central component in the unifying schemes as it is required to hide the active nucleus and the broad-line region in narrow-line AGN (or "type 2s"), but it also provides a reservoir of gas that will eventually fall into the black hole. Based on statistical analyses from X-rays and IR studies, we know that the torus must be geometrically and optically thick, and it is composed of dusty, molecular gas (see e.g. Ramos Almeida & Ricci 2017; Combes et al. 2019). However, despite decades

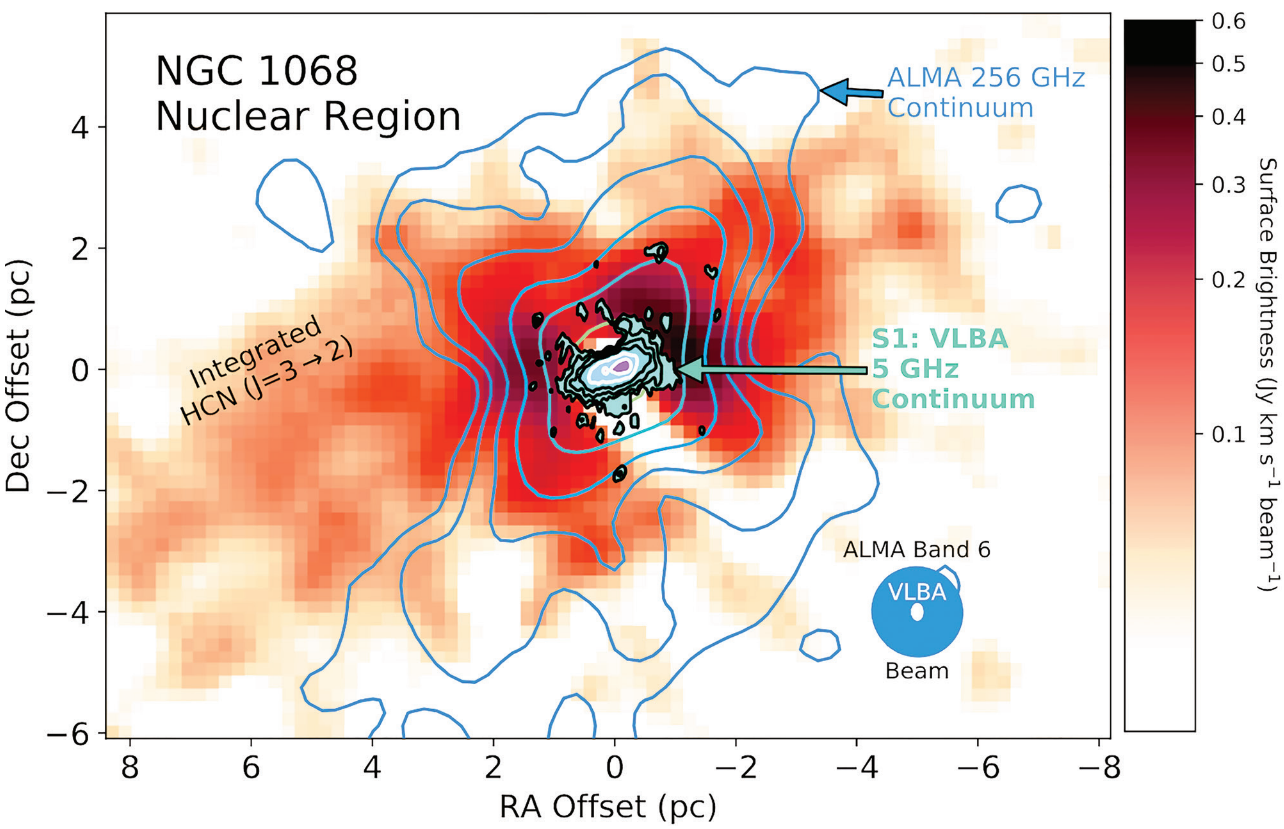


Figure 1: The nuclear region of NGC 1068 shown as overlays of the ALMA 256 GHz continuum (blue-green unfilled contours; Band 6), VLBA 5 GHz continuum (black contours filled with shades of cyan to magenta; and ALMA integrated HCN (J=3-2; Band 6) (background image in shades of yellow to dark red).

of studies, direct observations of the AGN tori have been extremely challenging, because the angular scales are so small; the torus has a characteristic scale of a few parsecs or less, requiring a resolution of a few milliarcseconds or better.

ALMA has revolutionized the study of AGN. First and foremost, ALMA provides both the resolution and sensitivity to map the kinematics of the molecular torus. In addition, ALMA has opened new spectral windows into the sub-mm molecular gas component and thus into the chemistry around AGN. One of the first targets selected for observations was the molecular torus of NGC 1068: one of the nearest and most luminous Seyfert galaxies known. It has been the archetype for unifying schemes since the 80s (e.g. Antonucci & Miller 1985; although there were hints in the late 70s). NGC 1068 has a flat spectrum radio source at its core, called "S1", marking the location of the central engine, and a kpc-scale radio jet emitted at right angles to a plasma disk located within the obscuring medium (Gallimore et al. 1997). The plasma disk is associated with H_2O megamasers. The masers, which have been resolved by VLBI (Greenhill et al. 1996), trace a thin, rotating disk. Derived from the position-velocity diagram, the rotation curve of the maser disk may fall more slowly than expected for Keplerian rotation. One interpretation is that the disk may be sufficiently massive to affect the rotation curve (Kumar 1999; Lodato and Bertin 2003).

We observed NGC 1068 in HCN (3-2) with ALMA in its longest baseline configuration. These observations improved the resolution of previous observations by a factor of two (~ 1.2 pc beam). I summarize here our three main results: 1) the integrated radio continuum emission has a flat spectrum consistent with free-free emission, and it resolves into an X-shaped structure resembling an edge-brightened bicone. 2) We detect HCN in absorption against the nuclear continuum, showing a pronounced blue wing that suggests a high-velocity molecular outflow with projected speeds reaching 450 km/s. This result demonstrates that the outflow originates from sub-parsec scales associated with the AGN. 3) Analysis of the molecular

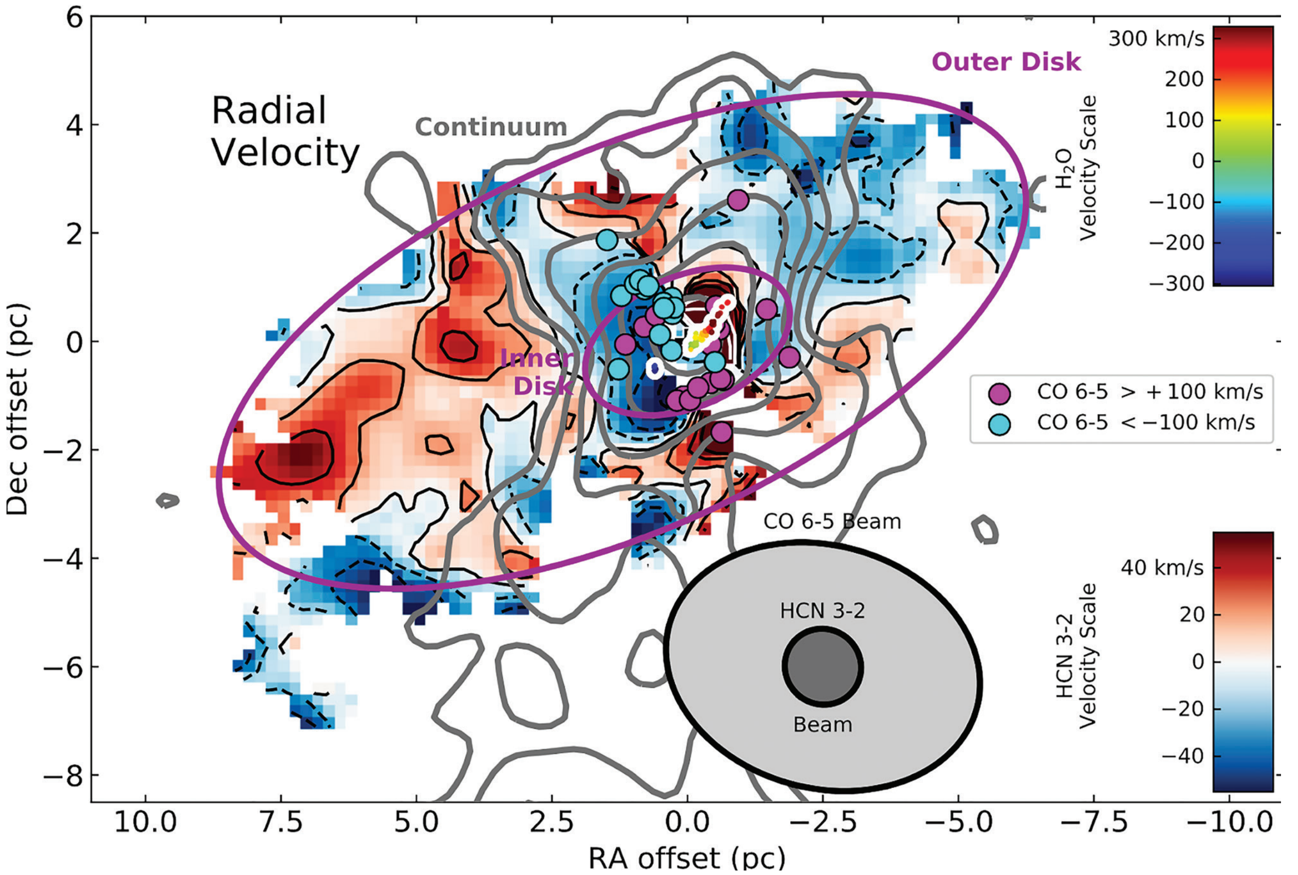


Figure 2: Radial velocities of molecular gas in the nuclear region of NGC 1068. Included in this figure are the H_2O megamaser spots (colored spots outlined in white) the 256 GHz continuum (gray contours), the velocity map of HCN (3-2)(black contours with red-blue shading), and spots marking the peak surface brightness emission of high-velocity CO (6-5) (magenta and cyan filled circles).

gas kinematics and morphology reveals two nested, rotating disk components. The inner disk, inside ~ 1.2 pc, has kinematics consistent with the nearly edge-on, geometrically thin water megamaser disk in Keplerian rotation around a central mass of 1.66 x10^7 $M_{\odot}$. The outer disk, which extends to a 7 parsec radius, counter-rotates relative to the inner disk. Both rings rotate around the central black hole as the rotation curve of the outer disk is consistent with Keplerian rotation around the same central mass as the megamaser disk, but in the opposite direction. We therefore conclude that the molecular torus consists of counter-rotating and misaligned disks on parsec scales (Impellizzeri et al. 2019). We speculate that the reason for this counter-rotation is that the outer disk formed from more recently introduced molecular gas falling out of the host galaxy or from a captured dwarf satellite galaxy.

Where do we go from here?

While further pursuing the nature (and possible consequences) of the counter-rotating disks, we decided to focus our efforts again on the 22 GHz water megamaser emission located inside the torus region (< 1 pc), which also appears to rotate counter to the outer disk. The reason was simple: the masers provide exquisite detail about the location and kinematics of the gas closest to the black hole, but the only published VLBI observations date back to 1996 (Greenhill et al. 1996; Greenhill & Gwinn 1997). We thus requested new observations predicting that the earlier studies miss fainter maser complexes owing to sensitivity limitations at the time. About a year ago (February 2020), we proposed to re-observe the water masers with the high sensitivity VLBI array (VLBA+GBT+VLA). The results of these observations are in the process of being analysed and will be published soon, but would like to provide a sneak preview of our main findings. We recover about twice as many maser spots as the previous observations, and, thanks to a nearby astrometric reference source, we obtained absolute astrometry with 0.3 milliarcseconds accuracy. We also recovered and resolved the 22 GHz continuum for the first time on VLBI baselines. Interestingly, we find that the maser spots organize within linear or arcuate structures that suggest the influence of magnetic fields. Finally, we find that the distribution of maser spots does not follow the standard model for megamaser disks (see Watson & Wallin 1999); rather, we find evidence for spiral arm structure. The spiral arms change the interpretation of the position-velocity diagram, and we find that, contrary to earlier analyses, the megamaser disk may follow Keplerian rotation after all.

We are planning to publish these results in the coming months. In the meantime, we plan to carry out new observations towards the core of NGC 1068, in the hope to unravel the true shape and dynamics of the torus and the mysteries of its accretion.

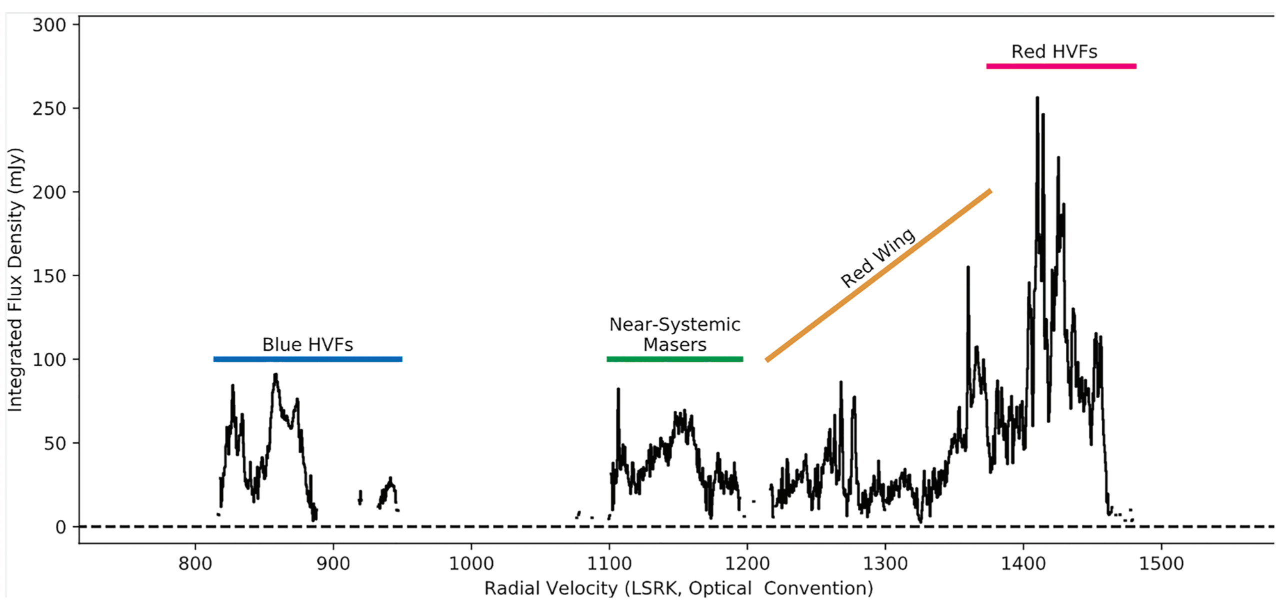


Figure 3: The reconstructed spectrum of the nuclear masers of NGC 1068.

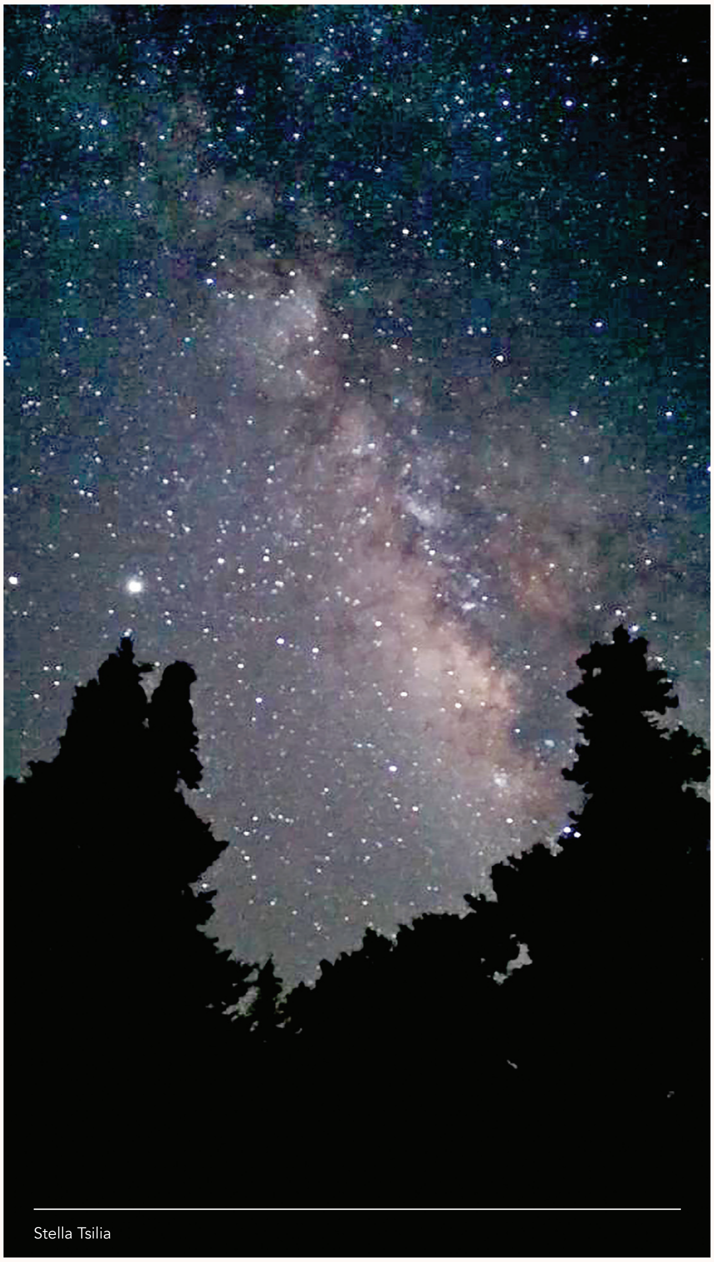
Matthew Kenworthy

Pedro Russo

Jelle Mes

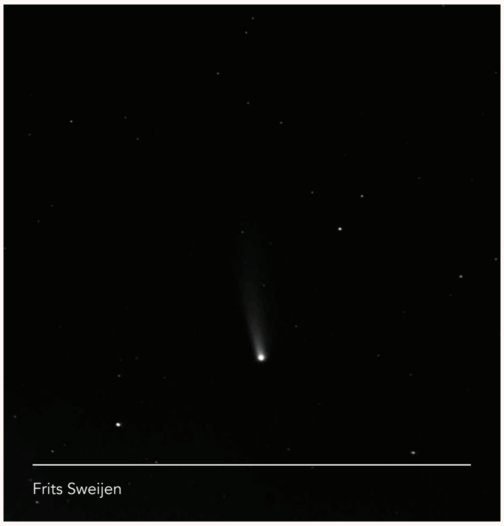
Stella Tsilia


Frits Sweijen


Stella Tsilia


Aleksandar Shulevski


Christoph Keller


Frits Sweijen

PhD Defences

NAME	DATE	SUPERVISOR(S)	THESIS TITLE
L.H. Quiroga-Nuñez	12.03.2020	Van Langevelde / Brown	Stellar radio beacons for galactic astrometry
S. Torres Rodríguez	30.04.2020	Portegies Zwart / Brown	Dynamics of the Oort cloud and formation of interstellar comets
Y.N. Cendes	12.05.2020	Tielens / Gaensler	Time Domain Imaging of Transient and Variable Radio Sources
D.N. Qasim	30.06.2020	Linnartz / Van Dishoeck	Dark Ice Chemistry in Interstellar Clouds
J. Albert	28.10.2020	Rottgering / Van Weeren	Dancing with the Stars
M.A.M. van Kooten	04.11.2020	Doelman / Kenworthy	Predicting the future: predictive control for Astronomical Adaptive Optics
L. Trapman	05.11.2020	Hogerheijde / Van Dishoeck	Sizing Up Protoplanetary Disks
S. Mandal	10.12.2020	Rottgering / Van Weeren	Revealing the nature of new low-frequency radio source populations
E. Por	11.12.2020	Keller / Kenworthy	Novel approaches for direct exoplanet imaging

Publication overview

In 2020, the members of Leiden Observatory published 640 papers in total. Astronomy & Astrophysics (194 articles), the Monthly Notices of the Royal Astronomical Society (141 articles) and the AAS Journals (127 articles) along with several other journals make up the published research output.

COLLOQUIA AND LECTURES

Scientific Colloquia

6 February 2020

Molecular cloud formation and dispersal by stellar feedback

Stefanie Walch-Gassner, *University of Cologne*

17 February 2020

Protoplanetary disks and the dawn of planets

Leonardo Testi, *ESO*

27 February 2020

Building virtual planets with Global Climate Models: a scientific endeavour

François Forget, *Institute Pierre Simon Laplace Université Paris*

5 March 2020

Putting Hubble Constant Measurements to the Test using High-precision Observations of classical Cepheids

Richard Anderson, *ESO Garching*

12 March 2020

Visualizing Connections

Nadieh Bremer, *Visual Cinnamon*

23 April 2020

Triple Systems and Black Holes

Johan Samsing, *Niels Bohr Institute*

7 May 2020

Panchromatic modelling of galaxies in simulations and observations

Claudia Lagos, *University of Western Australia*

11 June 2020

The Origin of Interstellar Turbulence

Mark Krumholz, *Australian National University*

18 June 2020

On the ultra-compact dwarf galaxy-nuclear star cluster connection

Michael Hilker, *ESO Garching*

25 June 2020

Accretion Disk Winds in Compact Binaries and Active Galactic Nuclei

Christian Knigge, *Southampton University*

17 September 2020

A string of pearls: the Orbital Internet and the urgent need for a global regulatory framework to protect scientific activities in outer space

Scott Millwood, *DLR Scientific Research Center*

1 October 2020

Exploring the dependence of galaxies on their cosmic formation history

Andrew Pontzen, *University College London*

8 October 2020

Formation of stellar clusters in spiral arms

Clare Dobbs, *Exeter University*

15 October 2020

Gravitational wave results from LIGO and Virgo

Jo van den Brand, *NikHef*

29 October 2020

Transformative advances in post-main-sequence planetary system science

Dimitri Veras, *Warwick University*

5 November 2020

On gender equality in ERC & its astronomy funding

Andreas Keil, *European Research Council*

12 November 2020

Feeding and Feedback in Nuclei of Galaxies

Anelise Audibert, *Observatory of Paris*

19 November 2020

Tidal disruption events: probes of supermassive black holes

Peter Jonker, *Astron*

26 November 2020

Anomaly Detection in Astronomical Data using Machine Learning

Michelle Lochner, *University of Western Cape*

10 December 2020

New light on Star Formation in the Local Group

Guido de Marchi, *ESA*

PhD Colloquia

10 March 2020

Stellar radio beacons for Galactic astrometry

Luis Henri Quiroga-Nūnez

24 April 2020

Dynamics of the Oort Cloud and the Formation of Interstellar Comets

Santiago Torres Rodriguez

28 May 2020

Dark ice chemistry in interstellar clouds

Danna Qasim

27 October 2020

Predicting the Future: Predictive Control for Astronomical Adaptive Optics

Maaike van Kooten

3 November 2020

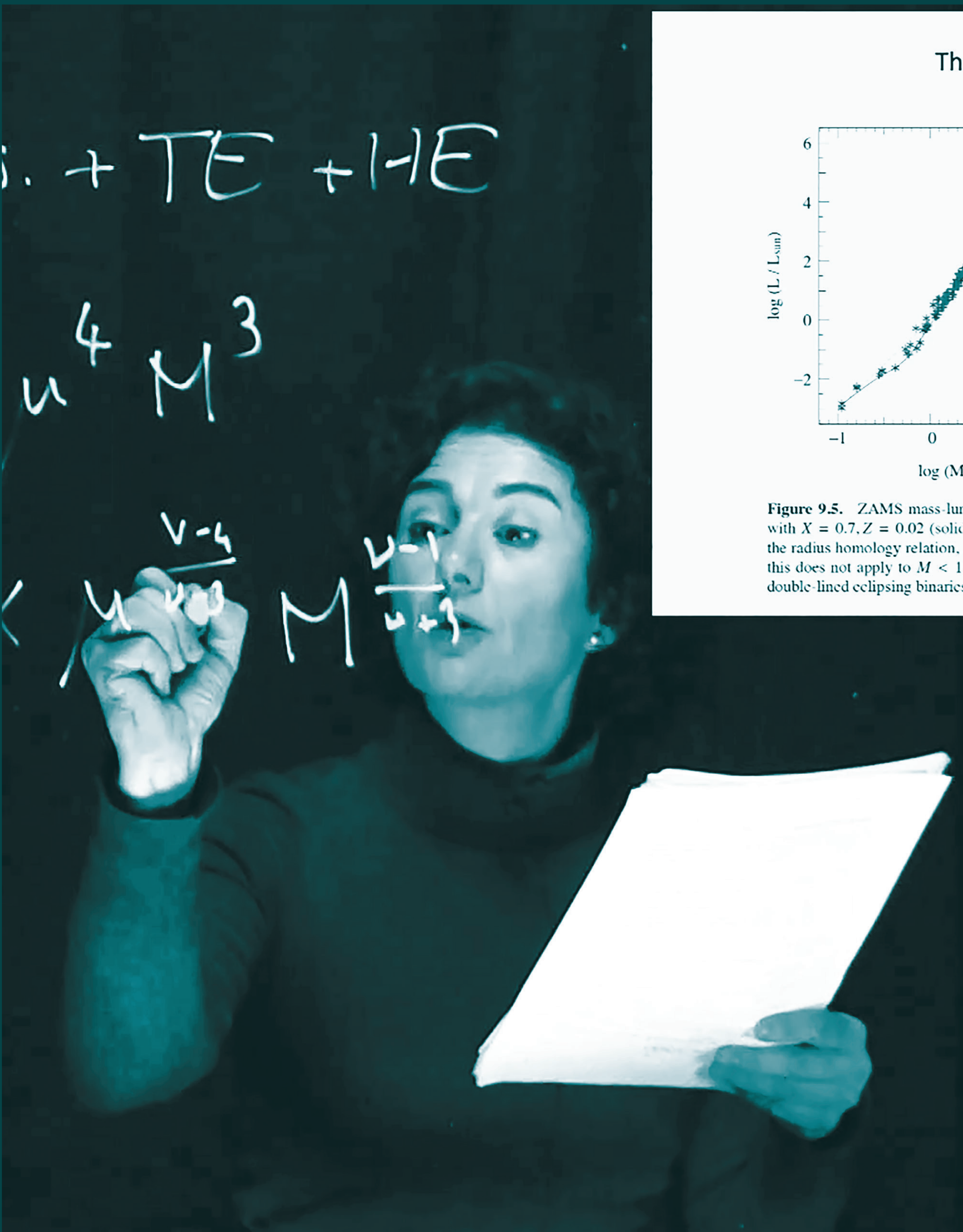
Sizing up protoplanetary disks

Leon Trapman

1 December 2020

Novel approaches for direct exoplanet imaging: theory, simulations and experiments

Emiel Por



EDUCATION

Bachelor and Master in Astronomy

The teaching and training of students is a major priority of Leiden Observatory, which offers both a university bachelor (BSc) and master (MSc) programme in astronomy. The BSc programme is 3 years and is partly taught in Dutch, with combinations of lectures, problem classes, and practicals. In addition to astronomy courses, the programme consists in the first year of a significant fraction of courses in mathematics, physics, and informatics. First year students conduct their first astronomical observations with the modern LUF/Gratama telescope on the roof of the historic Old Observatory building in the center of Leiden, and learn about coordinate systems during a lecture at the planetarium in Artis, Amsterdam. In years two and three the emphasis is increasingly on astronomy. Highlights include observations at the 2.4m Isaac Newton Telescope on La Palma (Canary Islands) carried out and analysed by the students, and the 6-months research project at the end of their BSc. The MSc programme is 2 years and taught fully in English, attracting many foreign students.

In 2020, the MSc programme in Astronomy offered seven specialisations:

1. Astronomy Research
2. Astronomy and Cosmology
3. Astronomy and Instrumentation
4. Astronomy and Data Science
5. Astronomy and Education
6. Astronomy and Business Studies
7. Astronomy and Science Communication and Society

Student Numbers

While student numbers have been continuously rising for several years, in 2020 most likely due to the Covid-19 situation we saw a slight drop in the trendline. Still 98 freshmen started in our bachelor astronomy programme. Of this number, 36 (37%) were women, and 35 (35%) pursued a combined astronomy/physics or astronomy/mathematics. The Observatory registered a total number of 265 BSc students at the end of the year, of which 101 aimed at a combined astronomy physics degree or astronomy/mathematics degree; 34% of all BSc students are female. Despite Covid-19 situation, in 2020, the inflow of master students has increased to 63 students. In total there were 118 MSc students, including 53 women and 49 of foreign nationality.

←

Remote teaching became the new standard and not only from home. Leiden Observatory invested in a Remote Teaching Facility with excellent online teaching tools. Credit: H.Intema

SpaceEU Teacher Training, 7 October 2020, Cite de L'espace

Organisation

The entire teaching program is organised and supported by the Education Office Astronomy (EOA), which deals with all aspects of the curriculum, including organisation, student support, outreach and internationalisation. The EAO team currently consists of a Director of Education, Head of Education Office Astronomy & Programme Coordinator, Study Advisor, PR Education Coordinator, Student Affairs Officer Bachelor, Student Affairs Officer Master and a Support Officer.

In addition to counseling by the student advisor, incoming bachelor students were assigned to small groups meeting at regular intervals with a staff mentor and a senior student mentor. In the tutor programme, physics and astronomy freshman students were provided on a voluntary but regular basis with coaching by senior students. In the master programme the buddy system has been continued. In both programmes students write a Study Plan, which must be approved by the Study Advisor. The astronomy curriculum is monitored by the 'Programme committee' (Opleidingscommissie), which advises the Director of Education on all relevant matters, and which was chaired by Hogerheijde. Under the authority of the Education Committee, the lecture course monitoring system was continued. In this system, students provide feedback to lecturers during and after the course.

Quality control of all aspects of the exams is the responsibility of the Board of Examiners (Examencommissie) chaired by Snellen. Admission to the master-curriculum for students without a BSc in astronomy from a Netherlands university requires a recommendation by the 'Admissions committee' (Toelatingscommissie) chaired by Schrier.

Academic courses and pre-university programmes

BSc courses

TITLE	LECTURER
Inleiding astrofysica	Hoekstra
Planetenstelsels	Brown
Praktische sterrenkunde	Van Langevelde
Modern Astronomical Research	Russo
Stars	Snellen
Galaxies and Cosmology	Hodge
Astronomy Lab and Observing Project	Van Weeren
Radiative Processes	Hogerheijde
Astronomical Observing Techniques	Röttgering
Astrobiology	Fridlund
Astronomical Relativity	Rossi
Research Skills and Scientific Integrity	Linnartz
Bsc Research Project	Linnartz
Statistics AN	Szabo (LIACS)+ Cautun
Keerpunten in de geschiedenis van de natuurwetenschappen	Van Lunteren
On Being a Scientist (facultair)	Van Lunteren

MSc courses

TITLE	LECTURER
Stellar structure and evolution	Miguel
Large scale structure and galaxy formation	Kuijken
Origin and evolution of the universe	Schaye
Interstellar medium	Van der Werf
Star and Planet Formation	Van Dishoeck / McClure
Simulation and Modeling in Astrophysics (AMUSE)	Portegies Zwart
Galaxies: structure, dynamics, and evolution	Franx
Astronomical telescopes and instruments	Keller / Kenworthy
Radio astronomy	Shimwell / Brentjes
Detection of light	Brandl
Science and the public: contemporary and historical perspectives	Van Lunteren
Observational cosmology	Bouwens
Astrochemistry	Van Dishoeck
Astronomy from Space	Fridlund
High Contrast Imaging	Kenworthy
Project management for scientists	Keller
Astronomical Spectroscopy	Bouwman
Modern Astrostatistics	Sellentin
Deep Learning in Astronomy	Portegies Zwart

Degrees awarded in 2020

A total of 55 students obtained their Bachelor's Degree.

NAME	DATE	PRESENT POSITION
Diamant, Sharon	28.02.2020	MSc at Leiden Observatory
Verberg, Govert	30.04.2020	unknown
Pilgram, Jonathan	29.05.2020	MSc Technische Natuurkunde, Delft
Broxterman, Jeger	30.06.2020	MSc at Leiden Observatory
Duijvenbode, Jeroen van	30.06.2020	reizen, in 21-22 MSc Leiden Observatory
Post, Jonah	30.06.2020	MSc Physics, Leiden
Rooijen, Victor van	30.06.2020	MSc at Leiden Observatory
Ruiten, Sascha van	30.06.2020	MSc Physics, Utrecht + Mathematics Teacher
Abbink, Daphne	31.07.2020	MSc at Leiden Observatory
Aretz, Joost	31.07.2020	MSc Physics, Leiden
Baert, Tjitske	31.07.2020	MSc Transport, Infrastructure and Logistics, Delft
Baggen, Josephine	31.07.2020	MSc at Leiden Observatory
Barendse, Joost	31.07.2020	MSc at Leiden Observatory
Barmentloo, Stan	31.07.2020	MSc at Leiden Observatory
Bax, Morris	31.07.2020	MSc Computer Science, Leiden
Bloot, Sanne	31.07.2020	MSc at Leiden Observatory
Boxelaar, Jort	31.07.2020	MSc at Leiden Observatory
Buiten, Victorine	31.07.2020	MSc at Leiden Observatory
Dekkers, Daniël	31.07.2020	MSc at Leiden Observatory
Die, van, Frans	31.07.2020	MSc Physics, Leiden
Dik, Christiaan	31.07.2020	MSc at Leiden Observatory

Dröge, Pim	31.07.2020	MSc at Leiden Observatory
Dullaart, Rick	31.07.2020	MSc at Leiden Observatory
Heesakkers, Sanna	31.07.2020	MSc MediaTechnology, Leiden
Hilhorst, Juliëtte	31.07.2020	MSc at Leiden Observatory
Hoogenboom, Rosa	31.07.2020	MSc at Leiden Observatory
Hooijschuur, Twan	31.07.2020	MSc Physics, Leiden
Jagt, Stefan van der	31.07.2020	MSc at Leiden Observatory
Jol, Paloma	31.07.2020	MSc at Leiden Observatory
Konijn, Yorick	31.07.2020	MSc Biophyisics, VU Amsterdam
Koopman, Gabriella	31.07.2020	MSc at Leiden Observatory
Loon, Marlies van	31.07.2020	MSc at Leiden Observatory
Lytens, Daan	31.07.2020	unknown
Molenkamp, Jaro	31.07.2020	MSc at Leiden Observatory
Monchy, Nicky de	31.07.2020	MSc at Leiden Observatory
Nieuwenhuijs, Ayla	31.07.2020	travelling, as of Sept. 2021 Master Environmental Science
Pruijt, Brigitte	31.07.2020	MSc at Leiden Observatory
Regt, Sam de	31.07.2020	MSc at Leiden Observatory
Rensen, Frank	31.07.2020	MSc at Leiden Observatory
Rog, Matthijs	31.07.2020	MSc Physics, Leiden
Rovers, Mats	31.07.2020	unknown
Ruigrok, Jasper	31.07.2020	reizen, in 21-22 MSc Leiden Observatory
Sacha Szkudlarek	31.07.2020	MSc Applied Physics, Delft
Schwander, Eliot	31.07.2020	MSc Physics, Leiden
Strelow, Kira	31.07.2020	MSc at Leiden Observatory
Temmink, Milou	31.07.2020	MSc at Leiden Observatory
Verkade, Rens	31.07.2020	MSc at Leiden Observatory
Vlasblom, Marissa	31.07.2020	MSc at Leiden Observatory
Wasala, Julia	31.07.2020	MSc Computer Science: Artifical Intelligence, Leiden
Wederfoort, Ashmara	31.07.2020	MSc at Leiden Observatory
Welsenes, van, Martijn	31.07.2020	MSc Theoretical Physics, Amsterdam
Witte, de, Job	31.07.2020	MSc Theoretical Physics, Amsterdam
Zwet, Ylke van der	31.07.2020	MSc at Leiden Observatory
Capelleveen, Richelle van	29.10.2020	MSc at Leiden Observatory (zachte knip)
Venselaar, Sophie	31.12.2020	MSc at Leiden Observatory

Degrees awarded in 2020

A total of 3 students finished the Leiden-Beijng Normal University programme

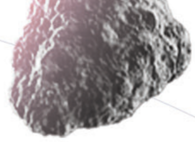
NAME	DATE	PRESENT POSITION
Lyu, Yipeng	31.07.2020	MSc at Leiden Observatory
Li, Tian	31.07.2020	MSc at Leiden Observatory
Shan, Xinrui	31.07.2020	MSc at Leiden Observatory

The following 32 students were awarded their Master's degree.

NAME	DATE	PRESENT POSITION
Chen Xie	31.01.2020	PhD at LAM, France
Hossein Hashemi	31.01.2020	Data Scientist KPN / Data & Analytics Trainee I Young Talent Program
Olivier Aartsen	31.01.2020	unknown
Sujeeporn Tuntipong	31.03.2020	unknown
Hidde Jense	28.05.2020	PhD at Cardiff, United Kingdom
Alex van Vorstenbosch	30.06.2020	Data Science Trainee at Autoriteit Financiële Markten
Andres Aramburo Garcia	30.06.2020	PhD at LION, Leiden

Brian Cook	30.06.2020	PhD at Georgia Institute of Technology
Christiaan Groeneveld	30.06.2020	PhD at Leiden Observatory
Christiaan van Buchem	30.06.2020	PhD at Leiden Observatory
Christopher Seay	30.06.2020	Data Scientist at Cognizant
Joey Braspenning	30.06.2020	PhD at Leiden Observatory
Lisa Dombrovskij	30.06.2020	Data scientist at a health insurance company
Matthijs Mars	30.06.2020	PhD at Data Intensive Science in Astronomy, London
Michael Keim	30.06.2020	PhD at Yale University, Conneticut, United States of America
Orlin Koop	30.06.2020	PhD bij Kapteyn Astronomical Institute, Groningen
Rachel Losacco	30.06.2020	PhD at University of Florida
Rico Landman	30.06.2020	PhD at Leiden Observatory
Robin Mentel	30.06.2020	PhD at UCD Dublin, Ireland
Thijs Stockmans	30.06.2020	PhD at Leiden Observatory
Aaron Seymour	31.07.2020	Scientist at VSL National Metrology Institute
Amy Louca	31.07.2020	PhD at Leiden Observatory
Andrea Manrique Yus	31.07.2020	PhD at Leiden Observatory
Ardjan Sturm	31.07.2020	PhD at Leiden Observatory
Judit Ferrer Asensio	31.07.2020	PHD Student at Max Planck Institute for Extraterrestrial Physics
Luther Algra	31.07.2020	unknown
Ruoyan Wang	31.07.2020	PhD at University of Leicester, England
Akshatha Gopinath	28.08.2020	PhD at Anton Pannekoek Institute, University of Amsterdam
Dennis Vaendel	28.08.2020	Author at New Scientist
Meng Yao	28.08.2020	Looking for job in Data Science
Geoffry Bethel	30.09.2020	Optical Design & Research, California
Javiera Taquias Gomez	30.09.2020	PhD at Hamburg, Germany

PUBLIC ENGAGEMENT WITH ASTRONOMY



Astronomy & Society Projects 2020 Highlights

The aim of Leiden Observatory, and specifically of the Astronomy & Society Group, is to engage the public with the wonders of the Universe and share the scientific, technological, cultural and educational aspects of astronomy with society.

De Oude Sterrewacht Leiden

The Old Observatory aims to share the beauty of the universe alongside the rich history of Leiden astronomy. The Visitors' Centre features a number of exhibitions about astronomy.

The Old Observatory offers educational programs for schools, tours of the building and telescopes by Leiden University astronomy students, and hosts events like open days, public talks and stargazing events throughout the year.

www.oudesterrewacht.nl

Space Scoop

Space Scoop is a weekly astronomy news service for children aged 8 and up, delivering news from across the Universe to the young around the world.

Sharing the excitement of the latest scientific discoveries is one of the best tools that we have to inspire the public — including children. The question isn't whether astronomical news can inspire children, but how we can best communicate this information to the young.

www.spacescoop.org

Citizen Science Lab

The Citizen Science Lab is an incubator for transdisciplinary projects and a knowledge hub for Citizen Science.

The Citizen Science Lab (CSLab) brings together scientists, policy makers, citizens, and other stakeholders in participatory research projects that address scientific questions and/or urgent societal issues that can only be solved by actively involving volunteers in the scientific process.

www.universiteitleiden.nl/en/citizensciencelab
www.plasticspotter.nl

Leiden, European City of Science 2022

In 2022, Leiden will be the stage for European knowledge and science, giving great momentum to the whole of the Netherlands. The Astronomy & Society Group is committed to contribute to a range of activities to celebrate and experience astronomy with society over the city. The Old Observatory's societies dedicate themselves during stargazing evenings, lectures on the size of the universe and workshops where children can make their own rockets. Stay tuned for a fantastic celebration of science!

www.leiden2022.nl

Universe Awareness

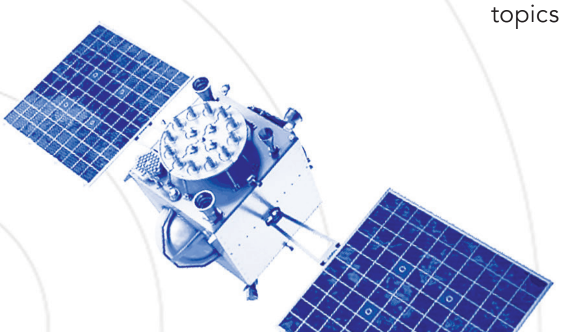
Universe Awareness (UNAWE) uses the beauty and grandeur of the Universe to inspire children between 4 and 10 years old and encourage them to develop an interest in science and technology.

The programme aims to introduce children to the idea of global citizenship at a crucial stage of their development – to show them that they are part of an international community.

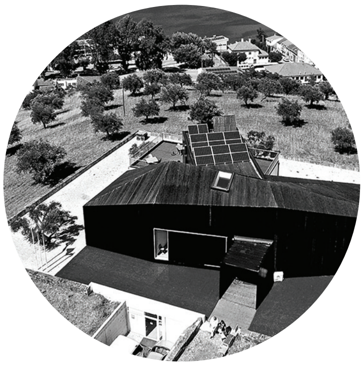
www.unawe.org

SKilled, Innovative and Entrepreneurial Scientists (SKIES)

SKIES, an European Union-funded project, works with astronomy PhD students in Germany, Poland, Portugal, South Africa and The Netherlands with skills and an entrepreneurial mindset that are an asset in any career path within or beyond academia. The focus will be on transferable skills from astronomy that can be used to address societal challenges. SKIES provides training on open science, innovation and entrepreneurship topics for astronomy graduate students.



Open Science Hub



Open Science Hub is a learning space for Science, Technology, Engineering, Arts and Mathematics (STEAM) education that fosters sustainable development of local communities.

The first Open Science Hub (OSH) opened in July 2017, in Barca d'Alva – Figueira de Castelo Rodrigo (Portugal), a rural border town in the northeast of Portugal. OSH-Portugal links science, technology and innovation to the daily life of local and regional communities, promoting school performance and boosting entrepreneurship and innovation in a sustainable way, grounded on the reality of the community.

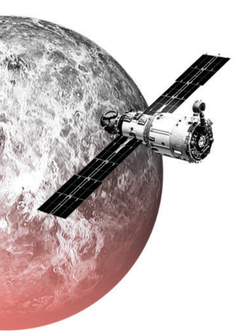
www.oshub.network
www.plataforma.edu.pt

Open Science Hub in The Hague, the Netherlands

The Students for Education (Studenten voor Educatie-SvE) initiative is part of the Leiden University's Open Science Hub project aiming to guarantee quality education for every child.

Involving 26 schools and 40 higher education students in The Hague, SvE is currently running its first year of activities. The university students support primary school children in their day-to-day needs such as reading, spelling and mathematical activities. They receive training in didactics, pedagogics and methods in monitoring and evaluation. This way teachers have support, students have a job, and children have extra help.

www.oshub.network/local_OSHub_NL.html



Astronomers for Planet Earth

Astronomers for Planet Earth (A4E) is a growing volunteer network of astronomy students, educators, and scientists around the globe committed to address the climate crisis and act together for climate justice.

The Astronomers for Planet Earth network plans and develops resources and relevant science policy initiatives to tackle climate challenges. Different working groups are in place to manage collective activities such as events, public outreach, communication, conference participation, public relations, developing educational materials, hosting regional specific discussions and more. These activities are targeted both towards the professional astronomy community and to the general public through outreach.

www.astronomersforplanet.earth

IAU European Regional Office of Astronomy for Development

The IAU European OAD Regional Office in Europe was established in February 2018 and will carry out and coordinate relevant astronomy-for-development activities in Europe and globally, focusing on accomplishing the United Nations Sustainable Development Goals. These activities will fall under three objectives: building a network of astronomy for development in Europe; capacity building around research and development; and use astronomy as an educational tool for peacebuilding and global citizenship. All initiatives will be carried out in cooperation with existing activities of pan-European and national astronomical organisations.

www.astro4dev.eu

SOCIAL NETWORKING

LAD F Kaiser

They first called it 'religion', then others started calling it 'time'. Soon seeing the demerit of both these names, a couple of renowned Greeks labeled it as being 'math'. But, as any good philosopher would say, the numbers were only there to find our raison d'etre. The new concept stuck quite well though: we still highly value mathematics and we also still consider a 'why' question in our science. Yet, these days we dropped its religious value, we call it astronomy and we've come a long, long way since just determining time. But not just in the science itself. Every day, astronomy becomes more and more of a global affair. This makes it important for people to understand what it is and how they can work together. These are exactly the goals L.A.D. 'F. Kaiser' strives to achieve: to connect the people in astronomy and to reach out to the general public.

The Leidsch Astronomisch Dispuut 'Frederik Kaiser' is a student society that was named after the founder of the Old Observatory in the center of Leiden. This location is also where L.A.D. 'F. Kaiser' would normally have most of its outreach activities. However, this year these activities have proven to be very hard to organize in a safe way. But this did not stop Kaiser, as we have found new and improved ways to reach the broader public. For example, Kaiser is involved in organizing the online streams 'Avondje sterrewacht'. These streams, set up by the WLS (Werkgroep Leidse Sterrewacht), are meant for the beginning astronomer to learn a bit more about many subjects of astronomy. Kaiser also collaborates in organizing an online activity for the 'Museumnacht 2021'. For these events, Kaiser recruits volunteers and helps plan and execute activities. Furthermore, the Kaiser Spring Lecture Committee is organizing the eighth edition of our annual public lecture series, de Kaiser Lentelezingen.

Besides connecting to the public, it is also important to connect as an astronomical community. Kaiser promotes the integration between students by organizing online activities in order to keep the students in contact with each other even if they can't meet physically. These online activities have had a broad range, from playing the latest game, to an online lecture about Corona. Last but not least, the contact between Kaiser and the VoS (Vereniging oud-Sterrewachters) contributes directly to student's careers. Through this collaboration we create connections between students and alumni, allowing students to better explore what they want to do after their studies and how to achieve these goals.

To make the above activities possible, L.A.D. 'F. Kaiser' has an annual board.

The 2020/2021 board consists of Hannah van Gemert *(chairwoman)*, Tessa Paauw *(secretary)*, Christian Groeneveld *(treasurer)*, Sharon Diamant *(vice-chairwoman/assessor Old Observatory)* and Jonathan Pilgram *(assessor Old Observatory)*.

The 2019/2020 board consists of Carmen Turner *(chairwoman)*, Hannah van Gemert *(secretary)*, Christian Groeneveld *(treasurer)*, Rick Dullaart *(vice-chairman/assessor Old Observatory)* and Jort Boxelaar *(assessor Old Observatory)*.

VO-S the Leiden Observatory Alumni Association

The Vereniging van Oud-Sterrewachters ("VO-S") is the Leiden Observatory alumni association. In 2020, a limited number of activities have been organised.

The VO-S organises several activities during the year for (under)graduates and staff that have left Leiden Observatory, not only to keep social ties between alumni alive, but also to feed their general interest in astronomical research. Due to the impact of the Covid-19 pandemic, however, most of the activities of 2020 had to be canceled or postponed (annual general assembly).

We were able to carry out two events, both organised together with L.A.D.F. Kaiser. In early February the students opened the domes of the Oude Sterrewacht for several VO-S members. Under a moonlit sky, those present highly enjoyed this opportunity to observe planets and stars.

A mentor lunch meeting for bachelor and master students at Leiden Observatory was held online in November. Four VO-S mentors were available for questions on future career paths beyond astronomy. The meeting was well attended and received positive feedback. The VO-S certainly plans to organise similar events in the future. Hopefully in a live setting.

Communication with our members on the latest research in astronomy and our upcoming activities took place via http://www.vo-s.nl, our newsletter and by email. The VO-S board thanks alumni officer Annette Heijn for her ongoing support in the organisation of and communication on these activities.

Join the VO-S!

The association has nearly 150 members, with membership open to all Leiden Observatory alumni and staff.

For contact and membership of our alumni association:

– visit our website:
  http://www.vo-s.nl

– send an email:
  vo-s@strw.leidenuniv.nl

VO-S Committee:

– Niels van Weeren *(chair)*

– Maaike Damen *(secretary)*

– Gerben Zwart *(treasurer)*

– Anthony Brown *(Leiden Observatory liaison)*

Credit: N. van Weeren

ORGANISATION

Observatory Staff

FULL PROFESSORS

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Prof.dr. E.F. van Dishoeck
Prof.dr. M. Franx
Prof.dr. H. Hoekstra
Prof.dr. M.R. Hogerheijde
Prof.dr. C.U. Keller
Prof.dr. K.H. Kuijken
Prof.dr. H.V.J. Linnartz
Prof.dr. F.H. van Lunteren
Prof.dr. S.F. Portegies Zwart
Prof.dr. H.J.A. Röttgering
Prof.dr. J. Schaye
Prof.dr. I.A.G. Snellen
Prof.dr. A.G.G.M. Tielens
Prof.dr. S. Viti
Prof.dr. P.P. v.d. Werf
Prof.dr. P.T. de Zeeuw

TEMPORARY ASSISTANT PROFESSORS

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Dr. M. Cautun *VIDI Fellow*
Dr. K. Chuang
Dr. M. van Daalen *VENI Fellow*
Dr. M. McClure *VENI Fellow*
Dr. M.A. Monreal Ibero
Dr. T. Stolker *VENI Fellow*
Dr. S. van Velzen *Oort Fellow*

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Dr. A.G.A. Brown
Dr. L. Burtscher
Dr. J.A. Hodge
Dr. M.A. Kenworthy
Dr. Y. Miguel
Dr. P.M. Rodrigues Dos Santos Russo
Dr. E.M. Rossi
Dr. E. Sellentin
Dr.ir. F. Snik
Dr. R. Stuik
Dr. L. Tilanus
Dr. R.J. van Weeren

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J.H. Oortfonds, TNO

Prof.dr. P. Ehrenfreund
CEO, German Aerospace Center

Prof.dr. M. Fridlund
J.H. Oortfonds

Prof.dr. C.A. Jackson
ASTRON

Prof.dr. J.S. Kaastra
Senior Scientist SRON

Prof.dr. H.J. van Langevelde
JIVE/Director EHT

LONG TERM GUESTS

T. Agócs MSc
M. Ahmadi
Dr. J. Bedorf
R. Bergsvik MA
Dr. J. de Boer
Dr. M.A. Brentjens
Dr. J. Brinchmann
Dr. X. Cai
Dr. A. Candian
Dr. S.M. Cazaux
Dr. N.E. Chisari
Dr. C.A. Correa
Dr. K.J. Duncan
Prof.dr. B.A.C.H.J.S. Foing
Prof.dr. J.E.Forero-Romero
Prof.dr. M.A. Garret
Dr. A.M. van Genderen
Dr. R.H. Hammerschlag
J. Hanse MSc
Prof.dr. J.F. Hennawi
Dr.ing. H.T. Intema
Dr. M. Kazandjian
Dr. L. Kreidberg
Dr. A. Kulier
Dr. N.F.W. Ligterink
Dr. S. Mandal
Dr. S.R. McAlpine
Dr.ir. A. van der Meijden
Dr. J.A. Meisner
Dr. F.D.M. Mernier
Ir. J.E. Miro-Carretero
Dr. R. Nanni
Dr. S. Notsu
Dr. J.B.R. Oonk
Dr. C.H.L. Patty
Dr. F.I. Pelupessy
W.P. Pieterse BSc
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Grants

P.I.	FUNDER	PROPOSAL TITLE	BUDGET (k€)
Portegies Zwart	NWO	Unraveling Neural Networks with Structure Preserving Computing	282
Rottgering	NWO NWA	"Center for Optimal, Real-Time Machine Studies of the Explosive Universe"	263
Hoekstra	NWO ENW-KLEIN	An all-sky monitor for the Vera Rubin Observatory	213
Stolker	NWO VENI	Unveiling formation signatures in the atmospheres of directly imaged exoplanets	244
Arias	NWO VENI	The Galactic Plane at Two Metres: Supernova Remnants with LOFAR	250
Van Weeren	NWO	DUPLLO: Digital Upgrade for Premier LOFAR Low-band Observing	230
Russo	EU	International Project Coordinator IAU	72
Linnartz	EU	Center for Interstellar Catalysis (InterCat)	972

Rocha	EU	Building blocks of the molecular universe: A coordinated laboratory and theoretical study of elemental C2X (X=N, O, Si, S) molecules	176
Hennawi	EU	Quasars in a Neutral Universe: Chronicling the History of Reionization, Enrichment, and Black Hole Growth	2496
Kuijken	EU	NEO Precovery Searches	77
Brown	EU	Who is In, and Who is Not? Determining the Gaia Survey Selection Function	531
Russo	EU	SKilled, Innovative & Entrepreneurial Scientists	94
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Rossi	EU ERC	Probing our Galaxy from the Center to the outskirts	2000

IN MEMORIAM

Jet Katgert

Recollections by Harm Habing

Jeannette Kate ("Jet") Merkelijn was born in 1943 in the middle of the second world war. She passed away on 10 June 2020 in Leiden.

Jeannette Kate ("Jet") Merkelijn was born in 1943 in the middle of the second world war. Her birth was at her grandparents' house in the Hague, while her father had gone into hiding to avoid being drafted to Berlin as a doctor. Her parents were Dutch Calvinists ("gereformeerd") – her faith has been important for Jet throughout her life and it never affected her interest in science. Jet attended school at the Middelburg Gymnasium, matriculated in 1960, and decided to study astronomy at Leiden.

She did well at university and served as an apprentice student to Gart Westerhout, famed for his large radio surveys of the Milky Way at 21 cm. After completing her "candidaats" examination in 1963, she did a minor research project with R. Steinitz and then completed a noted major research project with Mike Davis, an American postgraduate student of Oort's.

In 1966 Jet was offered the opportunity of doing research in Australia with John Bolton, one of the most renowned pioneers of radio astronomy. She accepted and was an active participant in the seminal radio surveys of the southern sky that were then being carried out with the Parkes radio telescope, then one of the largest in the world. Her main work concerned the survey of extragalactic radio sources at 2700 MHz (11 cm) and identified several hundred optical counterparts to the sources, a great success. After returning to Leiden, she used these data to determine the luminosity function of radio sources at 400 and 2700 MHz and wrote a PhD thesis under the supervision of Oort, and was awarded a PhD in 1970.

She then continued for a few years as a researcher at Leiden Observatory, when the new Westerbork Radiotelescope was being commissioned. Jet worked intensively with Peter Katgert and Rudolf Le Poole in testing the underground cables for leakages, but her collaboration with Peter resulted in more than just leak-free cables – at a meeting of the International Astronomical Union at Brighton in August 1970 I noticed Peter and Jet walking hand in hand, clearly in love with each other, and married soon after.

In 1974 they left for Cambridge, England, where Peter had secured a fellowship at the Institute of Astronomy. They both managed to survive on the modest English stipend – no mean feat! In 1975 their roles were reversed, with Peter accompanying Jet to Bologna for a year's visit to the Istituto di Radioastronomia. They made many good friends there, learned to speak Italian and acquired a love of Italy.

In 1976 they returned to Leiden, when Peter was appointed as a permanent member of the Observatory staff. Jet joined a collaboration that had been established between Leiden and the Center for Astrophysics at Harvard to carry out complementary radio observations of X-ray sources detected by the satellite. This project progressed with difficulty, partly because most of the newly detected X-ray sources did not emit strong radio emission. Meanwhile, Jet had become secretary of the Observatory Council.

In 1980 the Netherlands Organization for Scientific Research (NWO) set up a new organization, ASTRON, to serve branches of astronomy that were not dealt with by the radio astronomy institute at Dwingeloo (SRZM). Jet applied for the job of Executive Secretary of ASTRON and was appointed to this job by Adriaan Blaauw, the Chairman of ASTRON. The two worked well and effectively together. A few years later SRZM and ASTRON were fused by NWO into the present ASTRON organization and moved at Dwingeloo.

Meanwhile Peter and Jet had produced two young sons and Jet took a few years off to look after them. In 1985 the whole family went to La Palma. Peter worked there for a year as part of the Dutch contribution to the new British-Netherlands Observatory there, with its large 4.2m William Herschel telescope. It was not a very happy time. After their return to Leiden Jet occupied the position of Executive Secretary of ASTRON once more in 1987 during a sabbatical of her successor, Wilfried Boland.

In 1988, on the initiative of Butler Burton, a plan was made to set up and catalogue Oort's archive for the benefit of future science historians. NWO agreed to fund this project and awarded Jet a two-year contract to carry it out. However, this work could not be fully completed within the allocated two years. After her contract ceased, Jet took up a position as an English school teacher and occupied this position from 1991 until 1994 (As a hobby she had previously obtained an English MO-A teaching diploma). In 1994 the Oort fund decided to fund the completion of the archive work, and from 1994 until 1996 Jet worked hard to organize the archive. She published the results in a highly praised and highly cited book, "The manuscripts and correspondence of Jan Hendrik Oort".

In 1996, when she had completed her work on the Oort archive, she joined Harm Habing (then one of the chief editors of Astronomy & Astrophysics) in editing and producing the journal. After Harm's retirement in 2002, she continued for a year as language editor for A&A manuscripts, copiously checking their English. Afterwards she spent two years with the University library in a project to digitize Leiden PhD theses and make them available on the web, and retired thereafter.

Jet continued to publish and contributed in many ways to astronomy and to the Observatory: from the Oort archive work she set up an website with astronomical group photographs complete with as many identifications as possible https://www.strw.leidenuniv.nl/oortfotos/, and she acted as associate editor for the proceedings on the conference on "400 Years of Astronomical Telescopes".

She passed away on 10 June 2020 in Leiden.

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PUBLISHER:

Leiden Observatory, Leiden University

EDITORS:

Matthew Kenworthy, Jacqueline van Rooijen, Evelijn Gerstel, Huub Rottgering

DESIGN:

Aneta Margraf-Druc

IMAGE CREDITS:

ESO: covers, pages: 4, 20, 54, 58

Veldman Rietbroek architecten, pages: 18, 19, 35, 36, 78

www.universiteitleiden.nl/en/science/astronomy

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