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DTU

John Weaver and Vasily Kokorev moving to the new Niels Bohr Building at Jagtvej.
Image Credit: Guarn Nissen

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Image Credit: Gabriel Grammer

The Cosmic Dawn Center

From the Directors

It has been another exciting year at DAWN with many scientific high-lights that have helped ensure the center's continuing success and established it as a leading world class research center. DAWN has grown rapidly over the past year, due to excellent international scientists from diverse backgrounds joining the center.

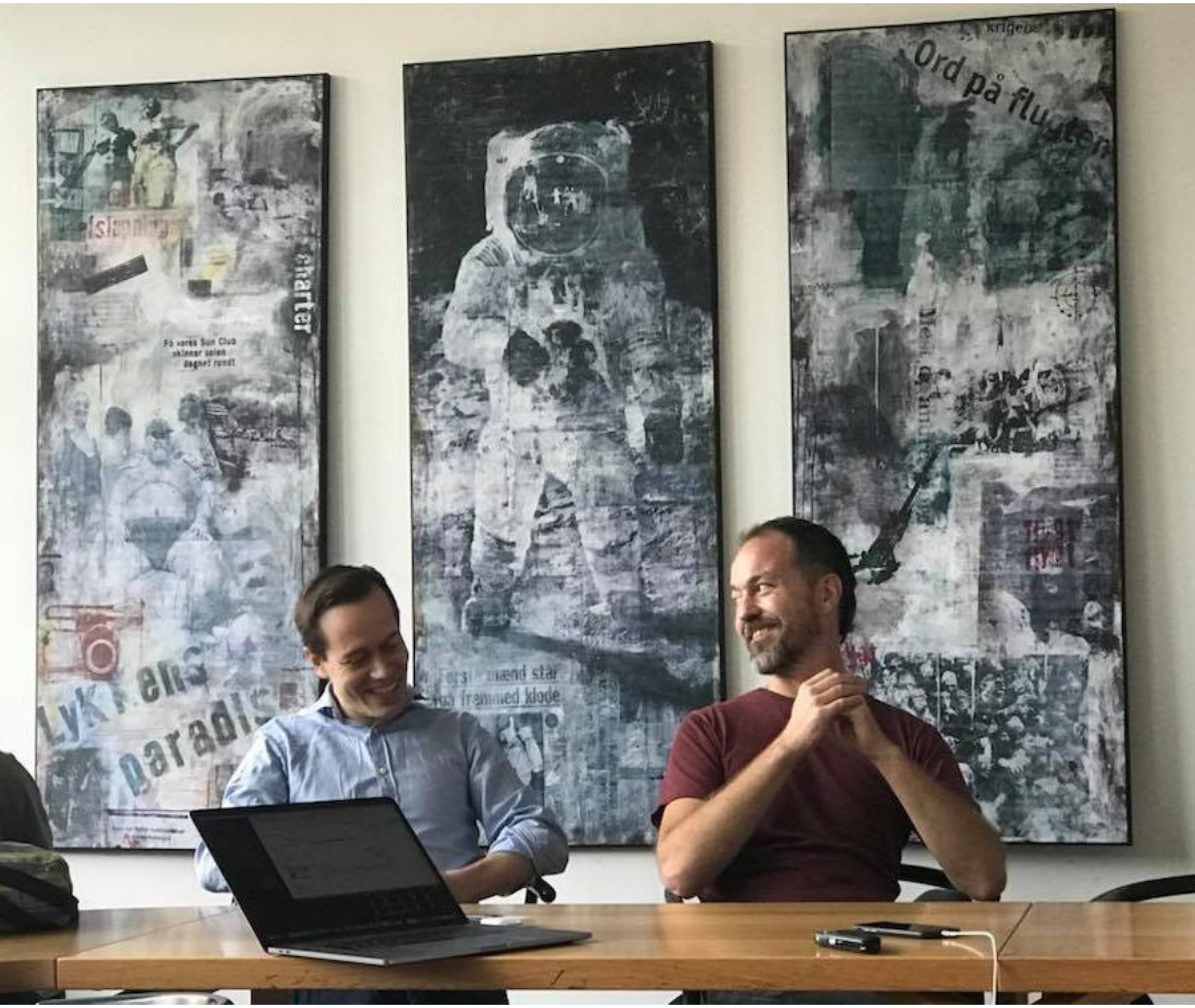
The COVID-19 pandemic has affected the center much like the rest of society. For most of the past year we have been working from home, which means we have missed out on the important social aspect and the spontaneous exchange of ideas that comes with being in an office environment. Nonetheless, we maintain daily interactions via Zoom and online meetings. As astronomers, collaborating in large international teams, we are to a great extent accustomed to this mode of working. This meant that it took little adaptation to switch to having our collaboration meetings and seminars online. In some sense, it almost brought us closer together - especially with our international associates, who were also in lockdown in their respective countries. After coming out of the pandemic lockdown and returning to our offices, we will maintain this close connection to our worldwide DAWN family.

In July 2020, DAWN finally moved into the Niels Bohr Building (NBB) located on Jagtvej, along with DARK and the Condensed Matter Theory groups of the Niels Bohr Institute (NBI). The building has not yet been taken over by the University, but one floor of the building where construction has been completed is leased and our first impression of the building is very positive. We look forward to welcoming the DAWN staff back after the pandemic lockdown. We also look forward to welcoming other colleagues from the various sections within NBI when they join us at NBB sometime during 2022.

The past year has also seen several major and prestigious grants awarded to DAWN scientists, or scientists coming to DAWN in the near future. Notable mentions are Dr. Charlotte Mason and Dr. Georgios Magdis who won the Villum Young Investigator and the Villum Young Investigator Plus prizes, respectively. Furthermore, two of our DAWN Fellows, Dr. Seiji Fujimoto and Dr. Francesca Rizzo, won INTERACTION Co-fund grants. Finally, Dr. Bitten Gullberg, currently a Lindblad Fellow at Chalmers University. Gothenburg, Sweden, won a Carlsberg Reintegration Fellowship to bring to DAWN in 2021. Our success at winning grants underscores that our strategy for hiring the best scientists who demonstrate high potential as future leaders in their field has paid off and is the right strategy going forward.

November 22, 2020 was a historic date as it was the proposal deadline for what will undoubtedly become one of the most impactful telescopes in decades, namely the James Webb Space Telescope (JWST). Leading up to the deadline, DAWN together with ESA organized a JWST Master Class workshop, where astronomers from the broader international community could learn the complexities of preparing JWST observations. DAWN scientists were strongly represented amongst the large pool of proposals that competed to win telescope time. It is a source of immense satisfaction and pride that DAWN scientists were Principal Investigators (PIs) on 6 JWST proposals and Co-Investigators (Co-I's) on 39 successful JWST proposals, for a total of 2138 hours of observations.

The successful PI programs include two programs led by junior DAWN scientist (a PhD student and a postdoc), and the largest program awarded (207 hours), with strong DAWN involvement. DAWN is thus involved in 35% of the 6000 hours of observations to be done in open time during the first year of observation. Additionally, we will be involved with three of the four guaranteed time observations and several early release science programs. Everyone at DAWN are eagerly awaiting the launch of JWST, which is on track to happen from French Guiana in October 2021, and the arrival about a year later of what will undoubtedly be revolutionary data. Exciting times ahead!



From the left Co-Director Thomas Greve and Center Director Sune Toft. Image Credit: Trity Pourbahrami

Annual highlights

Hiding behind a wall of dust

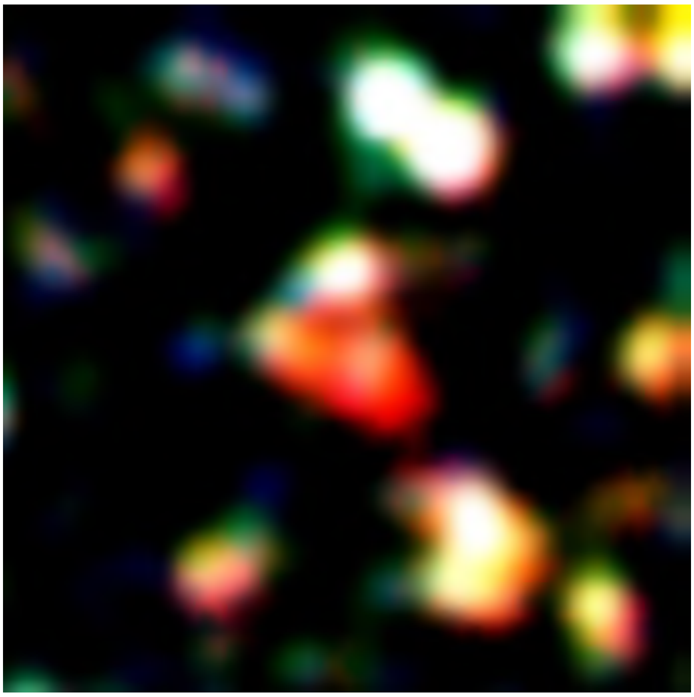
By Isabella Cortzen

The hunt for distant galaxies has traditionally been based on telescopes designed to detect their starlight emitted in the UV and visible spectrum. Naturally, this light becomes progressively fainter and harder to detect as we look farther out into space.

While missions like NASA's and ESA's new flagship, the James Webb Space Telescope, are specifically built to address this technical limitation, there is another, more fundamental barrier set by Nature: Galaxies are enshrouded in large amounts of dust and gas blocking the starlight, re-emitting it as infrared light.

Using a combination of state-of-the-art observations, DAWN members revealed that this "wall of dust" in some of the most star-forming galaxies in the early Universe blocks not only starlight but also a portion of the emitted light by the dust itself. DAWN PhD student Isabella Cortzen demonstrated that this "self-absorption" caused by thick layers of dust has profound implications for the observability and the very nature of these galaxies.

The new results suggest that some early galaxies are up to ten times more efficient at converting gas to stars than previously thought, calling for a radical rethinking of their dust and gas measurements, and the evolution of the first galaxies.



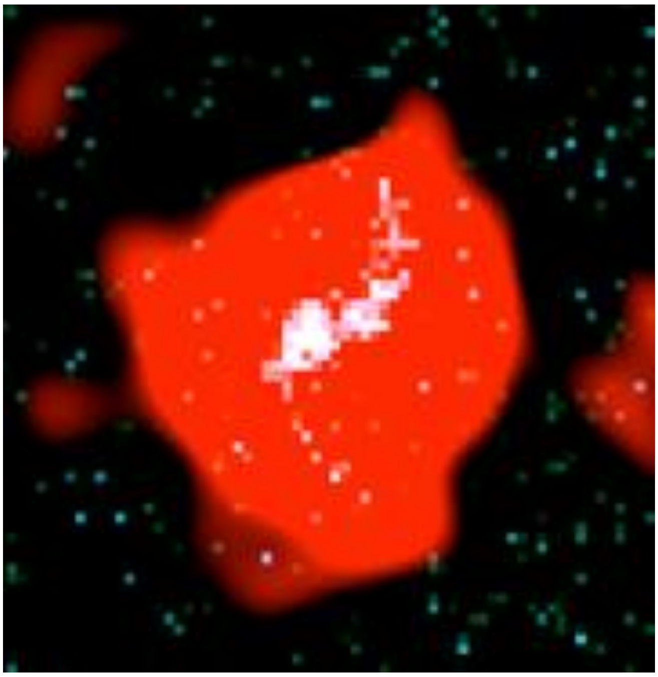
Infrared image of one of the galaxies in the study, GN20, seen when the Universe was but 10% of its current age, but already forming stars at a rate of more than a 1000 times that of our own galaxy. Credit: Isabella Cortzen.

Early, mature galaxies and the dispersion of heavy elements

By Seiji Fujimoto

Heavy elements (or "metals") such as carbon and oxygen did not exist in the Universe at the time of the Big Bang. They were formed later by nuclear fusion in stars. However, it is not yet understood how these elements spread throughout the Universe — an essential process to foster life.

To understand these processes, DAWN postdoc Seiji Fujimoto and collaborators undertook, for the first time, a systematic survey of distant galaxies with the ALMA observatory. And the result was unexpected: As a by-product of dying stars, galaxies already contained a significant amount of dust and metals when the Universe was only 10% of its current age.



Roughly 50,000 lightyears across, the stars (white) in this galaxy are seen enshrouded in a halo (red) of metal gas. Credit: S. Fujimoto.

In particular, they found that the gaseous metal clouds are always present, far beyond the stars, sometimes even forming an ordered rotating disk. That is, the galaxies are much more "mature" than previously thought.

Supernova explosions and energetic jets and radiation from supermassive black holes are likely to be the main drivers that transport the metal gas outside of the galaxies and finally throughout the Universe.

The DAWN Team: Credit: Seiji Fujimoto

The Organization

Covid-19

The pandemic had a large influence on life at DAWN. We were among the first to be sent home in the spring, and since then all teachings and collaborating activities have been online. We organized almost daily online gatherings for the whole center, in the form of working group meetings, journal clubs, talks, and happy hours. Luckily, astronomers are quite used to working and meeting remotely with international collaborators so we have not seen a significant decrease in the scientific output of the center during the pandemic. A positive effect has been that our international associates have become more closely integrated in the center's activities, as they could equally participate in online meetings with local center members.

Housing of the center

The Cosmic Dawn center was once again relocated during July 2020 to the new high tech Niels Bohr Building (NBB) located at Jagtvej 128. The move from our light and airy open loft space work environment at Vibenshuset to our permanent home at NBB with private offices and roomy common areas was fairly uncomplicated in spite of the COVID 19 challenges. We managed to move our entire center with minimal obstacles while most center staff members were enjoying vacations.

As mentioned in the directors' statement, we continue to expand our center with new staff and students and naturally concerns for our future office-spaces are already being considered. With regards to future space concerns, we estimate that the center will outgrow our current allocated office-spaces within the next year. However, NBI has developed an algorithm based on the number of staff members and students that allows for calculating, reviewing and reassigning the office-spaces as needed and required. Both DAWN and DARK are located on the second floor at NBB.

The DTU Space part of DAWN has moved from the ground floor offices to new offices on the second floor. This means DAWN is now on the same floor as the other astronomers at DTU Space, including the exoplanet group led by Lars Buchhave, as stated in the DNRF contract.

DTU and the Niels Bohr Building. Credit: DAWN/Peter Laursen

Hiring plan

The independent DAWN postdoctoral fellowship program continues to be competitive with the major international fellowships in astronomy. We advertise every year and consistently receive 80–100 applications from around the world. In 2020, we hired Dr. Francesca Rizzo from the Max-Planck Institute for Extraterrestrial Physics, as a DAWN Fellow at NBI, Dr. Lijie Liu from University of Oxford, and Dr. Steven Gillman from Durham University as postdocs at DTU.

Our strategy of supporting independent fellows has so far been successful. A DAWN fellowship is competitive among the strongest, most independent international young scientists who can bring new ideas and projects to the center. The high profile of the fellows qualifies them as good candidates for winning their own independent fellowship and young group leader grants. In fact, four of our DAWN Fellows have won their own grants (two INTERACTIONS EU-cofund grants, one Carlsberg postdoctoral grant and one Marie Sklodowska - Curie, MSC-EU fellowship). Additionally, two other fellows were appointed permanent positions in their home countries.

In the past year, DAWN has hired four new PhD students. Three students have started at NBI and one student has started at DTU. Dr. Charlotte Mason, who will join the DAWN faculty at NBI in August 2021, has filled the embedment associate professor position at NBI. Dr. Mason is a world-leading expert in studies of the very first galaxies and works at the interface between observations and simulations. In December 2020, Dr. Mason won a Villum Young Investigator grant, which will allow her to build a research group at DAWN. We have also hired Dr. Pascal Oesch who transitioned from being an international associate to an associate professor at DAWN/NBI where he will spend 20% of every year going forward. Dr. Oesch is a leading expert on optical/near-IR observations of early galaxies with Hubble and James Webb Space Telescope.

The process of filling the Professorship at DTU Space has been delayed by more than a year; however, an open call for the Professorship at DTU Space was advertised in March 2021. The call closed in April 2021, and it is expected that a successful candidate will be found not long thereafter.

Recruitment and gender strategy

Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

The DAWN recruitment strategy is simple: to hire the best talents in our field. This means our focus is to recruit internationally as well as nationally, and it means hiring the best and brightest, regardless of gender, ethnicity, and cultural background. We align our hiring cycle with the international PhD and postdoc recruitment calendar, and focus on hiring outstanding, independent fellows from a broad range of diverse backgrounds to our flagship DAWN fellowship. At DAWN, we strongly believe that a diverse working environment is one that fosters creativity, different ways of approaching challenges and, ultimately nurtures new ideas.

Science Progress & Research Updates in 2020

Research integrity

From the beginning, DAWN has been committed to the highest levels of research integrity. We continue our adherence to open access to our research products via arXiv.org and open access peer-reviewed scientific journals. This also includes the use of public research data repositories.

One of the most important tenets of our research integrity, and which is not highlighted in most codes of ethics, is the social responsibility we feel towards junior scientists and colleagues in non-permanent positions.

We therefore work with senior postdocs and scientific/technical staff on fixed term contracts in two ways: first to develop their skills portfolio with a view to future careers outside of a strict academic research environment. Secondly, they fill important scientific support roles at DAWN, until they find desired positions on their career paths. We regard this as an important aspect of building a trusted, caring, and supportive environment, vital for any successful research team.

Research plan

Research themes and DAWN's 2020 discoveries

The Cosmic Dawn Center studies the birth, the life, and the death of galaxies. In other words, we aim to detect the **first galaxies**, investigate their **evolution**, and learn which processes lead to their so-called **quenching;** a term describing how some galaxies cease forming stars. Additionally, we study the smaller scales, specifically the gas and dust that lies in between the galaxies' stars, known as the **interstellar medium.** We also study the larger scales, namely the effect that the galaxies have on their environment in the early Universe; the so-called **Epoch of Reionization**. These scientific goals are reached through our involvement in large **observational programs** and interpreted through both existing **theories and novel methodologies**.

First galaxies

Galaxies are the building blocks of the Universe, and understanding how, and how soon, these enigmatic structures of gas, stars, and dark matter arose, is an observationally challenging task that almost involves looking to the edge of the observable Universe.

Currently, the most distant galaxy is seen at an epoch where the Universe was only 400 million years old, 3% of its current age. The first stars were formed at half this age, but have not been directly observed.

This is expected to change with the launch of the JWST. Years of preparation will soon provide vast amounts of data to be interpreted by astronomers. While COVID-19 forced the JWST collaborators to once again postpone the launch of the telescope, 2020 was the year of the first cycle of JWST proposals. During 2020, DAWN did not lie idle, but submitted more than 20 proposals as Principal Investigators (PIs) and more than 100 as Co-Investigators, for a total of some 4000 hours of observing time.

Galaxy evolution

Galaxies evolve through both internal and external processes: Gas is converted to stars, which pollute the interstellar medium with heavy elements, some of which form dust grains. Spiral arms form, and gas is ejected as galactic winds, triggered by the feedback of stars and quasars. At the same time, galaxies accrete new gas from the intergalactic medium, and merge with other galaxies. The interplay between these processes determines the fate of a galaxy - whether it will turn out a disk like and star-forming spiral galaxy, an elliptical, red and "dead" galaxy, or something else.

The evolution of galaxies was investigated through observations by Walter et al. (2020). Where they established the need for galaxies to accrete gas from the surrounding intergalactic medium by constraining the cycle of stars and gas. Meanwhile, Steinhardt et al. (2020a) developed a theoretical model to explain how galaxies reach the so-called *main sequence*, which is a relation between galaxies' stellar mass and the rate at which they form new stars, thus finding that cosmic rays play a crucial role in this process.

Quenching

From the time they are formed, some galaxies continue to form stars and still do today. The beautiful bluish spiral galaxies are an example of this. However, others — typically the most massive and elliptical galaxies — at some point cease to form stars. As the short-lived, blue stars die out and the long-lived, red ones remain, these galaxies get their characteristic orange-reddish color.

For the Milky Way, forming its hundreds of billions of stars has taken the lifetime of the Universe - 13.8 billion years. It was therefore a surprise when two, possibly three, galaxies were detected already 1.5 billion years after the Big Bang with a similar number of stars, which had already stopped almost completely forming new stars (Valentino et al. 2020a).

To understand the Universe at a slightly later time, Stockmann et al. (2020) collected and analyzed one of the largest samples of galaxies, which are expected to evolve into the most massive elliptical galaxies in the local Universe. Surprisingly, a large fraction showed signs of ongoing or recent collisions with other galaxies, helping to explain how massive galaxies double in size over 10 billion years to match what we see now in the local Universe.

Structures in the Universe form "bottom-up", from little clumps of stars in the very early Universe, to galaxies, to groups and clusters of galaxies in recent times. Detecting a mature galaxy cluster, seen when the Universe was only 3.5 billion years old, with stars formed when the Universe was only 370 million years old, was hence a surprise (Willis et al. 2020).

The interstellar medium

Whether stars die with a whimper or with a bang, they return their gas to the space in between them, only now it is polluted with heavier elements, or "metals".

Not only the metals themselves, but also the molecules and the dust that they form, affect observations both in emission and in absorption. Moreover, they facilitate star formation, and they engender massive outflows through stellar and galactic winds.

These processes are interesting in themselves, but also have major impacts on the evolution of galaxies. Analyzing the interstellar medium, or the gas between the stars, is thus pivotal to understand galaxies.

During intense bursts of star formation, one might expect the interstellar medium to heat up. Observationally, however, in the early Universe such galaxies appear to become colder. An appealing solution to this puzzle was offered by Cortzen et al. (2020), who revised the way that temperatures are derived from carbon and dust in the interstellar medium.

Valentino et al. (2020b) and Valentino et al. (2020c) probed the carbon and carbon monoxide emission of a sample of galaxies, establishing relations between how efficiently gas turns into stars, how fast it happens, and the intensity of the radiation from these stars.

Reionization

Through its history, the Universe has experienced a number of global transitions. Most of these took place in the early Universe. Shortly after the Big Bang, the Universe was so hot that all atoms were ionized and electrically charged. When it had cooled enough that neutral atoms could form, it remained so for several hundred millions of years. However, roughly half a billion years after the Big Bang, a global phase transition took place, where the entire vast space between the galaxies was re-ionized.

While there is general consensus that the sources of the ionizing radiation was hot stars in the first galaxies, quasars (supermassive black holes) are also thought to play a role. An interesting discovery was made by Fynbo et al. (2020), who for the first time measured the distance to such a quasar based on its halo of hydrogen; this colossus is spewing out material at 10% the speed of light!

A theoretical breakthrough was presented by Naidu et al. (2020) in the form of an empirical model that accurately matches a number of observations and predicts testable results: Reionization was dominated by a few very bright galaxies, with the fainter majority contributing negligibly, contrary to what was previously thought. This study was co-authored by Dr. Pascal Oesch and Dr. Charlotte Mason (Naidu's supervisor), who both recently accepted a part-time and full time position, respectively, as associate professors at DAWN.

Major DAWN programs

DAWN is involved in a number of observational programs, or *surveys*, dedicated to unraveling the mysteries of the "cosmic dawn epoch".

The BUFFALO survey is a Hubble Space Telescope program, designed to investigate early galactic assembly and clustering. One of BUFFALO's key goals is to determine how rapidly galaxies formed in the early Universe. BUFFALO is led by Charles Steinhardt, and an already well-cited paper describing the survey came out recently (Steinhardt et al. 2020b).

BUFFALO utilizes a marvelous technique called *gravitational lensing*, where the very gravity of a massive foreground galaxy cluster *warps* space so much that light from distant background galaxies is deflected and amplified. This technique was also used by, Fujimoto et al. (2020a) to investigate the most massive black hole in one of the "first" galaxies.

Fujimoto and other DAWNers are active members of the ALPINE program, an international collaboration dedicated to measuring the infrared properties of the gas and dust in more than 100 galaxies 0.9 – 1.5 billion years after the Big Bang. This epoch "bridges" the time from the first galaxies to the more evolved galaxies, and a large number of studies have emerged from this study.

Fujimoto et al. (2020b) demonstrated how the size of galaxies evolve, and how some of them are surrounded by a large, carbon-enriched halo. Meanwhile, Fudamoto et al. (2020) and Béthermin et al. (2020), with a strong DAWN involvement, characterized the evolution of the properties of dust and the star formation properties, respectively, in these early galaxies.

Gravitational lensing is also the backbone of the ReQuieM survey, led by DAWN's international associate Kate Whitaker, studying the most massive galaxies in the early Universe. A pilot study of the methodology that will be used to analyze the sample was presented in (Akhshik et al. 2020).

The COSMOS survey is the largest survey ever with the Hubble Space Telescope, and this field has since been observed with virtually all major telescopes, providing measurements from X-ray to radio wavelengths. The survey "catalogs" containing physical properties of more than a million galaxies over most of the age of the Universe are among the most influential studies in astronomy.

DAWN is leading the latest version of the catalog, which was released internally to the COSMOS team in September and is currently under review for publication. The new catalog builds on new infrared data from the DAWN-led UltraVISTA survey (Co-PI Johan Fynbo), and optical data from the Japanese Subaru telescope in Hawaii. The new data finally makes it possible to find the rarest brightest galaxies during the cosmic dawn epoch. Several telescope proposals have been submitted involving almost all DAWN members to study these newly discovered galaxies.

The COSMOS survey is a prototype for the much larger Cosmic Dawn Survey to cover the deep fields of the Euclid Spacecraft mission (scheduled for launch in 2022) with deep multi-wavelength data to allow discoveries of thousands of cosmic dawn era galaxies. In early 2021, the DAWN-led Cosmic Dawn Survey was officially selected by the Euclid board as a pre-launch key project, of essential importance to the mission.

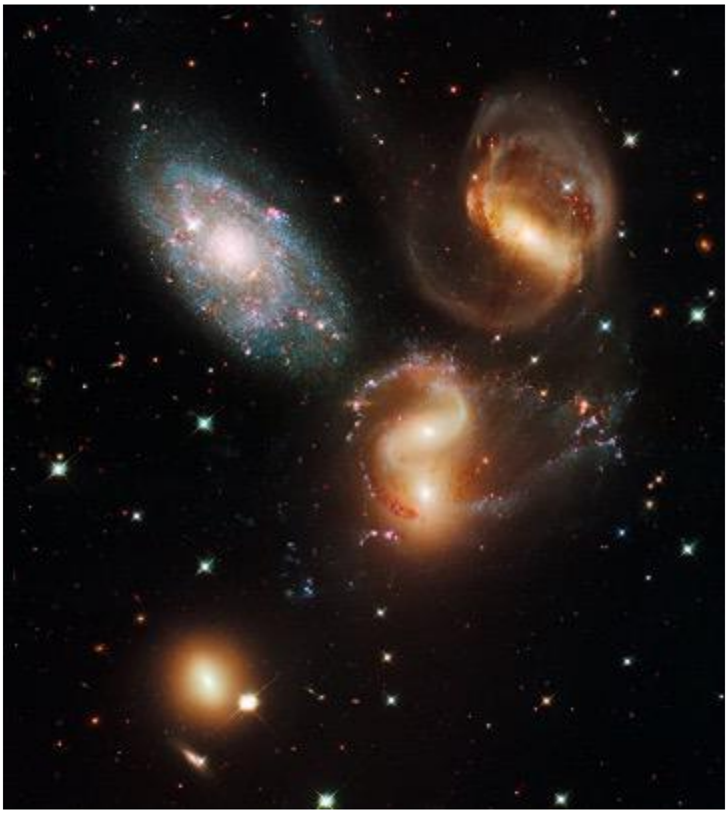
Theory and novel methodologies

While most research at DAWN is observationally inclined, theories are needed not only to explain and interpret observations, but also to predict what we may expect to observe. Lagos et al. (2020) did exactly this, studying the most massive, dusty galaxies through semi-analytical models that match observations remarkably well in a number of properties. In a more classical, numerical simulation of the hydrodynamical formation of galaxies, Salim & Narayanan (2020) implemented a sophisticated model of dust formation and destruction processes, calculating the extinction properties of dust in galaxies.

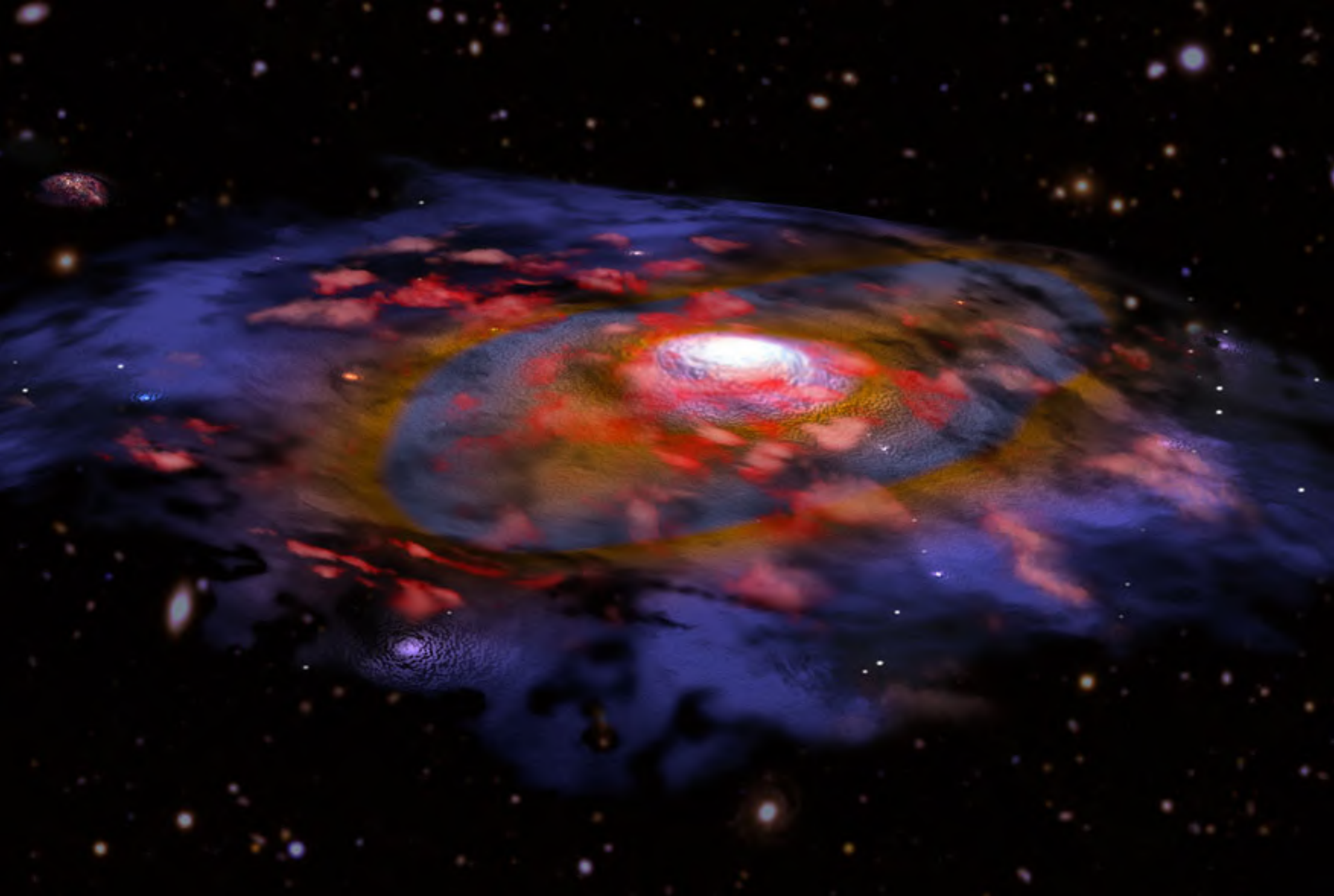
The phenomenological model of Kaufmann et al. (2020) demonstrated the need for observing larger areas on the sky, rather than small areas for a long time, in order to properly quantify the luminosity distribution of the brightest galaxies. A more empirical model by Gobat et al. (2020) showed how some galaxies may be quenched even though they have a fair amount of gas left.

A fairly novel methodology that has entered astronomy is *machine learning*. With this technique, DAWN BSc student Christian Jespersen et al. (2020) was able to classify so-called *gamma-ray bursts* (the most violent explosions in the Universe), which are also helpful in probing the interstellar medium of galaxies.

As described above, quenched galaxies turn redder with time. However, galaxies may also appear red due to the presence of dust. Distinguishing between the two can be a challenge, particularly in samples of thousands of galaxies where they cannot be inspected individually. Steinhardt et al. (2020c) presented a promising machine learning-based method to differentiate between the two.



Credit: NASA, ESA, and the Hubble SM4 ERO Team



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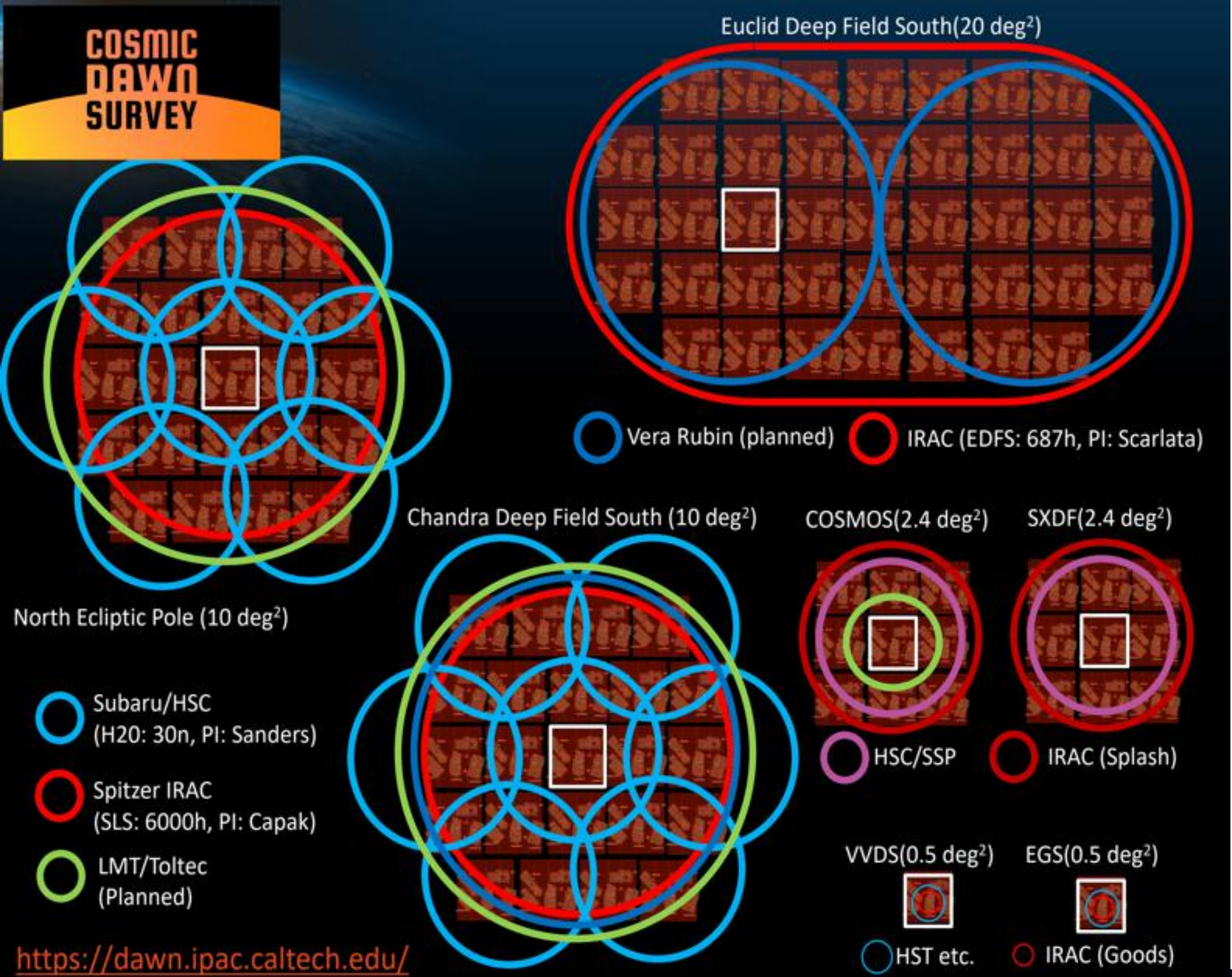


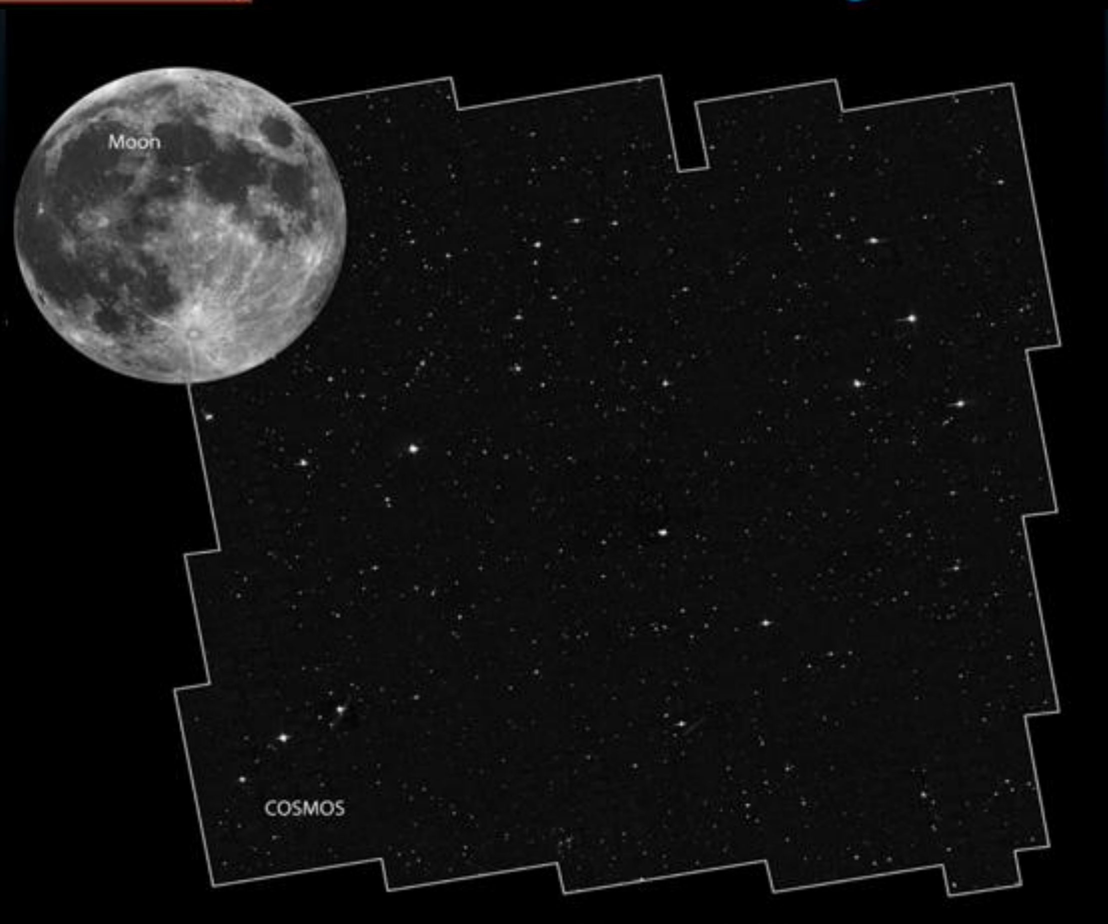


Image Credits: The Cosmic Dawn Survey

Largest Hubble Space Telescope program

Survey & Observation

Cosmic Dawn Survey

The Cosmic Dawn Survey is a 50 square degree multi-wavelength survey of the Euclid Deep and Calibration fields. The scientific aim is to understand the co-evolution of galaxies, black holes, and the dark matter haloes that host them from Re-Ionization (z~12, about 500 million years after the big-bang) to the present (z~0). The fields are some of the darkest and most observable fields on the sky and have existing multi-wavelength data that will enable immediate science. The survey parameters are designed to enable stellar mass measurement at 3 < z < 12 (2 billion years of Cosmic time, starting 500 million years after the Big Bang), to probe the large scale structure of reionization in the early Universe, and find luminous quasars to the highest redshifts where they exist.

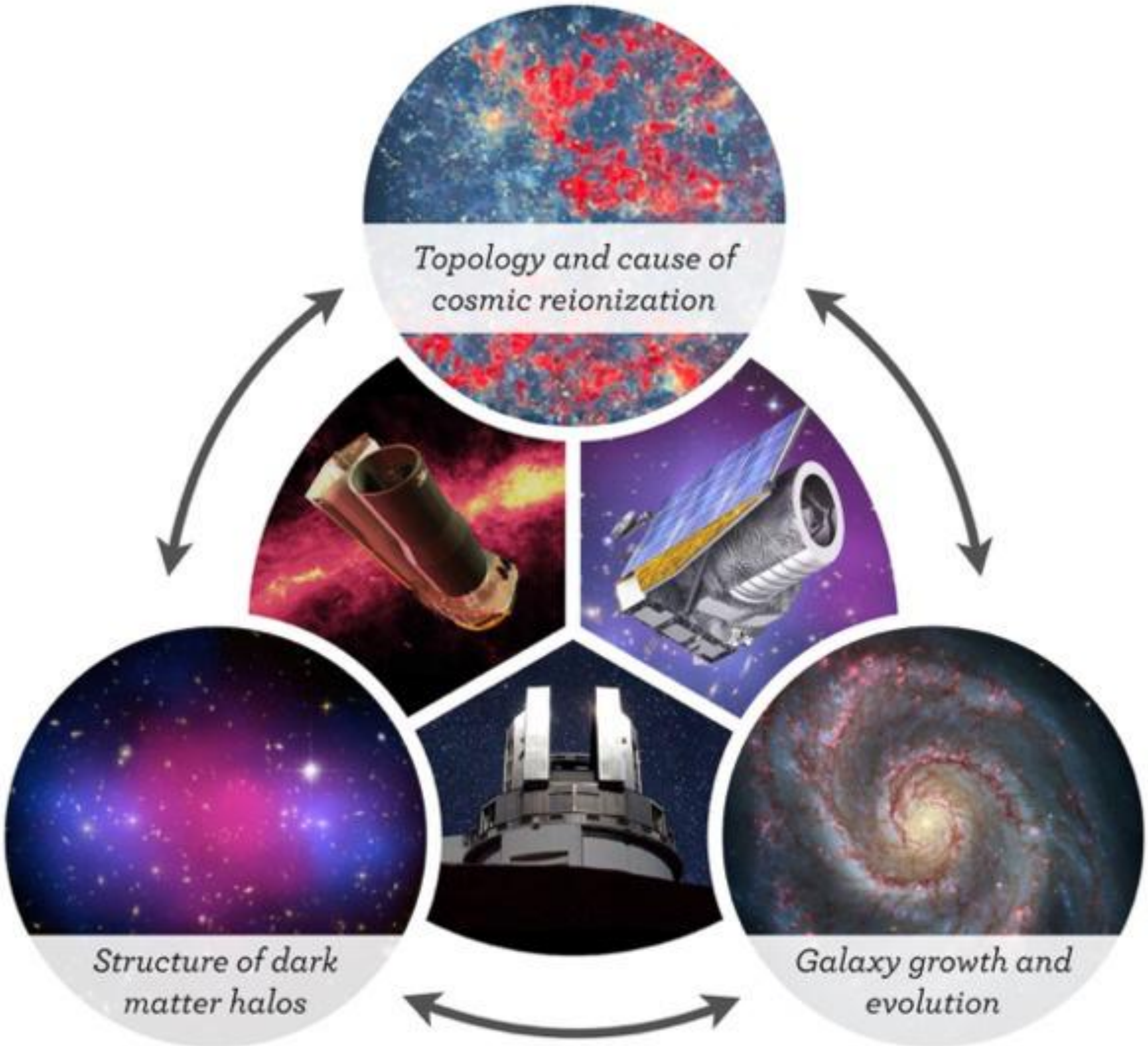


Image Credit: The Cosmic Dawn Survey

Happy Birthday to the Hubble Space Telescope

The satellite observatory has orbited the Earth some 165,000 times since its launch on board the Space Shuttle *Discovery* on 24 April 1990. A huge fraction of these orbits have yielded data and measurements that have helped us to better understand the cosmos and humanity's place in it, from characterizing the atmospheres of planets orbiting nearby stars in our own Milky Way galaxy to measuring the expansion rate of the Universe itself.

The Cosmic Dawn Center wish the Hubble Space Telescope a happy birthday celebrating 30 years in orbit.

Hubble observations form a critical part of many past discoveries and ongoing research projects at DAWN at the University of Copenhagen and DTU. For example, DAWN director and NBI Professor Sune Toft used *Hubble* images to resolve the extremely dense cores of distant massive galaxies and Associate Professor Gabriel Brammer used *Hubble* spectra to measure the distance to the furthest object currently known, a brilliant starburst galaxy as it formed just 400 million years after the Big Bang. *Hubble* is still going strong, with its data contributing to 1,000 scientific papers or more each year, and its spectacular images inspiring generations to both look up at the sky in wonder and also to appreciate the Earth around them.

We wish *Hubble* many more productive orbits to come!

Image Credits: Gabriel Grammer

Feature Articles

The James Webb Space Telescope

By Peter Jakobsen

Figure caption: The JWST spacecraft at Northrop-Grumman during a deployment test of its sunshield. Credit: NASA/ESA/CS

In July 2020, NASA announced that due to the impact of the COVID-19 epidemic, the launch of James Webb Space Telescope (JWST) had been delayed from March to October 2021. The year nonetheless saw considerable progress being made in the final integration and testing of the observatory. The fully assembled observatory is at the time of writing at the Northrup-Grumman facility in California, where all its deployable elements have successfully been tested, including the iconic 6.55 m hexagonal telescope mirror, and the tennis court sized five-layer sunshield whose shadow will allow the JWST telescope and its three instruments to cool down to their operational temperatures below -220 degrees C.

The fully assembled spacecraft has most recently undergone electrical check-out, and the verification of the end-to-end ground system is ongoing. The coming months will see the final deployment tests, after which work will focus on stowing all mechanisms in their launch configurations in preparation for transportation of the observatory by boat to the ESA launch site in Kourou, French Guiana, where it will be mated to the Ariane V launcher.

The deadline for the first open call for proposals for General Observer JWST time issued in January 2020, was also extended to 24 November 2020 in light of the epidemic. A total of 1173 proposals involving researchers from 44 counties were received. DAWN staff members led a healthy fraction of the proposals submitted from Denmark. The Time Allocation Committee met in February, and the selected proposals are expected to be announced in March.

DAWN staff are also actively involved in the development all three of JWST's instruments, and were kept busy during 2020 preparing in detail the Guaranteed Time Observations of these instruments.

Students exploring modern astronomical research challenges

By Charles Steinhardt

One of the wonderful things about astronomical research is that there are many fundamental problems which allow meaningful progress by a student who has not yet had time to acquire a strong technical background. Perhaps this is because even though astronomy is one of the oldest sciences, in many ways modern astronomy is actually one of the youngest. As a child, the problems that first inspired me were in number theory, and it was frustrating to find out that doing something new required first mastering thousands of years of past progress. In many areas of mathematics, even the most advanced students cannot begin to do research until they are close to their PhD. In contrast, our current picture of the Universe is less than a century old and several of the most important current problems are questions that we could not even have formulated when I was a bachelor student. A talented student can therefore very quickly pick up the background needed to work on problems at the forefront of modern astronomy.

Since the start of the Cosmic Dawn Center, we have been running an undergraduate research program, building off previous programs during my time at Kavli IPMU and Caltech. We bring students to Denmark for 11 weeks each summer, doing individual research projects with a mentor at DAWN. Funding comes from a partnership between Dawn and several American Universities, which over the past few years have included Caltech, Connecticut, Harvard, Minnesota, Princeton, and Riverside. Although many REUs focus on more experienced students, we reserve some spots for talented first-year students as well, so that often our program is their first research experience. As a result, our application does not focus on past experience, but rather creativity, and often includes a challenge question unrelated to astronomy. Past topics have included nuclear semiotics, population dynamics in turtle ponds, and how to choose optimal hubs for a new airline.

A key goal of the program is to ensure that students have a genuine research experience at the point when they are deciding whether to pursue research, or research in astronomy, as a career. With that in mind, every project focuses on a truly unsolved problem with the potential for a significant impact, and students have been able to make several important discoveries over the course of their summer research. To date, over the nine years of the program at DAWN, Caltech, and Kavli IPMU, we have had 28 students produce a combined 20 publications with over 1500 citations, so that several projects have had a significant impact. Of course, part of the tradeoff in choosing

PhD student Nikki Arendse and guest researcher Bidisha Sen take a bike ride along the southern coast of Zealand to Stevns Klint and Rødvig with Prof. Charles Steinhardt. Image Credit: DAWN Center potentially impactful problems is that they are also inherently risky, and several students have done excellent summer research only to show conclusively that the idea I encouraged them to pursue wasn't a very good one. Although this outcome is never the goal when picking a topic, unfortunately this is also part of being a researcher, and can be an important experience for young researchers to have while deciding whether this is the right career for them. In my view, a student has had a successful summer if they learn enough to figure out whether they want to become astronomers, even if that answer turns out to be no.

Many of our students have continued to graduate programs in astronomy, including Caltech, Harvard, Princeton, U. Penn., Berkeley, UCLA, Washington, and U. Mass. Because we have many first-year students, others have switched fields, and are instead in graduate school in geology, quantum informatics, condensed matter physics, and biophysics.   In order to encourage students to explore more widely, we have weekly talks by non- astronomers on topics ranging from climate science to reconstruction of Viking-age longships.

An additional advantage of the summer research program is that over the past couple of years, KU students have started to ask about similar projects, both during the summer and the academic year. This has developed into several projects, including one that gained considerable academic and media attention, classifying gamma-ray bursts using machine learning. These projects have also allowed top KU students to apply to top American graduate programs with a research portfolio comparable to strong American students. At present, the program is funded on a short-term basis, and it is necessary to source new funding every year, limiting our partner Universities to those which can provide partial contributions. We are currently in the progress of seeking long- term funding in order to run the program on a permanent basis and for a broader audience.

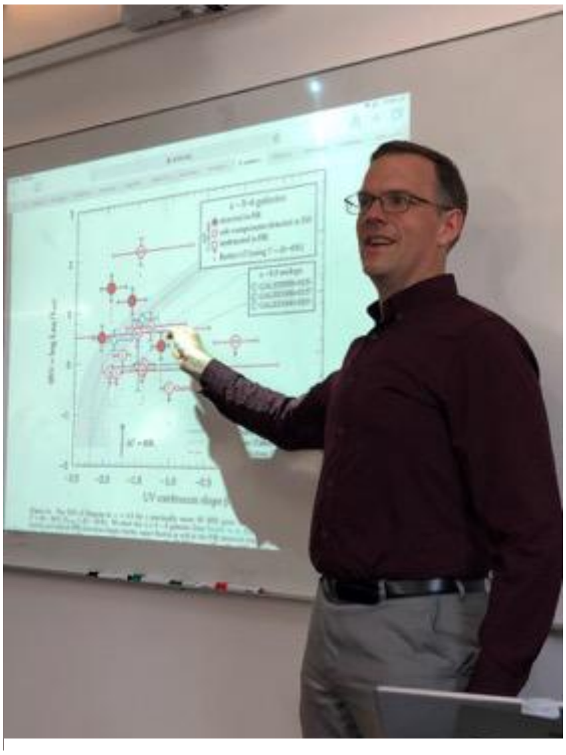
Image Credit: Roskilde Viking Ship Museum

Transitioning to industry may be easier than you think

By Peter Capak

In February of 2020, I decided to leave my academic position at Caltech for a position in industry at Facebook Reality Labs working in augmented and virtual reality. This may not seem like the most natural of transitions, when you think of virtual reality and social media, the physics of the early universe and galaxy formation is not the first thing that would come to mind. So, it might surprise you to learn that most of what I do day to day hasn't really changed from my academic position. The skills professional astronomers learn are highly valuable and directly applicable to many areas of industry. I would go even further to say that the skills emphasized at DAWN are some of the most transferable. Below are four examples to better illustrate the point.

Structuring white spaces at the edge of knowledge: To a scientist it is natural to explore the void of knowledge beyond what you know. Designing an experiment starts with mapping the edge of your knowledge, finding and adding in what others know, then choosing a path that is most likely to result in new information. This same skill applies to building a new device or a new system that has never been produced before.



Peter Capak. Image Credit: Guarn Nissen

Explaining complex ideas in one field to experts in another: At DAWN we intentionally mix theorists, observational astronomers, and instrumentalists to gain the maximum synergy and advantage in understanding the early universe. The same is true of my work at Facebook Reality Labs, I often cross disciplines and engage experts from different areas to tackle a problem. The ability to find common ground and exchange understanding at the boundaries of expertise allows us to address issues and find solutions that are much larger than the sum of their parts.

Communicating clearly constructed and justified arguments: While most scientist dread writing proposals, the ability to make a clear concise argument in short form is extremely valuable. It allows you to influence direction and to encourage large groups of people to follow your lead. This ability to explain complex topics, set direction, and amplify information is extremely valuable to organizations that need to move quickly to stay ahead of the competition.

Determining what data is most valuable and pursuing it: Data costs money. In astronomy that is abstracted into large telescope facilities and time, but in industry it actually costs something to go collect data. Being able to identify the most valuable data to collect and extract the most from cheap data is an extremely valuable skill.

So why do astronomers have a hard time making a transition to industry? Its largely because academia has a value system that is different from industry, which makes the process of applying to an industry job different than an academic position. Here are three tips for those who are contemplating a career transition from academia to industry:

Tell the story of your research through the lens of skills: You need to articulate how you applied skills to achieve a goal. Almost nobody will understand what it takes or means to get a few nights on the Very Large Telescope or to get a grant to pursue your research interest. You need to explain that this requires breaking down a problem into individual work packages, forming a cross functional collaboration, writing a detailed technical justification, and executing the project on time and budget. The same translation can be done for developing data reduction pipelines or developing new algorithms.

Focus on how you have supported the success of larger projects: In academia we place a heavy emphasis on individual contributions. Industry assumes collaboration is essential to success and that every position is important in a project. Leadership is seen as the ability to work in and with a group to achieve a common goal. Managers and directors are there to support the individual contributors that make a project happen. You are expected to be a team player and aim to combine and leverage your skills with those around you.

Build and use your professional network: Most companies use referrals to screen applicants, so establishing contacts with existing employees and recruiters is very valuable. In addition, your LinkedIn profile will likely be used interchangeably with your resume. So, it is important to keep it current. Networking is easier than you might think, ask your friends and colleagues to make introductions and set-up informational interviews to learn more about the areas of industry that pique your interest. Establish a LinkedIn connection with those you meet in industry and use those contacts to get more informational interviews to focus your search.

Image Credit: Terry Hancock (Down Under Observatory) and Subaru/NASA/JPL-Caltech

Measuring the expansion rate of the Universe

By Albert Sneppen

Credit: Anders Fjelbderg

In September 1998, the month I was born, the accelerating expansion of the Universe itself was uncovered and published. Suddenly, the celestial giants were not merely running away from us, but counter-intuitive to our very understanding of gravity, they are pushing the pedal and speeding away. In the 22 years that have passed, cosmology has matured quite a bit.

The significance of the original findings has improved with the Universes current expansion rate being ever more well constrained by an increasing number of supernova-observations. However, with greater constraints an unnerving tension, the so-called Hubble tension, between the early and late universe has emerged. The expansion rate measured locally by supernovas disagrees with the expansion rate inferred from the remnant radiation of the Big Bang. These widely different perspectives suggest an existential schism in Cosmology with new physics required to understand the Universe on its very grandest scale.

However, perhaps it is not the laws and models of the Universe which needs correcting, but merely the hidden assumptions of our techniques of observations. With this in mind, in collaboration with Bidisha Sen and Charles Steinhardt, we re-examined the supernova- measurements of the last 22 years. Digging into the uncertainties reported across datasets we found an intriguing and potentially dangerous assumption in the redshift [i.e. the velocity with which objects are moving away from us]. The large catalogues of observations mix redshifts from well-measured spectral features of host-galaxies with the poorly constrained redshifts of supernova explosions. The latter is a far more complicated endeavor, as it requires are precise model of the stellar explosion.

Therefore, in the collaborative environment which DAWN breeds we began the careful process of cataloguing supernovas, differentiating between methodologies and re-analyzing the cosmological fits of the Universes composition and expansion rate. To our great amazement the two samples of supernovas disagree. Furthermore, the more precise measurements not only disagree with the early Universes expansion rate but also its composition. This novel tension opens the door for entirely new physical explanations for the apparent incongruity of our Universe. New theoretical explanations with changes to Dark Matter or structure formation may solve both tensions and with new redshift-measurements at the Nordic Optical Telescope underway we may soon get a deeper understanding of the curious expansion of our celestial giants.

This project has certainly shown me the great opportunities within the academic world in general and specifically at DAWN. I am fortunate and privileged to be able to examine the most fundamental questions of our cosmos with the competent help and attentive supervision which Charles Steinhardt has provided.

My experience at DAWN was truly enriching

By Carlos Gomez

Credit: Carlos Gomez

I grew a lot as a young researcher at DAWN as a PhD student. Every year I could see how I was progressing at many different levels, from the pure scientific and technical knowledge to the development of independent ideas. Of course, all this could only be possible thanks to the great scientific and human atmosphere at DAWN. There, I worked in a topic that I always thought was truly important for our understanding of the entire history of the Universe, the evolution of massive galaxies in their most intense period of star formation. The science team at DAWN is composed of world class scientists of even greater human value. I always felt all these were the perfect combination: relevant science topic, great scientists, and good working atmosphere. A PhD is a challenging task with ups and downs, but when I remembered that I was at a place where I could enjoy these three pillars, it was always easy to keep myself engaged and motivated. In fact, after my PhD, I decided to continue my scientific career as a postdoc. These learnings are what I cherish the most of my PhD studies at DAWN and now I always try to carry with me these values to a new place: the interest for relevant questions and create a good atmosphere where everybody can find the best conditions to flourish.

From a more technical point of view, I learnt to investigate a broad science topic using a variety of techniques at DAWN. I acquired the technical competences to analyze multi-wavelength datasets, especially during my stay abroad at Cornell University. This was possible due to the exchange program of the University of Copenhagen that provided me with an excellent set of skills in millimeter interferometry. The combination of being able to think about a broad topic in a multi-wavelength fashion with the more in-depth knowledge about millimeter interferometry is exactly what my current team members found valuable and interesting about my profile. At the moment, I keep investigating the evolutionary pathways of massive galaxies in their most intense star formation phases in the distant universe. I work with a multi-wavelength approach with a focus on millimeter interferometry using ALMA and the preparation for future projects in the near and mid-infrared with the James Webb Space Telescope. I am leading my current team efforts in one of the largest ALMA surveys with complete independence to pursue my own projects. You can see a variety of dusty star-forming galaxies completely missed by optical surveys that I discovered in this survey. This is one of the most interesting topics these days as these galaxies are thought to dominate the contribution of massive galaxies to the star formation rate density in the distant universe.

I keep progressing as a scientist and now I am also able to transfer all of my acquired knowledge to a new generation of PhD and master students that I am involved in supervising. I feel that I fit like a hand in a glove in my current position and I am thankful for all I learned at DAWN and the resources made available to me.

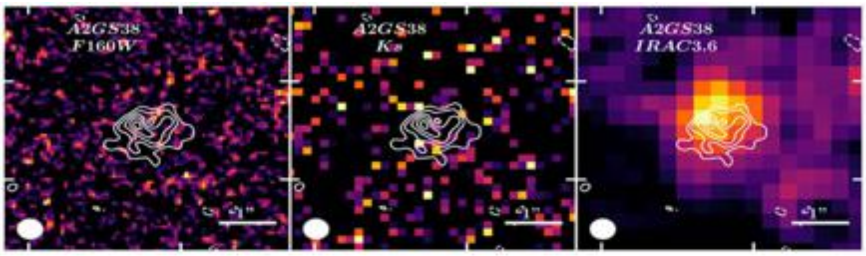


Image Credit: Carlos Gomez

A dream come true

By Nina Bonaventura

Credit: Nina Bonaventura

As one of the first post-doctoral researchers hired by the Cosmic Dawn Center (DAWN), I've had the privilege to witness its evolution into a world-class research facility, and play an active role in some of its most impactful scientific endeavors. My arrival at DAWN at the start of 2018 felt like a crowning moment at the end of the long and dedicated career journey that led me there. After having worked for a number of years as a professional astronomer in support of a NASA space mission in my home country, the United States, I made the difficult decision to leave that very rewarding and secure work position to complete an unfinished doctoral degree in astrophysics in order to finally fulfill my ultimate career goal of becoming a Research Scientist. It is therefore an understatement to say that it was a 'dream come true' when I landed my first 'post-doc' with this new title at a promising new center for astrophysics, in the heart of a beautiful and socially progressive European city such as Copenhagen. It is here that I would be afforded the rare opportunity to work *yet again* on the science team of a new NASA space mission, to exercise both my hard-earned academic and professional skills in a continued investigation of the mysteries of the Universe.

Credit: NASA

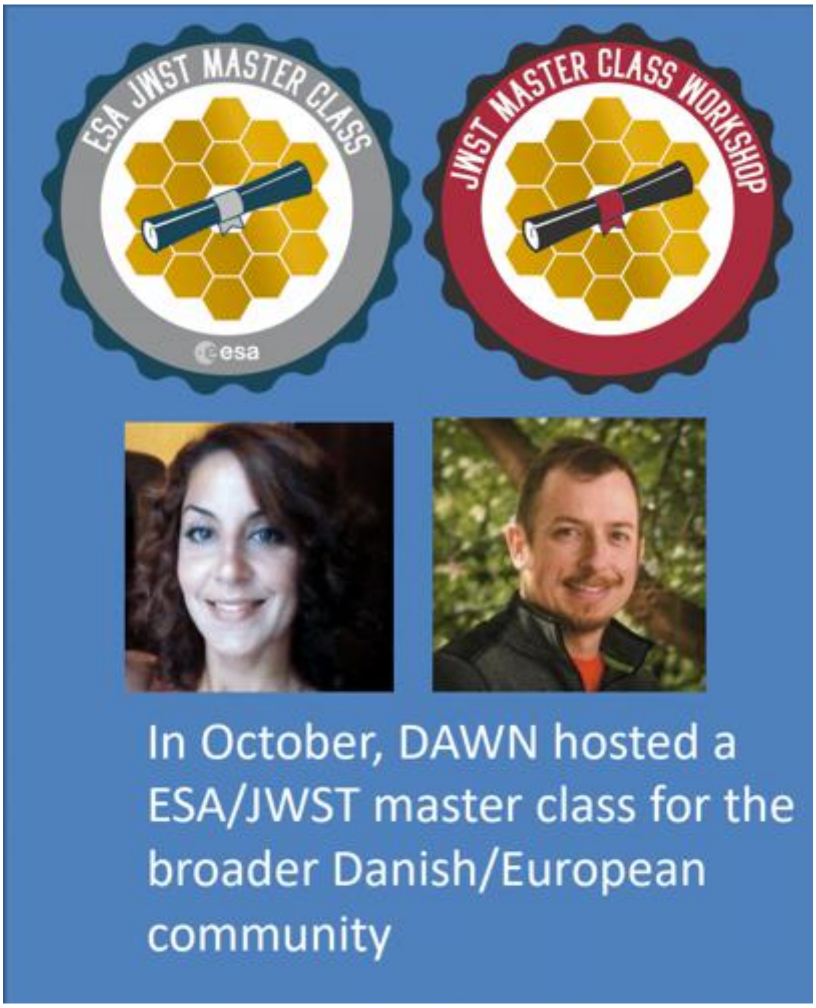
Shortly after earning my PhD degree in physics at McGill University in Montréal, I waved 'au revoir!' to friends, sold off most of my belongings, packed the remainder into two suitcases, and boarded a plane for Denmark. Once here, I was immediately greeted by my esteemed supervisor, Dr. Peter Jakobsen, wasting no time before diving into our joint tasks and responsibilities as key players on the *James Webb Space Telescope* (JWST) NIRSpec Guaranteed Time Observer (GTO) team (…except for the thirty minutes we each spent idly waiting to meet one another for the first time at a different "granite sculpture in front of the Niels Bohr Institute"; it turns out that there are two such locations). JWST is a revolutionary new space telescope that was designed to succeed the legendary *Hubble* Space Telescope and is the culmination of a joint international effort over many years by a variety of teams of science professionals at the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), and the Canadian Space Agency (CSA). NIRSpec, the Near InfraRed Spectrograph, is a major contribution from ESA to the JWST mission and is widely regarded as the 'workhorse' of the suite of impressive instruments onboard JWST, due to the promise of its plentiful scientific return across a number of research areas in astronomy. NIRSpec will also be the first instrument of its kind to fly in space.

The NIRSpec GTO program is responsible for the design and execution of a number of large and small scientific programs that cover a range of astrophysical topics, with the scientific results produced by NIRSpec at its heart. The most ambitious of these programs is the core, multi-tiered *physics of galaxy assembly* survey, with which we are actively involved at DAWN. In addition to working towards the primary goal of scientific excellence of this program, we also spend a significant amount of time optimizing the observation strategies of the NIRSpec instrument, which is helpful not only to the program itself, but also provides useful feedback on data quality and observing possibilities to the main JWST scientific operation center (Space Telescope Science Institute) and to the astronomical community at large. Fortunately, not long into my appointment as DAWN post-doc and NIRSpec GTO team member, I developed a novel algorithm that solved a long-standing problem of how to ensure the maximal, highest-impact scientific output of observations taken specifically in the "MOS" (multi-object spectroscopy) mode of the NIRSpec instrument. Since that time, the start of the mission - marked by the launch of the space telescope from a rocket ship to one million miles away from Earth, where it will begin its science operations - has been delayed significantly, a full three years from October 2018 to October 2021. Thankfully, in spite of having hurried over to Copenhagen from Montréal several years ago in anxious anticipation of what we thought would be the imminent start of the JWST mission, there has been no shortage of necessary and important tasks to continue to fulfill in addressing the scientific needs of the NIRSpec user community.

Credit: European Space Agency

As the major scientific focus of DAWN is on the study of galaxies in the high-redshift universe, many of our members are eagerly awaiting the discoveries that JWST was primarily conceived to detect: the first generations of galaxies ever to be born in the Universe, at the dawn of cosmic time. In order for DAWN astronomers, and astronomers across the world, to propose to secure 'time' on such a powerful space telescope to observe their favorite galaxies in the early Universe, an extensive and formal proposal preparation process must take place. In 2019, I shared the distinctive honor with DAWN colleague, Dr. Gabriel Brammer, of being selected to represent Denmark in the JWST Master Class hosted by ESA, an immersive program designed to train the twenty-four selected astronomers from their representative European countries to quickly become experts in proposal planning with JWST and its instruments: NIRCam, NIRSpec, MIRI, and NIRISS. This involved participation in a three-day workshop in Madrid, Spain, in early February 2020, where we received this intensive training in the form of informational presentations by ESA members, and associated hands-on exercises utilizing the various software applications developed to complete a JWST proposal. The purpose of this "master" training was to allow each of us to return to our host institution and disseminate our newfound knowledge in a workshop of the same format, for the benefit of our local astronomical community in preparing their own JWST proposals.

Sadly, in the weeks following the JWST Master Class training in Madrid, the *covid-19* pandemic struck and therefore prevented us at DAWN from hosting our planned face-to-face meeting with the workshop participants from around Scandinavia. While it was regretful that we could not, in the end, provide more personalized assistance to our local JWST proposers in the form of a physical workshop, with remote support from ESA staff we managed a very successful three-day virtual workshop over the *Slack* application, which is designed for easy online work collaboration. As a duty to those we were chosen to serve, we prepared for this online meeting no less than for a more formal and intensive in-person meeting, studying and exercising example proposals for a host of different science cases and instrument observing modes. As a result we felt confident that all involved in the workshop were rewarded. In fact, I personally observed this online workshop format to benefit the more junior and timid workshop participants in getting the help they needed with their proposals, having gotten the impression that it would have been more difficult for them to ask their questions in a more-open and public forum. It also goes without saying that our DAWN colleagues with whom we were able to interact more directly, were very thankful for having benefited from their own personal "JWST Helpdesk" in the preparation of their JWST science proposals. Now, we at DAWN must cross our fingers and wait for a successful JWST launch in October 2021, and to be granted as many of the hours of observing time that we requested to continue our contributions to great galaxy science!



From the left: Nina Bonaventura and Gabriel Grammer. Credit: DAWN

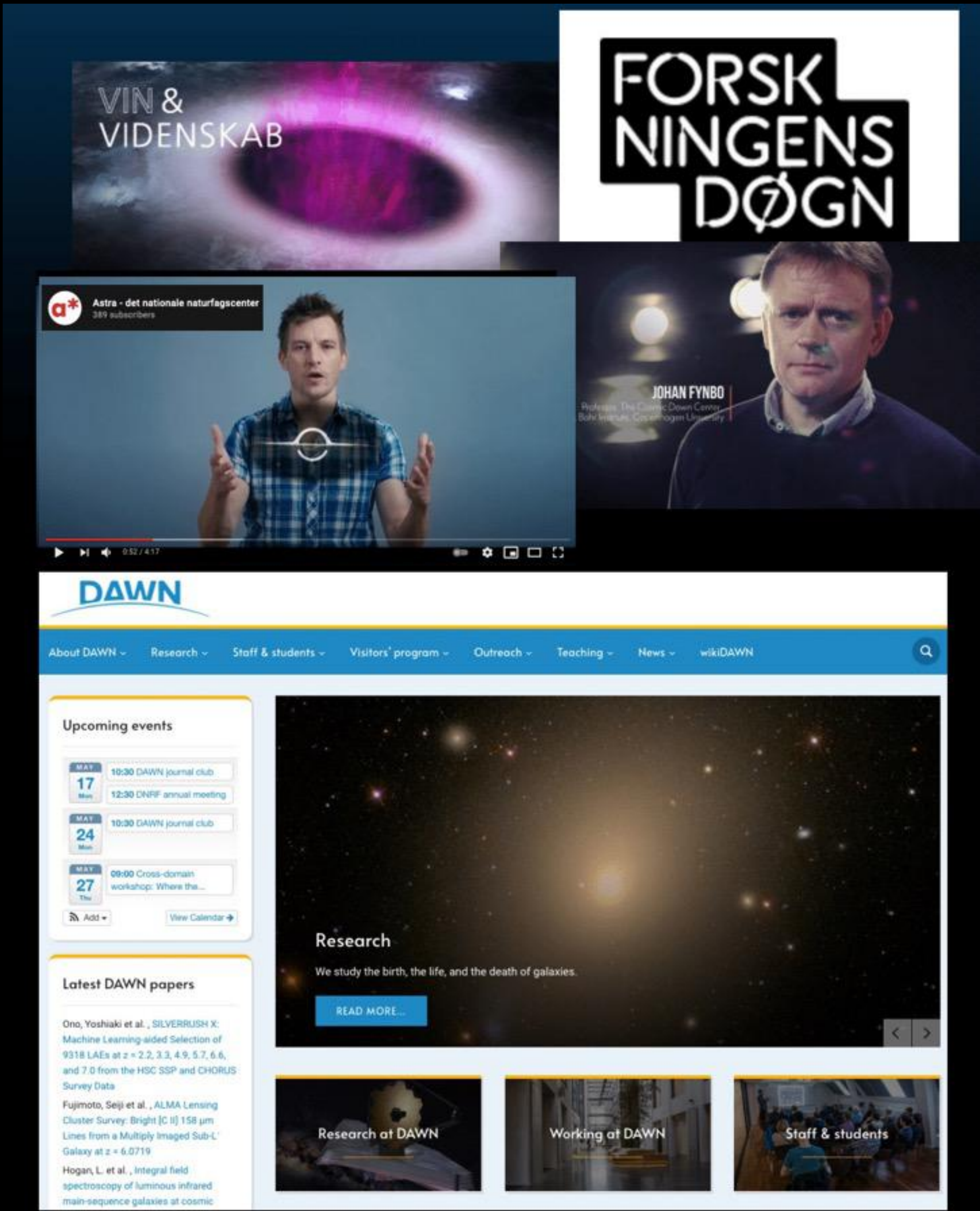


Image credits: Various website screenshots from outreach events

Public Outreach

Podcast. Endelig har astronomer fundet den halvdel af universets stof, som har manglet siden Big Bang.

Kosmisk daggry

LONE FRANK

Det lå og flød i det intergalaktiske rum, forklarer astronom Johan Fynbo og beskriver udviklingen fra det kosmiske daggry til nutidens midaldrende univers.

Weekendavisen - 24 spørgsmål til professoren

Kosmisk daggry

00:00 / 45:54

Tre danske studerende har løst astronomisk mysterium - folk ringer fra hele verden

21. aug. 2020, 20:14

af Julie Tantholdt & Nathalie Gjøtterup Jensen

Professor i fysik kalder de tre studerendes projekt for "bemærkelsesværdigt".

Da Christian Kragh Jespersen, Johann Bock Severin og Jonas Vinther skulle lave deres førsteårsopgave på fysikstudiet, besluttede de sig for at prøve at løse et 30 år gammelt astronomisk mysterium ved hjælp af en computer.

Og deres resultater har nu sat dem på verdenskortet inden for fysik.

Episode 12

Det store brag hvor alting begyndte

RUMSNAK

00:00:00 / 00:41:24 1.0x

16 March 2020

Link with Timestamp

41 mins 24 secs

Download MP3 (38.3 MB)

Season 2

Your Hosts

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About this Episode

Universet blev skabt i et stort brag for 13,8 milliarder år siden - men det vilde er, at mange af de helt fundamentale processer fandt sted i løbet af af de første brøkdele af sekunder.

https://www.kristeligt-dagblad.dk/

I gang med Firefox · Sektionsadministration · Requisitory · Finance - NBI · ERDA

Image credit: Various website screenshots from outreach events.

TV, Radio & Social Media

Type of outreach activity	Subject	Contributor from the center
Interviews	The paper "An Unambiguous Separation of Gamma-Ray Bursts into Two Classes from Prompt Emission Alone" by DAWN student Christian Jespersen led to a number of articles and interviews in various media, including "Go' Morgen Danmark" (TV2).	Christian Kragh Jespersen
TV show interview	Comedian Jonatan Spang interviewed DAWN's Peter Laursen in his show "Tæt På Sandheden" (DR) on the astrophysical implications of a giant rum truffle cake ("romkugle").	Peter Laursen
Podcast Interview	Journalist Lone Frank asks Professor Johan Fynbo 24 questions on "Kosmisk daggry". Johan reveals that finally, astronomers have found the half of the universe's matter that has been missing since the Big Bang.	Johan Fynbo
Feature Interview	Mellem Himmel og Ord	Johan Fynbo
Filming	"Stjernekigger"-pilot episode	Peter Laursen
Filming	Naturvidenskabernes ABC — alting er lavet af partikler"	Peter Laursen
Interview	Time and entropy in the movie TENET	Peter Laursen
Interview	Nobel Prize in Physics 2020	Peter Laursen
Interview	Astronomy on the university radio in the program "Aflønnede hjerner"	Peter Laursen
Live radio show (Radio4)	Time & entropy in the movie TENET	Peter Laursen
Podcast	The Big Bang	Peter Laursen
Video	Hubble's 30th Anniversary	Peter Laursen Sune Toft Gabriel Brammer

Berlingske

NYHEDER OPINION BUSINESS AOK

Dette er en kronik. Den udtrykker skribentens eller skribenternes holdning. Klik her, hvis du ønsker at sende et debatindlæg til Berlingske.

KRONIKKER

Pseudoløsninger på problemer med ligestilling fjerner fokus fra de egentlige problemer

Tvillinger brød den sociale arv og er nu begge fysikprofessorer - nu advarer de om bekymrende tendens.

»Det bør være underordnet, om du er mand eller kvinde, hvilken farve du har, hvilken Gud du tilbeder eller ikke tilbeder,« skriver Johan Peter Uldall Fynbo og Hans Otto Uldall Fynbo.
Foto: Tobias Nicolai

KRONIK

Søndag d. 13. december 2020, kl. 13.13 Del denne artikel

Johan Peter Uldall Fynbo, professor, a astrofysik, KU, og Hans Otto Uldall Fy eksperimentel fysik, AU

astrobites
THE ASTRO-PH READER'S DIGEST | SUPPORTED BY THE AAS

The Grand Twirl

by John Weaver | Mar 20, 2020 | Daily Paper Summaries

How well a galaxy dances may be a matter of life or death.

Deciphering Spitzer's Legacy: Signs of Dead Galaxies at Cosmic Dawn

by John Weaver | Feb 15, 2020 | Daily Paper Summaries

Is the so-called "IRAC-excess" due to interloping dead galaxies at extreme high redshift?

works in Massive Dusty

1, 2020 | Daily Paper Summaries

fireworks through the smoke?
gest we might be missing some

Information

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Hvorfor denne annonce?

INTERVIEW Læsetid 2 min.

Astrofysiker om sorte huller: »Selv Einstein tvivlede«

Nobelprisen i fysik gik i denne uge til tre videnskabsfolk som har påvist eksistensen af tunge og altopslugende sorte huller i universet. Astrofysiker Peter Laursen forklarer

W

SAMFUND KULTUR BØGER IDEER

Klumme. En ny algoritme gør det lettere at registrere gammaglimt og skelne mellem de korte og de lange.

Glimt fra rummet

ANJA C. ANDERSEN

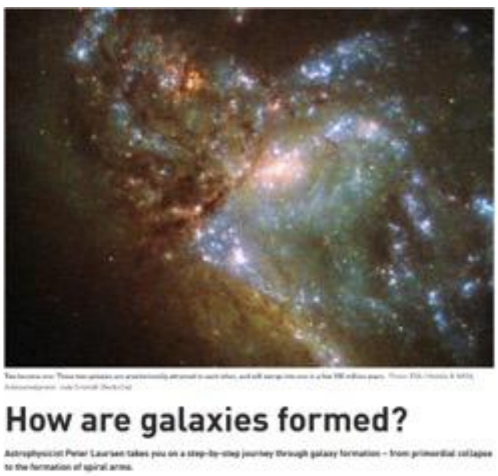
Universet er som bekendt stort og indeholder ufattelig mange galakser, som hver især typisk består af nogle hundrede milliarder stjerner. Det betyder, at man som astrofysiker ofte jonglerer med meget store datamængder. Så en del af kunsten består i at finde hoved og hale i alle de data, vi har.

Min gode kollega Charles Steinhardt fra grundforskningscenteret The Cosmic Dawn Center ved Niels Bohr Institutet har sammen med tre bachelorstuderende imponeret os alle ved at vise, hvordan deres machine learning algoritme kan skelne mellem såkaldt korte og lange gammaglimt.

Image credit: Various website screenshots from outreach events.

Articles & Features

Type of outreach activity	Subject	Contributor from the center
Popular science articles	DAWN's Peter Laursen wrote a series of popular science articles on galaxies and their formation on videnskab.dk/ForskerZonen. The articles were also translated to English and published on ScienceNordic.com.	Peter Laursen
Article	Tænketanken Eksistensen-Corona	Johan Fynbo
Astrobites	Publication summaries on interesting work in astronomy	John Weaver
Feature Article	Hubble Constant Paper, 2	Charles Steinhardt
Feature Article	Hubble Constant Paper, 1	Charles Steinhardt
Japanese feature article	"Discovery of Carbon cocoons surround growing galaxies"	Seiji Fujimoto
Kronik i Berlingske Tidende	Equality	Johan Fynbo
Person of the week in Dagbladet Information	On the Nobel Prize in Physics 2020	Peter Laursen
Press release including web article	"Galaxies in the Infant Universe were Surprisingly Mature"	Seiji Fujimoto
Web Article	What is a supernova?	Peter Laursen
Article	Glimt fra Rummet	Charles Steinhardt



Talks & Presentations

Type of outreach activity	Subject	Contributor from the center
Public talk series	Part of the worldwide initiative "Astronomy On Tap" in "Huset", Copenhagen, partly organized by DAWN's John Weaver.	John Weaver
Educational event	Hosted the local Danish JWST Proposal Planning Workshop	Nina Bonaventura
Educational program	Hosted a female high school student Freja Max Andersen at DAWN 2-6 March	Nina Bonaventura
Presentation	Det Kosmiske Daggry	Thomas Greve
Presentation	Gravitationsbølger og sorte huller	Johan Fynbo
Presentation	Rejsen til et Sort Hul	Thomas Greve
Presentation in a bi-annual Japanese conference	"Truth or Delusion? A Possible Gravitational Lensing Interpretation of the Ultraluminous Quasar SDSS J0100+2802 at z = 6.30"	Seiji Fujimoto
Presentation in a bi-annual Japanese conference	"[CII] Halo in the early Universe"	Seiji Fujimoto
Presentation in ESO	"[CII] Halo in the early Universe"	Seiji Fujimoto
Public Lecture	Folke Universitetet: Cosmic Dawn	Sune Toft
Talk	ScienceTalent	Charles Steinhardt
Talk (Planetarium)	Andromeda	Peter Laursen
Webinar	Middelfart Gymnasium, fysik B: Questions about cosmology	Peter Laursen

John Weaver speaking at the Astronomy Tap event. Image credit: Astronomy on Tap Copenhagen

Image from the Starformation Conference in Hertfordshire, UK.
Image Credit: NASA/JPL-Caltech/R. Hurt (SSC/Caltech).

Conferences & DAWN Summit

Conferences

Organization of international conferences, symposia, seminars etc.

Title of event:	Location:	Date:
Starfomation Across The Universe	Hertfordshire, UK	20-22 January
JWST Master Class Workshop	Madrid, Spain	3-5 February
Euclid Consortium Meeting	Virtual	May
SURF@DAWN Summer Undergraduate Research Program	Virtual	Summer
BUFFALO Collaboration Meeting	Virtual	June
EAS (European Astronomical Society) 2020, Session Organizer - (Special Session) SS04	Virtual	July
DAWN Summit	Virtual	July
JWST Proposal Preparation Master Class	Virtual	October

Images from the Starformation Conference in Hertfordshire, UK. Image Credits: NASA/JPL-Caltech/K. Gordon (University of Arizona). ESO/José Francisco Salgado

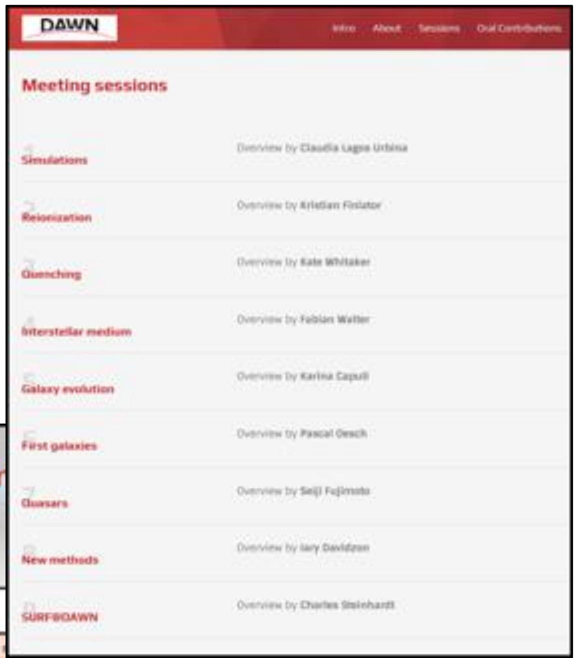
Events

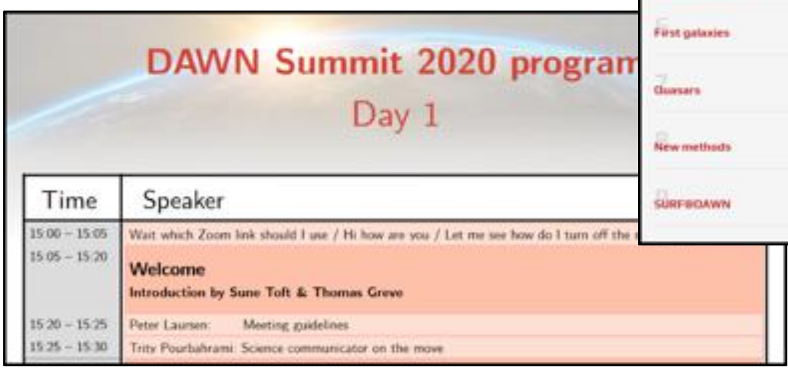
Title of event:	Location:	Attendee:
Invited Seminar	Harvard-Smithsonian Center for Astrophysics	Charles Steinhardt
Royal Swedish Academy Of Sciences Site Visit	Niels Bohr Institute, Auditorium A	Sune Toft
North Ecliptic Pole (NEP) Conference 2020	Virtual, (Tapei, Taiwan)	Thomas Greve
Protoclusters: Galaxies in confinement, IAC	Virtual (Gran Canaria, Spain)	Thomas Greve
Oskar Klen Centre Colloquium	Virtual (Stockholm University)	Gabriel Brammer
Summer All Virtual Epoch of Reionization Astronomy	Virtual	Seiji Fujimoto
The Rise of Metals and Dust in Galaxies Through Cosmic Time	Virtual (originally planned in Marseille)	Seiji Fujimoto
The Cold ISM During the Epoch of Reionization (CIDER)	Virtual (originally planned in Marseille)	Seiji Fujimoto
The Growth of Galaxies in the Early Universe	Sexten, Italy	Iary Davidzon
ESO weekly seminar	European Southern Observatory (ESO) HQ, Garching, Germany	Iary Davidzon
Workshop on Perspectives and Applications of Deep Learning for Accelerated Scientific Discovery in Physics	Virtual (University of Copenhagen)	Iary Davidzon
Conference Seminar	Virtual (BUFFALO Meeting)	Charles Steinhardt
Conference Talk	AAS Winter Meeting (440.04)	Charles Steinhardt
Seminar, Cambridge, UK	Kavi Institute, Cambridge	Thomas Greve
Seminar	Virtual (MPIfR Bonn)	Thomas Greve
Seminar	Virtual (Institute for Theoretical Physics, Oslo)	Thomas Greve
Subaru Telescope 20th Anniverseary	Hawaii, USA	Sune Toft
Royal Swedish Academy of Science	Niels Bohr Institute, Aud A (Visit)	Sune Toft

DAWN Summit 2020

Group photo from ZOOM at the virtual Summit 2020 at The Cosmic Dawn Center. Credit: DAWN

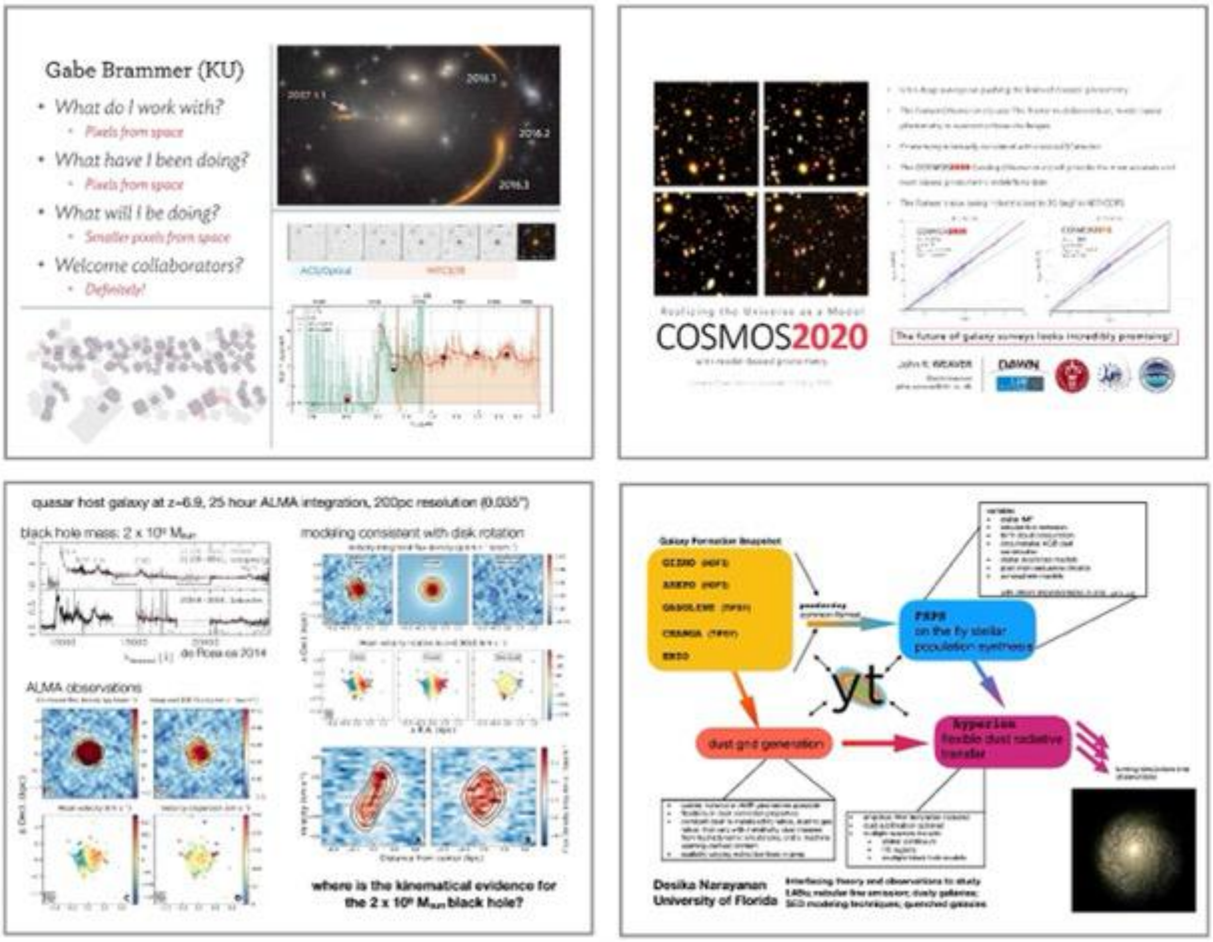
Since its inception, DAWN has hosted an annual summit for all DAWNers around the world. This is a chance to get together and touch base with each other. However, the overall purpose of this meeting is to get a feel for what everyone is working on, to learn new faces, as well as to spawn new collaborations within the "DAWN Family". Like most other meetings in 2020, the annual DAWN summit was held online. With participants from the US, Europe, and Australia, a time interval convenient for everyone was small. Therefore, we chose to keep it brief; a two-day workshop, with 3 hours each day, was arranged and featured nine sessions. Each session included an introductory talk and contributed 5 minutes' talks from almost every DAWNer.



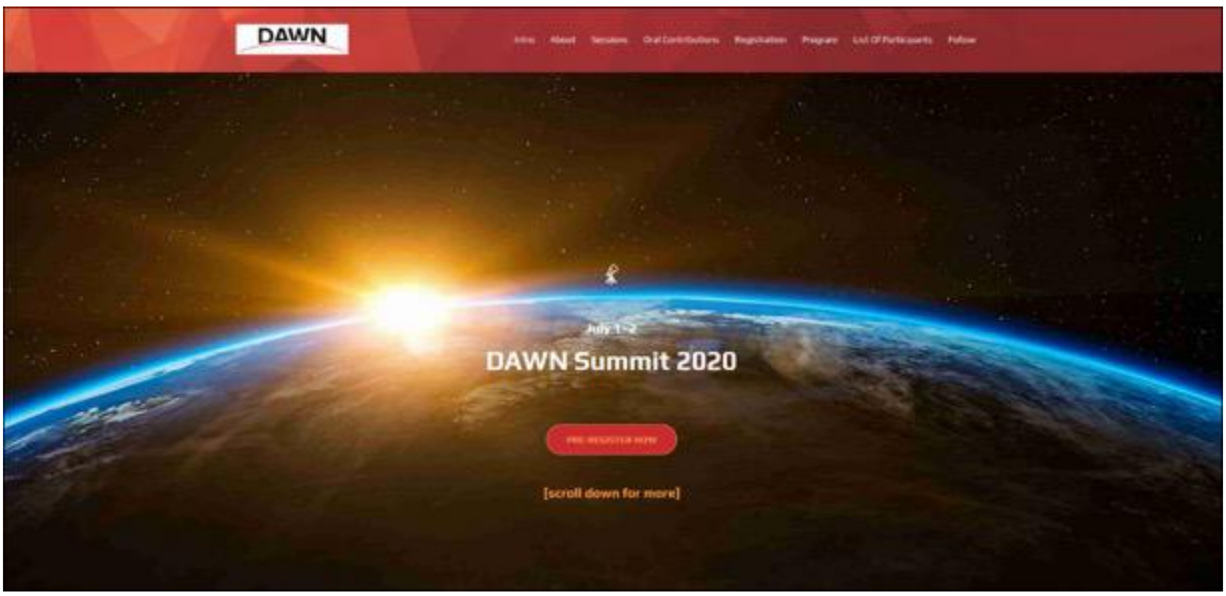


Screenshot of the program for day 1 and list of meeting sessions for the summit 2020. Image Credit: DAWN

An overview of the sessions and talks can be seen on the webpage created for the summit 2020 below and via this link anisotropela.dk/dawn/summit2020



One pagers submitted at the DAWN Summit. Image Credit: DAWN



The DAWN Summit event-webpage. Credit: DAWN

Top image credit: Ola J. Joensen.
Bottom image credit: Gabriel Grammer

Guest & Visitors

Visitors

Visitor	Arrival	Affiliation	Talk Title
Eric Rohr	18 February	Max Planck Institute for Astronomy	Describing the Galaxy-Halo Size Relation at Cosmic Noon in FIREbox
Maciej Koprowski	19 March (Virtual)	Nicolaus Copernicus University in Toruń	Determining star formation rates in high-redshift galaxies from IRX-beta relation
Lucas Makinen	08 September (Virtual)	Institut d'Astrophysique de Paris	Accounting for Incompleteness: Reducing Selection Effects Bias in Supernova Cosmological Inference
Sarah Leslie	17 September (Virtual)	Max Planck Institute for Astronomy	The rise and fall of cosmic star formation: results from 3GHz VLA COSMOS Large Program
Charlotte Mason	29 October (Virtual)	Harvard University	What can galaxies tell us about reionization?
Fabian Walter	05 November (Virtual)	Max Planck Institute for Astronomy	ASPECS: The ALMA Spectroscopic Survey in the Hubble Ultra Deep Field
Gergo Popping	03 December (Virtual)	European Southern Observatory	The dust-continuum size of galaxies over cosmic time in the TNG50 simulation: a comparison with the distribution of stellar light, stars, dust and H2
Francesca Rizzo	10 December (Virtual)	University of Copenhagen	A strong gravitational lensing view on the dynamical properties of high-redshift dusty star-forming galaxies (was postponed due to COVID-19)

Erik Rohr at DAWN Credit: DAWN and Max Planck Institute for Astronomy

Guest Researchers

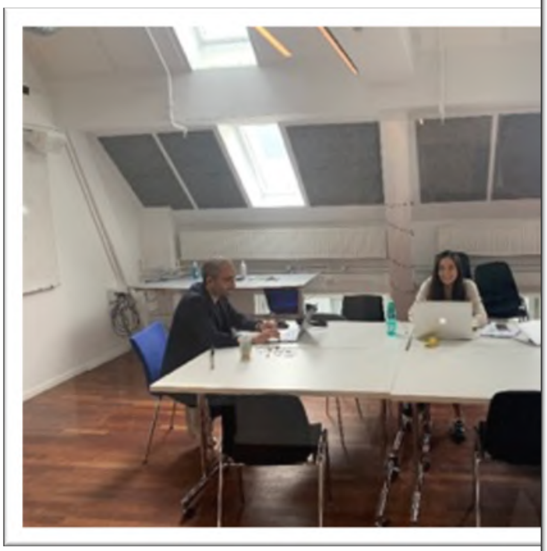
Collaborator	Arrival	Departure	Affiliation
Bidisha Sen	01 August 2019	08 July 2020	MIT
Giacomo Girelli	16 October 2019	15 January 2020	INAF - OAS Bologna
Ivana Langan	20 January 2020	20 May 2020	University of Montpellier
Timothée Vene	20 February 2020	20 July 2020	Ecole Centrale Marseille, Marseille
Freja Max Andersen (Intern/Practical)	02 March 2020	06 March 2020	High School Student

A socially distanced outing at the northern seaside town of Hornbæk with friends. Image Credit: Guarn Nissen

PhD & Master Defences

PhD

Name	Primary Supervisor	Censor	End Date	Title of thesis
Isabella Cortzen	Georgios Magdis and Sune Toft	Dave Clements and Caitlin Casey	04 June 2020	A view into the interstellar medium of galaxies across cosmic time



From the left: Georgios Magdis and Isabella Cortzen. Image Credit: Guarn Nissen

From the left: Sune Toft, Isabella Cortzen and Georgios Magdis. Image Credit: Guarn Nissen

Master Students

Name	Primary Supervisor	Censor	End Date	Title of thesis
Athanasios Anastasiou	Georgios Magdis	Frank Grundahl	08 December	Galaxy Evolution studies with the new, state of the art, multi-wavelength catalog in the COSMOS field
Simon Pochinda	Georgios Magdis	Maximilian Stritzinger	30 September	A panchromatic and structural study of high redshift star forming galaxies
Malte Brinch	Darach Watson	Jérôme Chenevez	17 August	Reverberation mapping of nearby Seyfert galaxies for cosmology - Determining the dust torus time lag
Clara Giménez Arteaga	Gabriel Brammer	Maximilian Stritzinger	30 June	Resolving the Properties of Dust and Stellar Populations of Nearby Galaxies with the Hubble Space Telescope
Suk Joo Ko	Johan Fynbo	Allan Hornstrup	06 January	Spectroscopy of red Quasars

Suk Joo Ko defending his Master Thesis. Image Credit: DAWN

Looking down on a shooting star.
Image Credit: NASA/Ron Garan

Meet the Cosmic Dawn Team

Staff and students

 Sune Toft Center Director	 Thomas Greve Center Co-Director	 Guarn E. Nissen Senior Coordinator
 Johan Peter Uldall Fynbo Section Leader	 Dorte Garde Nielsen Section Secretary	 Helena Baungaard Section Secretary
 Charles Steinhardt Associate Professor	 Darach Jafar Watson Associate Professor	 Georgios Magdis Associate Professor
 Gabriel Brammer Associate Professor	 Pascal Oesch Associate Professor	 Hans Ulrik Nørgaard-Nielsen Senior Scientist
 Francesco Valentino Assistant Professor	 Allan Hornstrup Associate Professor	 Peter Jakobsen Affiliated Professor
 Iary Davidzon DAWN Fellow	 Seiji Fujimoto DAWN Fellow	 Francesca Rizzo DAWN Fellow

 Steven R. Gillman Postdoc	 Lijie Liu Postdoc	 Nina Bonaventura Postdoc
 Bo Milvang-Jensen Senior Researcher	 Anton Norup Sørensen Senior Researcher	 Peter Laursen Senior Scientific Communication Coordinator
 Trity Pourbahrami International Associate and Communications Consultant	 Kate Whitaker International Associate	 Karina Caputi International Associate
 Kristian Finlator International Associate	 Peter Capak International Associate	 Desika Narayanan International Associate
 Fabian Walter International Associate	 Luis Colina International Associate	 Claudia Lagos International Associate
 Birgitta Nordstrom Associate Professor Emeritus	 John R. Weaver PhD Student	 Meghana Killi PhD Student
 Vasily Kokorev PhD Student	 Clara Giménez Arteaga PhD student	 Malte Brinch PhD Student

Vadim Rusakov

PhD student

Katriona (Kate) Mai Landau Gould

PhD student

Simone Vejlgaard

MSc Student

Magdalena Maria Otap

MSc Student

Albert Sneppen

BSc Student

Christian Kragh Jespersen

BSc Student

Alumni

Carlos Gómez-Guijarro

PhD

Mikkel Stockmann

PhD

Isabella Cortzen

PhD

Athanasios Anatasiou

MSc Student

Cecilie S. Nørholm

MSc Student

Christina Konstantopoulou

MSc Student

Simon Pochinda

MSc Student

Suk Joo Ko

MSc Student

Jonatan Selsing

Postdoc

Daniel Ceverino

Assistant Professor & DAWN Fellow

Kimihiko Nakajima

Post Doc DAWN Fellow

Image Credit: Gabriel Grammer

Publications

Appendix: DAWN Publications, 01.01.2020– 31.12.2020

Below we have compiled all of the articles in the refereed literature that include one or more authors from the Cosmic Dawn Center and its international associates. These are items limited to publication dates between 01 Jan 2020 – 31 Dec 2020 obtained from the comprehensive research information management system PURE. All of the publications listed in this report have been peer reviewed and published by the journals indicated in the bibliographic entries. Digital Object Identifiers (DOIs) are provided for all entries where available. The journals indicated have a variety of Open Access (OA) policies; a query on these paper DOIs at the Web of Knowledge indicates that 103 articles are currently available with Open Access. Often-used journal names are abbreviated as:

AJ – The Astronomical Journal

ApJ – The Astrophysical Journal

ApJSS – The Astrophysical Journal Supplements Series

A&A – Astronomy & Astrophysics

MNRAS – Monthly Notices of the Royal Astronomical Society

PASA – Publications of the Astronomical Society of Australia

PASJ – Publications of the Astronomical Society of Japan

PASP – Publications of the Astronomical Society of the Pacific

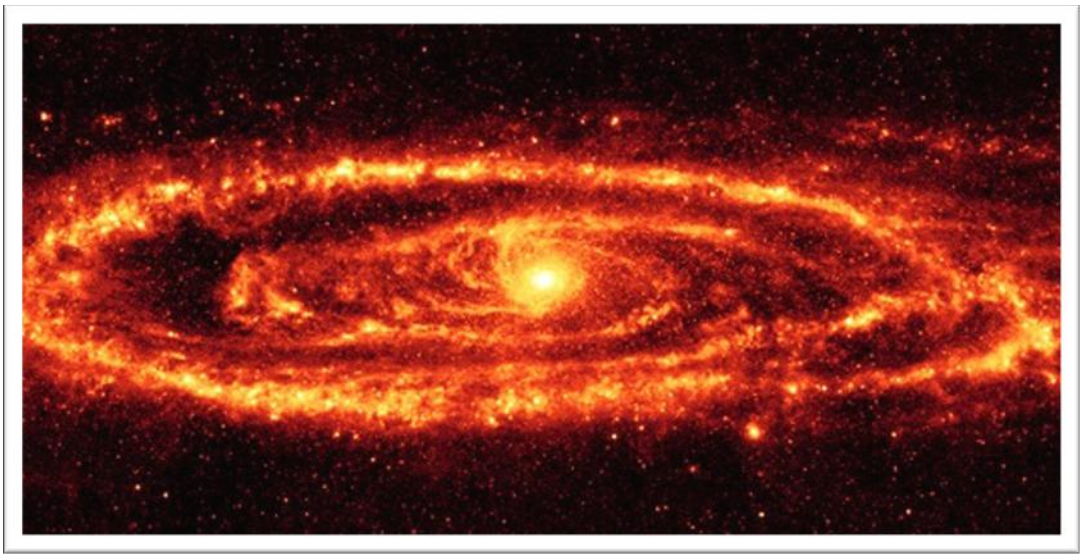


Image Credit: NASA/JPL–Caltech/K. Gordon, University of Arizona

DAWN Publications:

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9. Bielby, Richard M., Michele Fumagalli, Matteo Fossati, Marc Rafelski, Benjamin Oppenheimer, Sebastiano Cantalupo, Lise Christensen, et al. 2020. “Into the Ly jungle: exploring the circumgalactic medium of galaxies at z 4-5 with MUSE.” *MNRAS* 493 (4): 5336–56. https://doi.org/10.1093/mnras/staa546.

10. Bouwens, Rychard, Jorge González-López, Manuel Aravena, Roberto Decarli, Mladen Novak, Mauro Stefanon, Fabian Walter, et al. 2020. “The ALMA Spectroscopic Survey Large Program: The Infrared Excess of z = 1.5-10 UV-selected Galaxies and the Implied High-redshift Star Formation History.” *ApJ* 902 (2): 112. https://doi.org/10.3847/1538-4357/abb830.

11. Bowler, R. A. A., M. J. Jarvis, J. S. Dunlop, R. J. McLure, D. J. McLeod, N. J. Adams, B. Milvang-Jensen, and H. J. McCracken. 2020. “A lack of evolution in the very bright end of the galaxy luminosity function from z = 8 to 10.” *MNRAS* 493 (2): 2059–84. https://doi.org/10.1093/mnras/staa313.

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14. Collacchioni, Florencia, Claudia D. P. Lagos, Peter D. Mitchell, Joop Schaye, Emily Wisnioski, Sofía A. Cora, and Camila A. Correa. 2020. “The effect of gas accretion on the radial gas metallicity profile of simulated galaxies.” *MNRAS* 495 (3): 2827–43. https://doi.org/10.1093/mnras/staa1334.

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16. Cullen, F., R. J. McLure, J. S. Dunlop, A. C. Carnall, D. J. McLeod, A. E. Shapley, R. Amorín, et al. 2020. “The VANDELS survey: a strong correlation between Ly equivalent width and stellar metallicity at 3 z 5.” *MNRAS* 495 (1): 1501–10. https://doi.org/10.1093/mnras/staa1260.

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19. Decarli, Roberto, Manuel Aravena, Leindert Boogaard, Chris Carilli, Jorge González-López, Fabian Walter, Paulo C. Cortes, et al. 2020. “The ALMA Spectroscopic Survey in the Hubble Ultra Deep Field: Multiband Constraints on Line-luminosity Functions and the Cosmic Density of Molecular Gas.” *ApJ* 902 (2): 110. https://doi.org/10.3847/1538-4357/abaa3b.

20. Dessauges-Zavadsky, M., M. Ginolfi, F. Pozzi, M. Béthermin, O. Le Fèvre, S. Fujimoto, J. D. Silverman, et al. 2020. “The ALPINE-ALMA [C II] survey. Molecular gas budget in the early Universe as traced by [C II].” *A&A* 643 (November): A5. https://doi.org/10.1051/0004-6361/202038231.

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SDSS J010013.02+280225.8 at z = 6.30." *ApJ* 891 (1): 64. https://doi.org/10.3847/1538-4357/ab718c.

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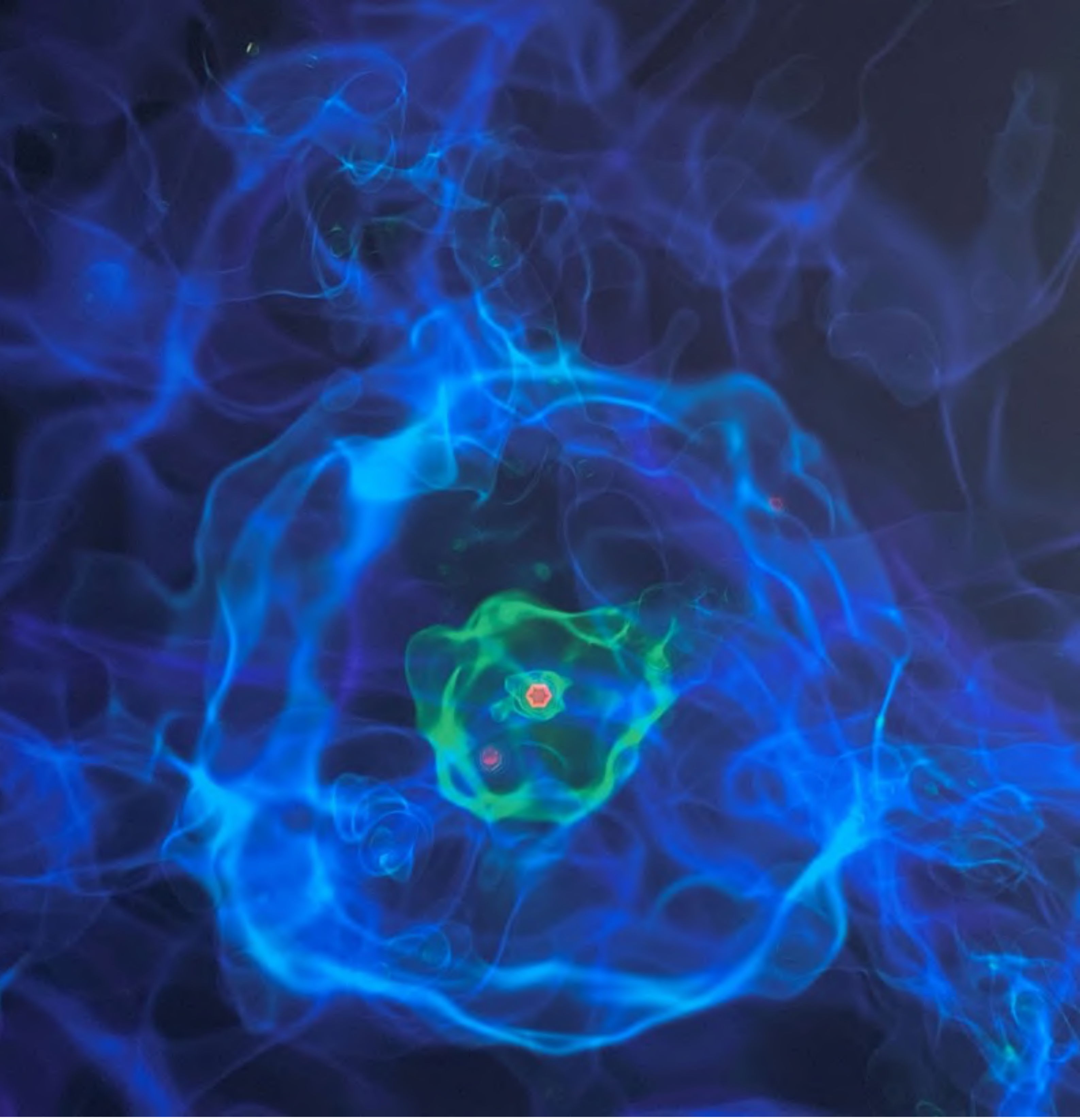

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