CAP journal
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Communicating Astronomy with the Public

SPECIAL EDITION II
CELEBRATING 100 YEARS OF THE PLANETARIUM: PLANETARIUM STORIES

Dark Sky Oases
Planetariums as venues for multifacted and multimodal learning.

An Archaeoastronomical Planetarium
Learn how one planetarium promotes tourism as well as cultural hertiage preservation.

Understanding Origin Stories
Do you know the history of your local planetarium? Join Armagh Planetarium's exploration of its exciting past.

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The Communicating Astronomy with the Public (CAP) Conference is the only large-scale international conference for astronomy communication. The next CAP conference will be held in hybrid mode from 24 – 28 June 2024, in-person at Cité de l'espace, Toulouse, France and online. The conference will feature participant-led sessions in their state-of-the-art planetarium. For more information, see our website: cap2024conference.org

Pierre Carton/Cité de l'espace

Editorial

Between October 2023 and May 2025, we celebrate the Centennial of the Planetarium: one hundred years of storytelling, learning, and exploration under the dome. In these one hundred years, countless planetariums have emerged to bring the awe-inspiring night sky to people worldwide. This issue of CAPjournal represents a special edition of our special edition. All of the articles published in this issue are planetarium stories: non-peer-reviewed accounts of the diversity of planetariums worldwide. These articles collectively tell an important story about the different forms that planetariums can take in their communities, as driving forces of STEM learning and engagement.

Dani LeBlanc of the Museum of Science, Boston and co-Chair of the International Planetarium Society's Equity, Diversity, and Inclusion Committee describes the ever-evolving landscape of storytelling in the planetarium. She prompts us to consider that the planetarium has always been a venue for community building through sharing experiences of the night sky.

This issue presents a diverse collection of articles that span a wide range of the planetarium's functions. In an interview with Noreen Grice, Carolyn Collins explores the important and long-term process of creating accessible planetarium materials with and alongside communities. Accessibility, equity, and inclusion are prerequisites for establishing representation in STEM, generally, and in astronomy in particular. *Aruba's first planetarium: A work in progress* details the developing plans to establish the first planetarium in Aruba, epitomising the phrase "you can't be what you can't see". Similarly, in *Planetarium María Reiche: A vintage planetarium in the digital age* the author presents a planetarium dedicated to the archaeoastronomical work on the Nasca Lines of María Reiche and pairs cultural preservation with a unique tourism environment, shining a light on the incredible ingenuity of the Nasca people. Planetariums of all sizes can inspire learners of all ages to explore their curiosity in astronomy. The article *Celebrating the Centennial of the Planetarium – Reflections and innovations in the planetarium community in Kuwait* discusses a planetarium and museum that work in tandem to bring impactful experiences to the next generation of scientists in Kuwait. In recent years, we have seen the planetarium move from being solely dedicated to displaying the night sky to hosting a wide variety of creative events that bring the community into the immersive environment of the planetarium. In *Unisphere after three years of operation*, the authors describe their many creative uses for their young planetarium. Also touching on this topic, the authors of *The Infini.to planetarium: One tool, many ways to make the most of it!* offer a case study and best practices of a science center and planetarium that bridge researchers and teachers alike to make the most out of their planetarium experience. Of course, planetariums can be important tools in academic settings. In *The first planetarium in an astronomy department in Turkey*, the authors describe how the Instanbul University Planetarium was conceived, constructed and operated to this day. Highlighting the historical importance of planetariums, the authors of *Archival research in a planetarium: The first projector at Armagh Planetarium* sift through the history of the Amagh Planetarium to better understand their beginnings.

As the planetarium has evolved over these last one hundred years, its function has broadened to include a varied collection of creative and innovative community-driven activities. We hope that these articles inspire you to get curious about the unique ways you could interact with your local planetarium, and the diverse communities you could invite into the space to not only experience a true dark sky, but also to engage in multidisciplinary STEM learning.

As a note to our readers and potential authors: all articles in this are exceptions to our new guidelines for submission. Typically, each article will be reviewed by a member of our Editorial Board and an external Peer Reviewer. In this special edition, however, we decided to publish these stories alongside our peer-reviewed issue (CAPjournal #33) to promote the accomplishments of planetariums worldwide. We welcome submissions on a rolling basis and invite everyone to learn about our new Submission Guidelines for peer review on our website, www.capjournal.org.

Kelly Blumenthal
Editor-in-Chief and Managing Editor

Cover: This issue is part two of our special edition of CAPjournal, celebrating one hundred years of the planetarium. From the first planetarium in 1923 (pictured in the foreground of CAPjournal Issue #33) to today, planetariums have undergone a substantial change. Once a venue to view only the stars in the night sky, planetariums are now educational powerhouses, transporting audiences across space and time. This image shows a view from inside the state-of-the-art planetarium at Cité de l'espace in Toulouse, France, where audiences are shown dazzling images of galaxies and brought on journeys to black holes.

Image Credit: Cité de l'espace

Contents

Column

Planetariums as venues for dynamic storytelling

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Keywords
Planetarium, Storytelling, Immersive

From 2023 to 2025, we celebrate the centennial of the planetarium: one hundred years of storytelling under the dome. As the projector technology has changed and become much more sophisticated, so have the ways in which we communicate science in the immersive environment of the planetarium. However, throughout this century, planetariums have remained an exciting venue to learn, share stories, connect, and experience the awe of a truly dark sky.

Introduction

For more than 23 years, the book *Window to the Universe* (*Hagar, 1980*) has sat on my office shelf. An inherited gift from the previous Planetarium Director, it describes the quintessential planetarium of the late 70's era and details the extraordinarily precise inner workings of optomechanical star projectors, the usage of slides and special effect projectors, and step-by-step instructions for the planning and production of original planetarium shows. This matches the nostalgic memories of my first childhood visits, when the ultra-dark night sky of my local planetarium transported me, like magic, instantly outside, allowing all of us in the room to gaze up into the infinite expanse. While this experience still represents the essence of a planetarium's general allure, much else has changed in the last 40+ years.

Today, modern digital planetariums are one-of-a-kind venues unmatched in their versatility and range of programming. These domed theatres continue to be a place to celebrate and share the beauty and mystery of the cosmos with schoolchildren, adults, and general audiences. The planetarium's advanced technological systems display immersive 360-degree imagery and access astronomical datasets and visualisations based on active research to create experiences unlike any other digital medium. Here, science, technology, and art blend seamlessly to bring visitors into the cosmos and inspire awe and curiosity in a way that any other form of educational material cannot.

A quick search on the Worldwide Planetariums Database[1], which was developed by industry colleagues from the Association des Planétariums de Langue Française (APLF), reveals a map of over 4,000 Planetariums around the globe. No two planetariums are exactly alike – they range from small, portable setups that can inflate and be set up within minutes to enormous, multi-million-dollar installations and represent every level of technology from simple pinhole-and-light-source devices to classic optomechanical projectors to elaborate digital projection systems backed by high-powered graphics computers. Many of the most famous venues are part of science centres or natural history museums; others are affiliated with universities and colleges, and some are found within elementary, middle, and high schools.

While each Planetarium facility is unique, they all serve the same notable purpose: to convey the concepts of astronomy through impactful storytelling techniques and strategies while bringing in a sense of physical immersion and engagement that allows viewers to personalise the experience. Just as there are multiple ways to build a planetarium, there are even more ways we can use these environments to astonish, excite, and fascinate. And, just as planetarium technology has evolved over the years, storytelling has flexibly adapted to the ever-changing medium.

Multimedia storytelling

As digital production technologies have advanced and become ubiquitous in media such as films, immersive room exhibits, projection mapping, VR experiences, and more, new opportunities have emerged for skilled creative and documentary writers and large-format filmmakers to use the dome to inspire awe through the spectacle of high-quality prerecorded feature shows – often referred to in the planetarium field as fulldome productions. Storytellers, scriptwriters, 3D animators, and multimedia producers develop 360-degree experiences designed specifically for immersion in a dome, which can bring astronomy concepts to life through artistic renderings and animations, allowing audiences to make impossible journeys across space to explore new environments and imagine possible worlds. The multisensory audiovisual experience rounds out with elaborate sound design, often including celebrity narrators and/or original musical scores.

Science visualisation and data storytelling

Complimentary to artistic renderings of 3D worlds, the planetarium is also emerging as a powerful display and storytelling vehicle driven by data visualisation tools. More software packages are emerging that add to the planetarium's toolkit and open up doors for showcasing massive amounts of data from the astronomical research community on the large-format immersive dome. In fact, most major planetarium software packages now include, by default, impressive dataset libraries and feature access to user-generated data visualisations. When discoveries are made, new data can be imported directly into planetarium systems to showcase, for example, orbital paths, or can be handled by other open-source visualisation software that is mapped onto the dome and "flown through" in real-time. Planetariums can

share data and scripts with other planetariums worldwide, pull instantly from thousands of unique user-created submissions (e.g., images, audio, video, 3D models, etc.), as well as access diverse and continually growing scientific data from projects such as DATA2dome[2], Science on a Sphere[3], OpenSpace[4], and astronomical research databases. With this ability to bring data and display it in immersive, three-dimensional environments, planetariums can support researchers and enable them to become explorers of their own data and, in turn, create opportunities for them to share those experiences with fellow researchers or general planetarium audiences.

Live, interactive storytelling

Although the planetarium – both technologically and as a venue for storytelling – has advanced over the years, the exchange of stories and human-to-human interaction underneath a dark, starry sky (whether natural, digital, fibre-optic or otherwise) is still very effective at drawing people together in shared experience, awe, and wonder. Live, interactive, unscripted storytelling by an adept and charismatic presenter brings the visual experience to life and can provide a personal, in-the-moment connection to unfolding cosmic stories. The direct interaction of the presenter with audiences can add relevancy and accessibility to the experience, as the presenter can respond extemporaneously to the room's dynamic. Thus, visiting the planetarium becomes a fun, memorable tour of the Universe and a unique learning experience that can stay with an individual forever.

Community-building storytelling

None of these approaches to planetarium content and storytelling will inspire the broad swaths of audiences – particularly those who are traditionally marginalised and underserved – or have a positive impact if we cannot make planetariums and their tools inclusive and accessible to everyone. It is our responsibility as science communicators to ensure that the repertoire of content we share within our domes is relevant and can meaningfully resonate with all communities. There is, unfortunately, no one-size-fits-all model for achieving this. Instead, planetariums can strive to become true conveners by diversifying offerings, opening their doors to all voices, and actively seeking out opportunities to welcome the many lenses through which science stories are told and shared, using any and all of these storytelling tools to elevate and amplify community voices. In recent years, there has been a shift in the industry that aims to dismantle the traditional notion of "expert delivering information" in favour of co-creation and collaborative models of programme development with strategic partners (e.g., research, public, government, industry, and local community sectors). This work is expanding how we can experience science and can include innovative forms of science communication such as live theatre pieces in the dome, music performances, audio works based on the sonification of data, and other products at the intersection of science, technology, and art. By bringing community into this work and encouraging others to participate directly in the creation of these experiences, we enrich our storytelling of the Universe with a diversity of knowledge and perspectives on science and re-examine the kinds of stories we tell. Through this intentional practice, we will better engage and inspire audiences and reach more communities in authentic and relevant ways in the hopes that more people can see themselves reflected in the scientific narrative.

The years 2023 and 2025 bookend the 100th anniversary of the planetarium. As we all partake in this breathtaking new era for astronomy and space science, where our understanding of the Universe is growing at an astonishing rate, we value modern planetariums and their unique ability to serve as conveners, connecting the work of astronomers and multidisciplinary researchers with the general public, K- 12 schools, communities, artists, makers, innovators, dreamers, and many more.

Each year, we lose more and more of the beauty of the night sky to light pollution, and the opportunities to gaze up at a natural star-filled sky in wonder are becoming rare. The planetarium, just like the real night sky, is a place where we can preserve a sense of wonder and awe, contemplate our humanity, share stories, inspire hope for the future, and stand in common ground on our one planet, under one sky.

Notes:

[1] Refer to the Worldwide Planetariums Database: https://planetariums-database.org/

[2] Refer to the Data2Dome website from ESO: https://www.eso.org/public/outreach/data2dome/

[3] Refer to the Science On a Sphere website: https://sos.noaa.gov/

[4] Refer to the OpenSpace website: https://www.openspaceproject.com/

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Hagar, C. F. (1980). *Planetarium: Window to the universe*. Carl Zeiss.

Biography

Danielle LeBlanc is the inaugural Director of the Center for Space Sciences, the Director of Immersive Theaters and Programs, and the strategic programming and vision lead for the Charles Hayden Planetarium at the Museum of Science, Boston. Ms. LeBlanc currently sits on the Advisory Council for Immersive Media Entertainment, Research, Science & Arts (IMERSA), and since 2019, has served as a founding co-Chair of the Equity, Diversity, and Inclusion Committee for the International Planetarium Society (IPS). She received her BA in astronomy and physics from Boston University.

Pioneering accessible astronomy under the planetarium dome: An interview with Noreen Grice

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Keywords
Accessibility, Astronomy, Astronomy Education, Best Practices, Inclusion, Planetarium, Public engagement

Accessibility in the planetarium requires architectural accommodations for differently abled people and careful preparation of accessible content. Noreen Grice has worked in content accessibility for astronomy in the dome and publications with NASA and other organisations for many years. This interview encapsulates her work and experiences.

Preamble

Planetarium theatres stand out in the public mind as places where people can go to learn about astronomy and space science, astronomers, space scientists, astronauts, and others who are exploring the Universe. However, even with the outreach that planetarians do, an important segment of the population misses out on the message: those who are differently abled.

Accessibility for them in the dome has always been a challenge. Physical access can be handled with proper architectural techniques. However, there is also the issue of accessible content. What do you do if members of your audience are blind, low vision, or otherwise unable to access your content? Some solutions present themselves in the form of closed captioning, for example. But, to make content available to all is challenging and requires multiple solutions.

It is a challenge that Noreen Grice first confronted many years ago when she worked at the Museum of Science Boston. Noreen is widely considered the pioneer in astronomy accessibility, a topic she's dedicated her career to since 1984. Over the years, she has created a series of tactile Braille and print books and products designed to bring the Universe to these visitors. She is often asked to consult on planetarium productions and facilities. Along the way, she's broadened the Universe for people who do not sense the cosmos like others do. Noreen shared many thoughts about her groundbreaking work in a wide-ranging interview.

Noreen is now president of You Can Do Astronomy[1], the company she founded after talking with blind and low-vision visitors about their experience at the Museum.

Noreen, what prompted you to make materials for differently abled visitors?

Back in the summer of 1984, I was an astronomy major going into my senior year at Boston University, and I had just started working in the Charles Hayden Planetarium at the Boston Museum of Science. One day, I noticed a group of blind students in line for the planetarium show. At that time, I didn't know anyone who was blind, and I wasn't sure what to do. The manager said I should just help them to their seats, indicating that was all I had to do. So, I guided the group to their seats, stepped into the console, welcomed everyone to the planetarium and pressed the button on the computer to start a pre-recorded show. I recall the narration was something like: over here is the Ring Nebula, and over there is the Big Dipper. During the show, I followed the script and

Figure 1: *Noreen Grice and Max Mutchler presented a paper about the Tactile Carina Nebula Project at the January 2010 American Astronomical Society (AAS) Meeting. The tactile prototype was tested by learners with blindness and low vision. The final version was displayed at the meeting. Scientists in attendance were encouraged to touch the different textures of the Carina Nebula. Image Credit: Noreen Grice*

moved the Zeiss projector to specific coordinates.

I wondered what the students thought about the planetarium show, so when the show ended, I stepped out of the console and asked them. I thought they might say the show "was nice," but instead, they said it was not accessible to them. I felt terrible. To me, the planetarium was the most wonderful place in the world, but clearly, it was not that way for them.

I could not stop thinking about the students walking away disappointed. The next day, I took a bus to the Perkins School for the Blind in Watertown, Massachusetts. I visited the campus library and asked if they had any astronomy books for blind students. The librarian directed me to a shelf filled with very thick Isaac Asimov books. I pulled a book from the shelf, flipped through it and saw pages with Braille code. But something was missing. I asked the librarian if Braille books had raised pictures. They explained that raised pictures are very expensive and labour-intensive, so not many Braille books have touchable pictures.

Then, I understood something crucial. The narration of the planetarium show was not descriptive, and the images projected on the dome were not accessible to visitors who were blind or low vision. I did not know how to solve this problem, but I was determined to try and figure out solutions to make astronomy more accessible non-visually. This moment changed my career and set me on a course to develop a new field of accessible astronomy.

How did your museum administration react to your efforts?

Two things happened. At Boston University, I met with one of my astronomy professors and proposed doing a directed study to write an astronomy book specifically geared toward blind or low-vision learners. This book would be very descriptive, have Braille and print text with raised pictures, and would be called *Touch the Stars.* The professor (Dr Janes) agreed, and I began work on the book.

At the Museum, I think my manager was a little uncertain about creating materials for blind visitors. But, I wanted to learn how to make tactile images, so I visited the Massachusetts Association for the Blind. A volunteer showed me that she glued string to cardboard to make tactile images. Then, I went to Howe Press at the Perkins School and learned that I could make images one at a time using special plastic pages and etching tools. I purchased a tactile drawing kit and began to teach myself how to make tactile images. I bought a template of Braille characters and practised making Braille labels and raised patterns. I wanted to create a series of tactile pictures on topics that could be used in any of the planetarium shows. It was a very slow process, and took me weeks just to make one image.

By the time I graduated from Boston University, I had completed the text and identified the types of tactile images needed for *Touch the Stars*. However, the lack of available technology prevented me from producing it. So I packed up my work in a box, left Boston, and headed to San Diego State University to complete my Master's degree in astronomy. When I finished, I returned to Boston and to the Museum of Science and picked up where I left off. I got a grant to purchase a Braille embosser, and I redrew all of the designs I had made on the plastic pages with a mouse and saved it to the computer. Once I had the design saved, I could quickly print out copies of the images and create tactile picture booklets for all of the planetarium shows. Finally, there were tactile picture books for every planetarium show!

Then, I approached the Vice President of Education about using the Braille embosser to create the tactile images for *Touch the Stars*. National Braille Press could print the text pages in Braille and print, as long as I provided the accompanying tactile images. The Museum of Science agreed to act as publisher, and the first edition of *Touch the Stars* came out in 1990. Since then, it has gone through many updates and expansions. National Braille Press is now the sole publisher of the 5th edition of *Touch the Stars*. It has received very favourable reviews in *Sky & Telescope* and *Physics Today* magazines.

Figure 2: *Noreen Grice reads a pictorial description of features in the Carina Nebula to a low-vision student who is exploring the first of three different tactile prototypes of the nebula at the National Federation of the Blind Youth Slam. Image Credit: Noreen Grice*

So, you founded your company – which you describe in your motto as an accessibility design and consulting company focusing on making astronomy and space science accessible to people through universal design. What kinds of projects have you taken on in this effort?

I named my company "You Can Do Astronomy LLC" because I want to promote a positive message on making astronomy accessible for learners of all abilities. Whether you learn non-visually or have a disability-related to mobility, communication, learning or hearing, you can do astronomy, too!

Originally, I began my accessibility work for learners who are blind or have low vision. I created tactile images that were available any time a blind or low-vision visitor came to the planetarium.

But, it was time to tackle another problem. While at the Museum of Science, I turned my attention to visitors who were deaf or hard of hearing. At that time, one sign language-interpreted show was offered every other month on a Saturday morning. That meant visitors who were deaf or hard of hearing had to plan well ahead to visit the planetarium. If they missed the specific show and came to the planetarium at any other time, they were out of luck.

That didn't seem fair to me. I began exploring captioning options and found that the local public television station (WGBH Boston) was also testing potential captioning devices for theatres. I participated in a test they did with three different devices at a local movie theatre. One of the devices, a vacuum fluorescent display, was the size of a shoebox and was attached to the back of a theatre seat in a metal housing. I thought this device had potential for use in the planetarium.

I contacted Design Continuum, an engineering design company. They agreed to donate the research and development, and I got a grant to pay for materials. It took over a year of testing, but the new modular captioning system debuted in the Charles Hayden Planetarium in 1996. It could display narration in the form of text from pre-recorded programs and was used for about 20 years.

A surprising thing happened: people who spoke English as their second language requested captioning because they said for them, it was easier to understand English by reading rather than by listening. This was a great lesson in how an accommodation for one group can be an accommodation for others, much like how a curb cut designed for people with mobility disabilities is used by many people, especially those pushing baby strollers. I also received a different grant for the planetarium assistive listening system so people who needed volume amplification could borrow a unit and adjust the volume to their specific needs.

Beyond my work at the Museum of Science, I edited a book for the Great Lakes Planetarium Association entitled *How to Make Planetariums More Accessible to People with Disabilities* (1996). I wrote and designed the tactile images for three NASA Braille/print books, a children's book about learning the Moon's phases and a combination educational/travel guide on accessible astronomy and places to visit. Most recently, I collaborated with planetary astronomer Dr Heidi Hammel and co-wrote the digital book *Touch the Solar System*, published in 2022.

I designed tactile graphics for the Space Telescope Science Institute (3D representation of NGC 602 (2014) and The Tactile Carina Nebula[2] poster (2010)) and tactile images for a different NASA book (*Touch the Earth: A Multimedia Book about Earth's Biomes* (2010)). Some of my tactile designs have been used in museums and visitor centres. I created tactile graphic designs for the *Chandra X-Ray Observatory* Exhibits (From Earth to the Solar System (2009), Here, There and Everywhere (2014) and Light Beyond the Bulb (2015)) and the tactile designs for *The Solar System Radio Explorer Kiosk Exhibit* (Goddard Space Flight Visitor Center, 2007). Recently, I designed accessible modifications for outreach activities in the *Big Astronomy* outreach toolkit (2022).

How have you seen your efforts grow across the domed community over the years?

Figure 3: *Noreen Grice speaks with a conference participant and discusses how astronomy topics were made more accessible to blind and low-vision high school students during the National Federation of the Blind Youth Slam (held at Johns Hopkins University). Image Credit: Noreen Grice*

Figure 4: *Noreen Grice stands inside a tactile tent and guides a low-vision high school student as he explores a tactile picture of a constellation during the National Federation of the Blind Youth Slam. This tactile tent was built by teacher Ben Wentworth and his students at the Colorado School for the Blind and brought to Johns Hopkins University for this Event. Image Credit: Noreen Grice*

In 1984, when I first began my efforts to make astronomy and the planetarium more accessible to blind or low-vision audiences, I was the only person doing it. I made presentations at planetarium and astronomy conferences, displayed my tactile materials, and advocated for more accessibility in the planetarium. Over the years, educators have contacted me for advice on how to make their facilities and programs more accessible, and people with disabilities have contacted me asking where accessible astronomy places are located. Those questions prompted me to write the resource book *Everyone's Universe: A Guide to Accessible Astronomy Places (2011,2012)*.

Over time, students, educators and amateur astronomers began expanding upon my work, creating their own tactile materials and testing methods of applying different sounds (sonification) to represent different characteristics of astronomical objects. I'm pleased to see that there are more people now interested in making the planetarium welcoming and accommodating for people who are using different strategies for learning.

How did NASA get interested in your work?

After *Touch the Stars* was published, I received an email from Dr. Bernhard Beck-Winchatz of DePaul University. He was working in the NASA Broker Facilitator office at DePaul and saw the book in a Chicago bookstore. He wondered if it was possible to do something like that for the *Hubble Space Telescope* images. We applied for and received an E/PO (Education/Public Outreach) grant to develop a new Braille/print book with *Hubble* tactile images. The grant was received, and Ben Wentworth, a teacher at the Colorado School for the Blind, tested my tactile designs with his students. In June 2001, Bernhard, Ben and I presented a paper and participated in a press conference at the American Astronomical Society conference with a few prototype copies of the book. National media picked up on the project, and *Touch the Universe: A NASA Braille Book of Astronomy* was published in 2002 by Joseph Henry Press, an imprint of the National Academies Press. I was told that it was the first Braille book on Amazon!

After it was published, I was approached by Dr. Joseph Gurman and Dr. Steele Hill at Goddard Space Flight Center and asked to create a tactile book about solar science. *Touch the Sun: A NASA Braille Book* was published in 2005. In the third NASA book, I collaborated with two other authors (Dr. Simon Steel and Doris Daou) to write a book about astronomical objects not visible to any human eyes. *Touch the Invisible Sky: A Multi-Wavelength Braille Book Featuring Tactile NASA Images* was published in 2007.

How many books do you have out now?

I am the author of seven accessible astronomy books…currently! They're all listed on my website, along with other projects in progress.

Are they quite widely used?

I have found my books in museum gift shops and libraries across the United States. Many planetariums, amateur astronomers and astronomy instructors have copies of my books ready to pull out for learners who are blind or have low vision. They are proactive in teaching non-visual audiences. I love that!

What sort of feedback do you get about the books?

I often get feedback when I least expect it. Occasionally, I'll receive an email from an educator who is using my books as resources in their planetarium or classroom or from a person who is using a book (say, *Touch the Stars*) as a resource for their own learning. I remember meeting a 13-year-old girl in 2005 at the book launch for *Touch the Sun*. She and her mother had driven hours to be there. She carried a big bag with my other books for me to sign, and she told me in no uncertain terms that she planned to be the first blind astronaut on Mars! The last time I attended the National Federation of the Blind conference in person, I went to the Science and Engineering Division meeting. We went around the room and said our names so everyone knew who was there. When I said my name, two college students immediately turned around and said that it was my

books that got them interested in science, and my books made them believe they could be scientists, too. I can't tell you how that tugged at my heart.

If a group or organisation has funding and wants to involve you in a new accessibility project, would you be interested?

Definitely! I enjoy new challenges and the opportunity to create methods and materials for removing barriers for all learners. My goal is for people of all abilities to experience the universe in new ways, get excited to learn more, and maybe become a scientist and contribute to new discoveries themselves. We live in a time where technology has made the world a community where we can all be involved, where accessibility is or can be made available, and where we can all do astronomy together. I hope to be involved in accessible astronomy for another 40 years! I can be contacted through my homepage[1].

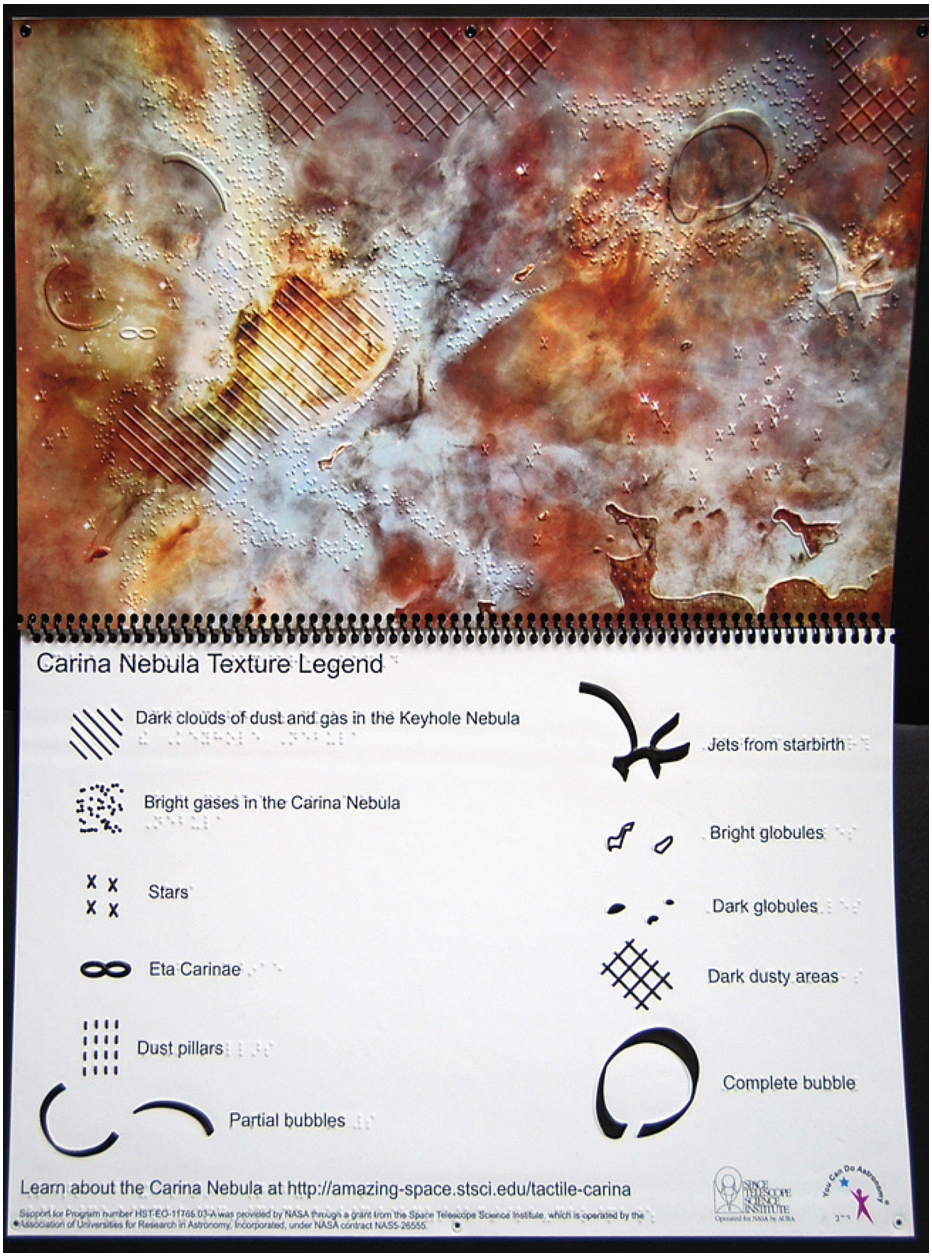

Figure 5: *This is the final tactile Carina Nebula poster produced for the Space Telescope Science Institute in the summer of 2009. The top half (above the spiral binding) highlights different aspects of the nebula, matching visual elements of the nebula's image with tactile features. The bottom half (below the spiral binding) is the Carina Nebula texture legend, which identifies by touch, print and Braille, each of the featured textured areas of the poster. Image Credit: NASA, ESA, Max Mutchler and Noreen Grice*

What's your next project?

I can't tell you until it's published. Stay tuned!

Any final thoughts?

I have been working with the National Federation of the Blind since 2002. I became a member in 2003 and served on the Board of Directors of the Central Connecticut Chapter of the National Federation of the Blind. It's not okay to create materials for a group of people without making sure it's a good fit. I feel that it's important to work directly with the target audience, and I work with non-visual learners to test out my tactile designs and materials to be sure they are working as intended. I also teach astronomy education workshops at schools and museums for blind or low-vision students and their teachers.

Notes:

[1] For more information about Noreen Grice, her work, and how to contact her, refer to her webpage: www.youcandoastronomy.com

[2] Additional information about the tactile Carina Nebula can be found online at www.nasa.gov/mission_pages/hubble/science/carina-touch.html.

Biography

Carolyn Collins Petersen is a long-time planetarian and science writer of 8 astronomy books and many articles. She is the CEO of Loch Ness Productions and has created a number of dome shows. She also writes and consults on science exhibits for clients such as Griffith Observatory, NASA-JPL, the California Academy of Sciences, and the Shanghai Astronomical Museum.

Aruba's first planetarium: A work in progress

Column

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Writing in the name of Space and Nature Aruba Foundation (SNAF)

Keywords
Mobile Planetarium, Amateur Astronomy, DIY

The Space and Nature Aruba Foundation (SNAF) has acquired a mobile inflatable planetarium with the goal of inspiring young students on the island of Aruba to pursue careers in science and technology. Despite lacking the necessary funds to buy an off-the-shelf projector for the planetarium, SNAF debuted it to the public on 14 October 2024 during the partial solar eclipse. Ideally, the mobile planetarium will introduce young students to the wonders of the Universe and inspire them to pursue careers in science and technology, making astronomy and Earth science accessible to the local community.

Astronomy in the Dutch Caribbean

Aruba is part of the Dutch Caribbean Islands: Aruba, Curacao and Bonaire (the Lesser Antilles), and Sint Marten, Sint Eustatius and Saba (the Leeward Islands). These islands are known for their beautiful beaches and warm climate and are a popular vacation destination for tourists worldwide.

Currently, astronomy has a small presence in the Dutch Caribbean Islands. Some astronomy enthusiasts often share their knowledge of astronomy by organizing sidewalk astronomy events and sharing their astrophotography with the rest of the world on Facebook. However, to our knowledge, only two organisations are dedicated solely to astronomy: the Lynch Planetarium and Museum on Sint Eustatius and the Space and Nature Aruba Foundation (SNAF) in Aruba. In this article, we will focus on the current activities of SNAF.

The history of the Space and Nature Aruba Foundation

SNAF began as a collaboration between two lifelong astronomy enthusiasts who actively engage the public with astronomy through school visits and public events. The Foundation has snowballed through amateur astronomy connections. Though it began as a group of people who thought it would be nice to do astronomy together, we started to organize workshops, star parties, and other events. In 2017, our group officially became the Space and Nature Aruba Foundation, and the same people who started in 2015 are now the Board Members.

Currently, SNAF has no official programme, as the Board consists of volunteers – SNAF dependents in their free time. For now, SNAF primarily engages the public through lectures requested by schools, scout groups or vacation camps. Over the next year, we hope to set up some fixed public activities covering space and nature. These fixed events will centre around predictable astronomical phenomena such as planetary oppositions and solar or lunar eclipses. Through these fixed public activities, SNAF will be able to bring in a reliable income to develop more teaching materials in Papiamento, the primary language spoken on the island.

To reach its goals, SNAF must recruit volunteers available to do school events during the day, perhaps by working with a teacher volunteer at every school. Ideally, this would be a science teacher who can be trained and use SNAF's materials to lecture at their schools.

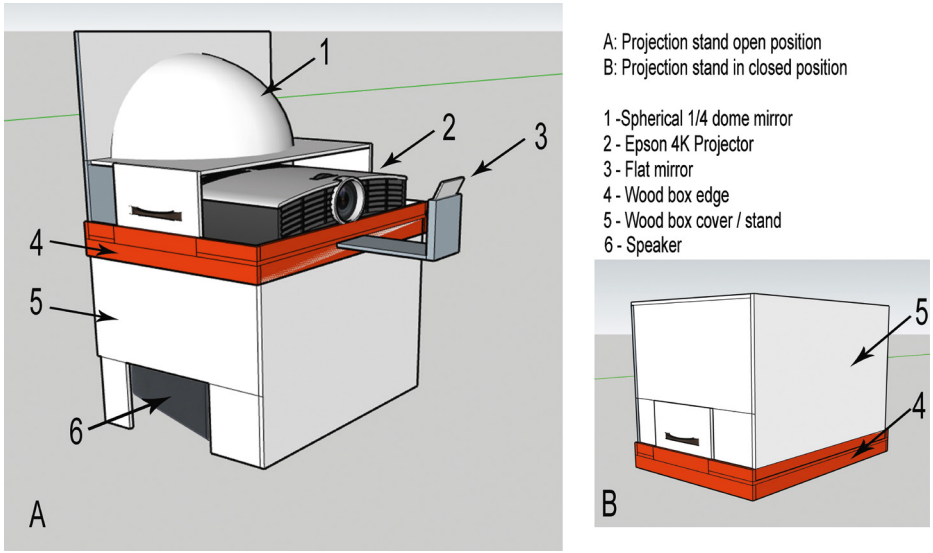

Figure 1: *A schematic of the SNAF projector stand.*

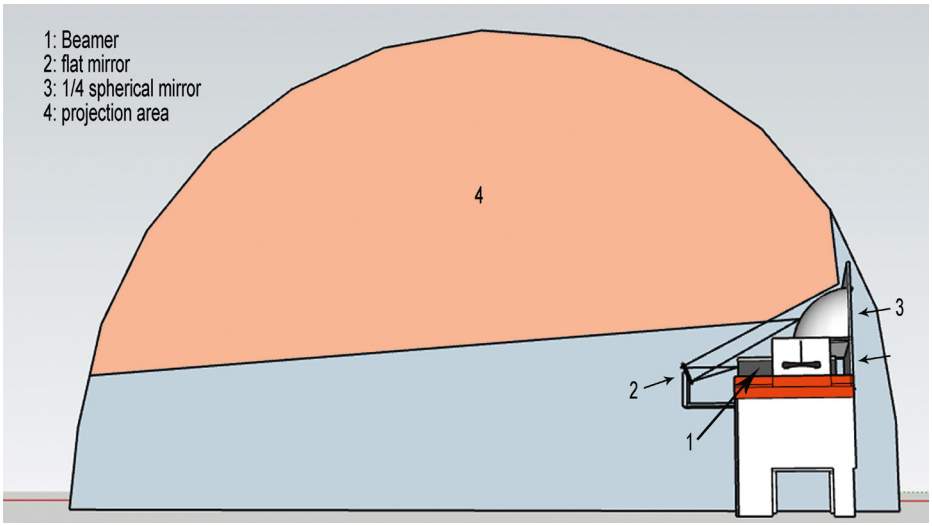

Figure 2: *A schematic of the projection area showing the projection setup and its components.*

The SNAF mobile planetarium

Just before Covid- 19, the members of SNAF were discussing options for purchasing a mobile planetarium and brainstorming about several companies that sell complete sets of planetariums. Unfortunately, these companies were too expensive for SNAF. One of the members came across a DIY mirror projector (*Bourke, 2005*). This system would perform as a typical planetarium projector for a fraction of the cost of a dedicated planetarium projector but would mean that we need to edit the video to be projected properly. Though the system was bulky and used a small computer table, the projector system could be easily transported and used. Using this as a base schematic, we began to design a new system that could be used as a storage box, a stand and a speaker container at the same time (Figure 1). Figure 2 shows how the projector system works; the beamer projects the image onto a flat mirror that reflects onto a spherical mirror and subsequently onto the planetarium dome.

While testing the planetarium, we concluded that if the video is too bright, it loses its essence, and the seams of the dome become noticeable; a dark video produces a truly immersive experience. The typical fulldome videos used for planetariums cannot be used with the mirror system described here, as the image will be distorted. Normally, a fulldome video needs to be warped in order to be projected correctly in the planetarium, represented in Figure 3 with a polar grid, as might be seen in a fulldome projection and a warped frame suitable for projection with a spherical mirror.

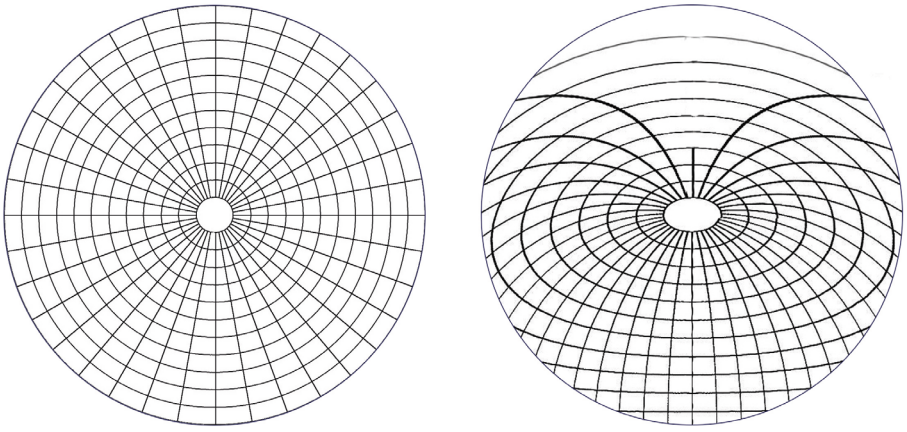

Figure 3: *A representation of the fulldome (left) and warped fulldome (right) projections. Fulldome videos must be warped to use a projection system containing a spherical mirror. Image Credit: After Bourke (2007)*

Unfortunately, no free pre-warped projection videos are available online; specialised software is required to appropriately warp the fulldome videos.

To avoid this extra cost, we instead used a typical flat video. One drawback of using typical square videos is that the edges of the image will be clipped, as seen in Figure 4. This clipping will give extra unnecessary illumination in the planetarium. This can be minimised by painting the back panel matte black.

The SNAF mobile planetarium debuted publicly during the annular eclipse on 14 October 2023. During this event, we gained some new insights:

- The back panel that holds the 1/4 dome mirror needs to be painted matte black to minimise the reflection of the projected video.
- To help senior citizens in the planetarium, the entrance must be illuminated, and chairs must be provided.
- Several people commented that they enjoyed the movie but would prefer it to be in Papiamento to understand it better.
- Because the air temperature in Aruba is consistently around 32°C, we needed to acquire an air conditioning system for the mobile planetarium. For the first trial, we decided to put the planetarium in an air-conditioned auditorium (Figure 5), where the temperature in the auditorium was about 24°C. We found that the temperature inside the planetarium dome was always somewhat higher than the room's temperature, even with no people inside.
- The planetarium needs about 15 minutes to cool down again after 20 people visit and sit in the dome for roughly 10 minutes. Otherwise, we must use an internal air conditioning system, which poses a unique challenge. The operation of the fan to maintain the planetarium inflated, plus the beamer and computer operate at 6 Amps. The air conditioning system works with 8 Amps. During previous testing, we noted that the inflation fan and air conditioning system could not work

together on a single fuse. This imposed a challenge as each classroom only has one fuse for the whole classroom. This would require using an external power source or an extension cord to use the fuse of another classroom to power the air conditioning system.

Conclusions

Some further research needs to be done to produce local materials for the planetarium. This might include working with local teachers to understand the standard curriculum as well as students' interests to develop lesson plans and other materials for the planetarium.

Despite the distortion of the projection image close to the mirror, the audience enjoyed their time at the planetarium and expressed interest in seeing different kinds of movies presented in Papiamento. The next phase for the planetarium will be to train teachers from different schools to operate the planetarium so they can use it at their school. Additionally, we hope to film local movies about the Aruban flora and fauna to provide an exciting opportunity for the public to explore and learn about the Universe.

In Aruba, astronomy is not part of the official curriculum. However, some high school students are expected to do fieldwork in math, chemistry or physics. Their teachers often encourage the students to contact SNAF for guidance on topics related to astronomy.

SNAF's mission is to increase the love for space and nature on the island of Aruba. We hope we can spark children's interest in STEM, creating a snowball effect that inspires the next generation to pursue a career in science.

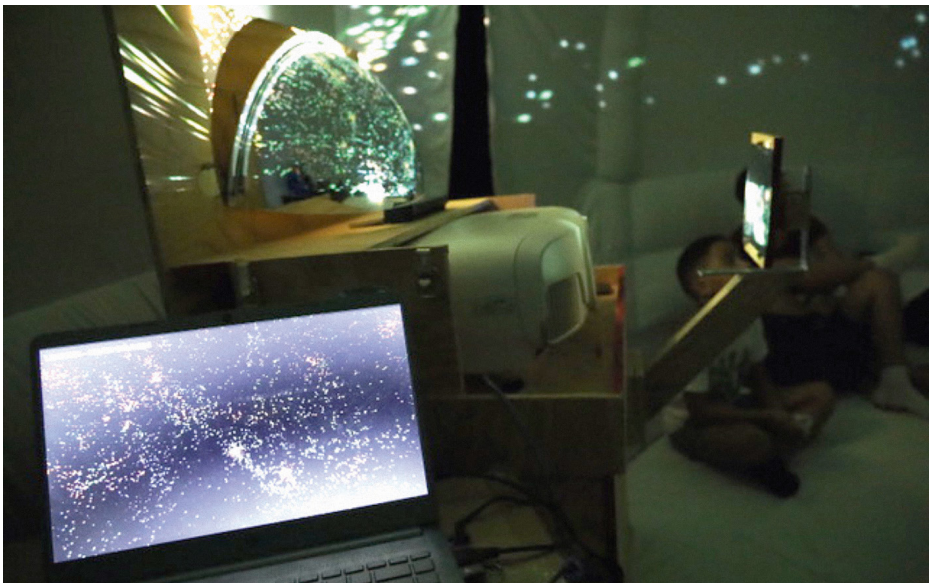

Figure 4: *The first run of the SNAF mobile planetarium first run, including its projector and mirror. Image Credit: Fransisco Croes/Space and Nature Aruba Foundation*

Figure 5: *The first run of the SNAF mobile planetarium showing the dome inside the air-conditioned auditorium during its first run.*

Acknowledgements:

We would like to express our appreciation to all the individuals and organisations who contributed to the Space and Nature Aruba Foundation's efforts to bring astronomy and earth science education to the public through various initiatives, including acquiring a mobile inflatable planetarium.

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Biography

Space and Nature Aruba Foundation (SNAF) is a non-profit organisation based on the Caribbean island of Aruba. Its main goal is to bring astronomy and Earth science to the public through education, research, and public events to improve the status, understanding, and enjoyment of amateur astronomy and Earth science.

News

The Four-Dimensional Digital Universe (4D2U) Dome Theater at the National Astronomical Observatory of Japan, Mitaka, Tokyo, uses a state-of-the-art projection system to produce bright, high-contrast and high-resolution images in full-dome 3D.

National Astronomical Observatory of Japan

Planetarium María Reiche: A vintage planetarium in the digital age

Column

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Keywords
Planetarium, Cultural Astronomy, Archaeoastronomy, Public Understanding of Science, Women in Astronomy, Hands-on

The Lines and Geoglyphs of Nasca and Palpa are among archaeology's greatest enigmas because of their quantity, nature, size, and continuity. The several kilometres-long geoglyphs depict living creatures, stylised plants, and imaginary beings, as well as geometric figures (Figure 1). They are believed to have had both ritual and astronomical functions (e.g., *UNESCO World Heritage Centre, n.d.*), and today, they are considered one of the most emblematic places related to ancient civilisations. Based on the studies of mathematician María Reiche, who dedicated most of her life to researching and protecting this highly symbolic natural environment that survived intact for over 2,000 years, she postulated that the Nasca lines probably represented the largest open book of astronomy on Earth. To communicate the complexity of this region and its connection to ancient astronomy, we created a unique planetarium experience that explains basic astronomy and the cultural uses of the night sky.

The beginnings

Since the 1970s, the Nasca Lines (Figure 1) have been one of the favourite destinations for tourists who love archaeological mysteries. A tour of the Nasca Lines typically consists of a visit on the ground with very limited access to the geoglyphs due to cultural heritage protection. Aerial tours on a small plane enable visitors to appreciate the scale of the figures and lines. This adventure awakens tourists' imaginations, and many questions arise, particularly when the tour guides indicate that some of the lines could have been used for astronomical purposes. In the 1990s, a visit to Nasca would not be complete without participating in the evening talks by María Reiche, "La dama del desierto", given from the "Nasca Lines Hotel". In these talks, Dr Reiche disclosed the different interpretations of the function of the geoglyphs and the many anecdotes about studying and protecting this incredible archaeological wonder.

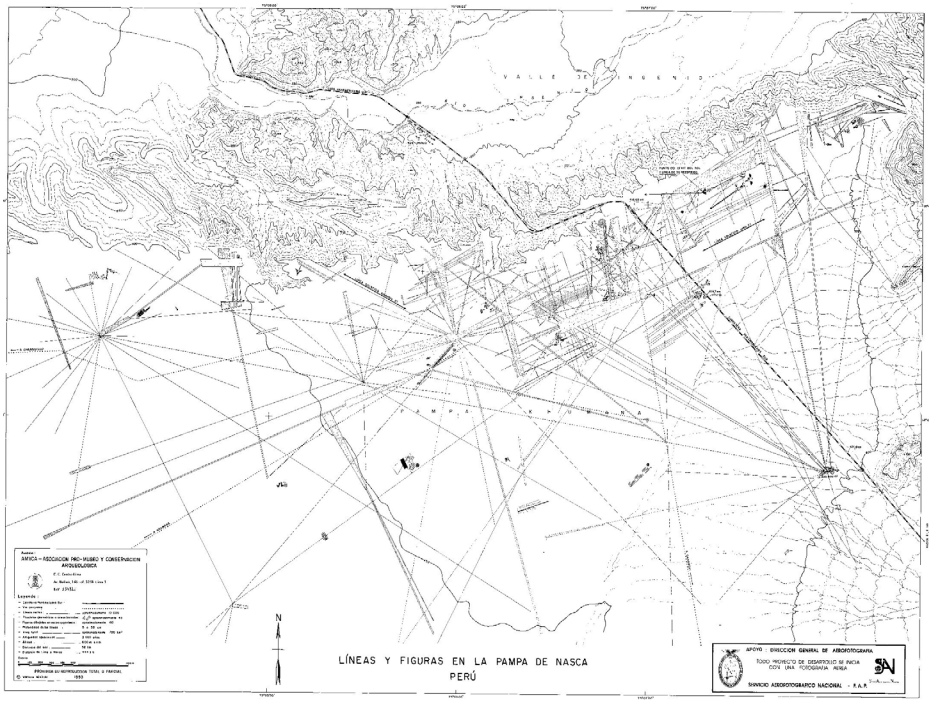

Figure 1: *A map drawn by María Reiche and the National Aerophotographic Service of the Peruvian Air Force based on orthophotos. Image credit: Reproduced with the permission of María Reiche's estate.*

The origin of the María Reiche Planetarium

The Peruvian Institute of Astronomy was established at the end of the 20th century by science, technology, engineering and mathematics (STEM) graduates – including the author – interested in astronomy. We acquired a portable planetarium and visited schools to teach astronomy classes. In this context, the María Reiche Association for the Conservation of the Nasca Lines invited us to present in Nasca. We were lucky enough to give talks at the same hotel where Dr Reiche lived and gave her famous lectures. Months after the death of Dr Reiche,

the Hotel contacted us again as many people came expecting to hear the famous lectures. Thus, we decided to install a small planetarium to carry on the legacy of María Reiche's lectures by adapting her writings and interpretations into a full dome format.

A low-cost planetarium

We adapted our portable planetarium, replacing the inflatable dome with a fixed dome. We constructed the 6-meter-diameter dome with adobones as in the "Nascas" style, carved with clay in the "Nascas" style and decorated with motifs and application techniques of wall art of the ancients (Figure 2). We made the dome with a construction iron structure covered with reeds and plaster.

We use two projectors with two cylinders that show the Southern sky and the Western constellations. The great challenge was to generate a cylinder that could project the Nasca Lines in location and orientation as they are arranged, but on a scale large enough so that they can be seen without difficulty, to explain the sunrises, sunsets, and constellations in relation to the geoglyphs. Our portable planetarium system was crucial, allowing us to continue without high production costs. The system was composed only of a projector with a cylinder screen of stars, which was complemented by a second projector that worked alongside a cylinder that projected the lines and figures of Nasca onto the dome, supported by slides and multimedia projectors (Figure 3).

Perhaps one of the first planetariums dedicated exclusively to archaeoastronomy, the María Reiche Planetarium opened on 15 May 2000 in commemoration of the date María Reiche was born. Initially, it was very challenging to establish the planetarium in the tourist circuit because the tour operators were unfamiliar with planetariums, and changing established itineraries proved difficult. In response, we planned around the tours' times and schedules. We regularly updated the planetarium script to incorporate the latest research on the Nasca Lines, including developments from those who worked on the heritage site.

To attract a broader audience, we began to include astronomy observations of the sky every night alongside our archaeological

Figure 2: *The exterior of the María Reiche Planetarium, built of "adobones" and cane. This image also shows the telescopes used for observation after the performances, weather permitting.*

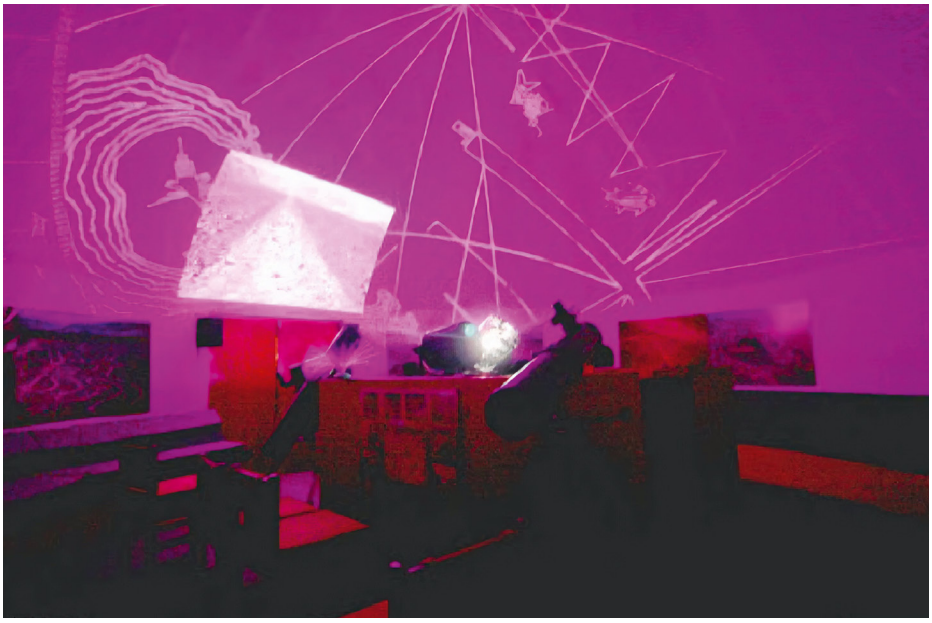

Figure 3: *A photograph showing the projections of the mapping of the Nasca Lines with the cylinder adapted to our portable planetarium system. Image Credit: David Pickering*

and astronomical topics in the planetarium. Using naked-eye and telescope observations, our visitors saw the craters of the Moon, the planets and other celestial objects at the end of the planetarium show, generating a space for conversation and exchanging ideas. Today, the planetarium shows are mixed with a full dome digital projector, allowing us to generate an immersive 360-degree flight over the Nasca Lines. We additionally maintain our "vintage" cylinders, as they are highly requested by our visitors, especially when we relate the contributions of María Reiche to cultural astronomy.

Cultural astronomy and local development

The popularity achieved by this small and exotic planetarium makes it the third most visited attraction within the tourist circuit in Nasca, with more than four performances every night of the year. To do this, we provide the shows in different languages, mainly English, French, Italian, German, and Spanish – the local language. In its lifetime, the planetarium has offered many internships among tourism and education students from the region. In addition, it opened doors to new projects related to astro tourism and cultural astronomy, not only in Peru – linking them with different cultures and destinations such as Ica, Lima, Arequipa and Cuzco – but also exporting the concept and model to Mexico at the heritage sites of Chichén Itzá and Uxmal, as well as on Rapa Nui (Easter Island). Our format includes highlighting the culture of local populations, whether past or present, embedded into basic sciences alongside the experience of night sky observations.

This model ensures that visiting the María Reiche planetarium is a varied and attractive experience for all ages. We are also very pleased to contribute to the development of regional education. Though the project is sustainable thanks to tourism-oriented functions, the planetariums have contributed to local education. Each planetarium has telescopes that students can use to introduce astronomy to their peers, and various activities are organised with local astronomy clubs. In addition to offering free functions to local students, we have translated our shows into native languages, including Quechua, Yucatec Mayan, and Rapa Nui. This allows attendees to contribute new ethno-astronomical data and strengthen the content of the planetarium shows.

Two decades ago, this initial venture allowed us to emerge with very few resources. We continue to provide an experience in which cultural astronomy and traditional planetarium shows converge, linking with tourist and educational circuits. We hope that this concept can be replicated in other cultural spaces.

Acknowledgements

I want to extend my gratitude to INVERTUR, who believed from the beginning in the project of a touristic planetarium, and to the current owners of the Hotel "Nasca Lines". In addition, I would like to thank the population of Nasca and, in particular, express gratitude for the legacy of María Reiche.

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Biography

Barthélemy J.C. d'Ans Alleman is the Founder of the Peruvian Institute of Astronomy and President of the Inter-American Society of Astronomy in Culture. d'Ans Alleman is also the manager of the Planetariums and Educational Observatories María Reiche located in Peru (Nasca, Ica, Arequipa, and Cusco); Mexico (Chichén Itzá and Uxmal); and Chile (Rapa Nui). He is also a member of the IAU Inter-Commission C1-C2-C3-C4 Working Group on Astronomy in Culture.

Case Study

Celebrating the Centennial of the Planetarium – Reflections and innovations in the planetarium community in Kuwait

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Keywords
Planetarium, Dark Skies, Light Pollution, Accessibility, Edutainment, Astronomy Education

In celebration of the planetarium's 100th anniversary, this article offers a case study of the Sheikh Abdullah Al Salem Cultural Center Planetarium. The planetarium emerges as a paramount symbol of the enduring significance of these celestial learning centres, uniquely positioned to champion astronomy education and the preservation of the pristine night sky. Through innovative initiatives and immersive experiences, this planetarium inspires the next generation of scientists and illuminates the path to a future shaped by scientific curiosity and cosmic exploration.

Introduction

As we celebrate the planetarium's centennial anniversary, it is important to recognise the vital role that planetariums play in promoting scientific literacy and public engagement. The planetariums of today are continuing to evolve in innovative ways to inspire and educate audiences of all ages and backgrounds. As the largest planetarium in Kuwait, Sheikh Abdullah Al Salem Cultural Centre Planetarium has been at the forefront of these efforts nationally, continuously pushing the boundaries of what is possible in planetarium design and programming.

Leading the planetarium at Sheikh Abdullah Al Salem Cultural Centre, we have witnessed firsthand the transformative power of a planetarium experience. In this article, we will share some valuable lessons we have learned and the innovative ways our planetarium continues to evolve in its mission to educate and inspire.

This article celebrates the 100th anniversary of the planetarium and reflects on the lessons learned by the planetarium leads at Sheikh Abdullah Al Salem Cultural Centre. It also explores the role of the planetarium in promoting astronomy education and preserving the night sky as dark sky oases. We introduce the planetarium at Sheikh Abdullah Al Salem Cultural Centre as a case study. This article discusses the challenges of establishing and growing a planetarium, including adapting to the pandemic, promoting diversity and inclusivity, and the need to provide meaningful experiences for people with impairments. We highlight the Centre's cultural contributions to Arabic, Islamic, and Kuwaiti astronomy, its collaborations with local organisations and its participation in international events.

Sheikh Abdullah Al Salem Cultural Centre

Sheikh Abdullah Al Salem Cultural Centre, a cultural hub in Kuwait, was established in 2018 to foster a love for art, science, culture, and entertainment among its visitors. We realise this mission by creating a series of world-class museums, a fine arts centre, and a theatre, aiming to position Kuwait as a prime cultural destination. Covering over 120,000 square metres, the Centre is home to an array of more than 3,000 exhibits spread across 22 galleries. With a tradition of welcoming an average of 250,000 visitors annually, the Centre recently achieved a significant milestone by extending its warm embrace to its millionth visitor, further cementing its status as a premier destination for cultural enrichment and knowledge dissemination.

The vision of Sheikh Abdullah Al Salem Cultural Centre is to embrace and showcase the diversity of the world's finest cultural achievements by maintaining a state-of-the-art museum complex. The complex comprises unique components, including the Natural History Museum, Science and Technology Museum, Arabic Islamic Museum, Space Museum, Fine Arts Centre, and Theatre. However, in this article, we will be delving into two of the most captivating attractions within the Centre: The Planetarium and the Space Museum.

The Space Museum is an exceptional destination for space enthusiasts and learners, featuring 131 exhibits across its three main galleries. Visitors can explore various space artefacts, such as replicas of space vehicles, spacecraft, space suits, and equipment. In addition, the museum provides interactive displays and exhibits that provide visitors with a hands-on experience of space exploration. The exhibits are organised to cater to all age groups and learning levels, making the Space Museum a valuable resource for both families and educational institutions seeking to expand their knowledge of space science and technology.

The Planetarium, situated at the heart of the Space Museum (see Figure 1) and celebrated as one of the most captivating attractions at the Sheikh Abdullah Al Salem Cultural Centre, welcomes an average of 3,000 visitors annually. With a 19-metre diameter, the planetarium offers visitors a fascinating immersive experience through the cosmos. The facility has a maximum capacity of 107 visitors, including four designated seats for visitors with special needs. The planetarium features an advanced projection system, which includes five projectors, creating a stunning display of realistic 3D images of the night sky. The theatre's dome-shaped ceiling is covered with a high-resolution screen tilted at a

Figure 1: *Left: The Planetarium is immersed within the Space Museum, creating a harmonious astronomical experience. Right: The Planetarium's main entrance door beckons visitors into a world of celestial wonder. Image Credit: Sheikh Abdullah Al Salem Cultural Centre*

20-degree angle, allowing for a breathtaking display of the Solar System, galaxy, and beyond. Visitors can sit back and enjoy a variety of educational and entertaining programmes, including astronomical lectures, shows about the prominent astronomical legacy of Arabia and its contribution to the identification of the stars, and many more.

The Planetarium and the Space Museum, while distinct in function and form, harmoniously coalesce into an indivisible unit, pulsating with the same celestial narrative. It is the epicentre where the captivating astronomical wonders, meticulously curated within the museum's halls, seamlessly meld with the immersive experience. This intentional amalgamation is born from a strategic vision crafted to foster a dynamic synergy. It is a deliberate orchestration, igniting a profound interplay of knowledge and wonder, where the tangible exhibits stand as testaments to the past and present. At the same time, the Planetarium propels visitors into awe-inspiring and educational journeys of the future.

Within this symbiotic relationship, the Space Museum is a foundational knowledge repository, offering visitors a comprehensive understanding of the celestial marvels that await exploration. It lays the intellectual groundwork, presenting historical, scientific, and cultural contexts that enrich one's appreciation of the cosmos. The museum sets the stage, sparking curiosity and illuminating pathways for deeper inquiry.

In contrast, the Planetarium is an immersive vehicle, translating acquired knowledge into an experiential odyssey. Having absorbed foundational knowledge from the museum, visitors step into the Planetarium to witness the vastness of space firsthand. The astronomical concepts gleaned from the museum come alive in the Planetarium's dome, captivating and educating in equal measure.

This dual entity, the Space Museum and the Planetarium, engages visitors in a holistic intellectual and sensory embrace. The museum instils the understanding, while the Planetarium elevates it to a visceral encounter, creating an educational tapestry that is both informative and immersive. Together, they embody an educational ecosystem that resonates with enthusiasts, students, and the curious alike, enriching their cosmic journey within the walls of the Cultural Centre.

The Space Museum and Planetarium at Sheikh Abdullah Al Salem Cultural Centre offer visitors a unique and engaging experience that combines education and entertainment. The facilities are not just for those with a passion for astronomy or space exploration but for anyone who wants to learn about the history and science of our universe.

The Centre also hosts several events and activities throughout the year, including lectures, workshops, school tours, and stargazing sessions (see Figure 2). These events provide visitors with an opportunity to interact with experts in the field of astronomy and learn more about the latest developments in space exploration.

Establishing a planetarium is no small feat and requires careful planning and attention to detail. One of the critical considerations is choosing the right equipment and technology to ensure a high-quality viewing experience for visitors. The planetarium systems at Sheikh Abdullah Al Salem Cultural Centre are among the most advanced and sophisticated in the world, employing cutting-edge technology to provide visitors with a truly immersive and engaging experience. The Centre's planetarium systems include two separate platforms, which offer high-quality visual and audio, as well as advanced dome projection and image blending capabilities. Together, these systems allow the planetarium to present a wide range of immersive and engaging shows, from stunning visual tours of the universe to interactive educational experiences that help visitors better understand the mysteries of space and the cosmos.

Promoting diversity and inclusivity

Planetariums can be critical in promoting diversity and inclusivity in science education and public outreach. The Sheikh Abdullah Al Salem Cultural Centre Planetarium is a good example of how planetariums can cater to the needs of visitors with disabilities, including those with blindness, low vision, physical disabilities, or those who are hard of hearing. We achieve this by providing specialised programmes and tours that incorporate tactile experiences, audio descriptions, and other accommodations. These efforts ensure that everyone has the same opportunities to learn and explore the Universe.

Moreover, planetariums can be a powerful resource for promoting diversity and inclusivity in science education by highlighting the achievements of scientists and researchers from diverse backgrounds,

Figure 2: *The Planetarium at Sheikh Abdullah Al Salem Cultural Centre captivates audiences with a breathtaking live show. Image Credit: Sheikh Abdullah Al Salem Cultural Centre*

including women and other underrepresented groups in science, technology, engineering, and maths (STEM) fields. By showcasing the contributions of these individuals, planetariums can inspire the next generation of diverse scientists and researchers while breaking down barriers and increasing awareness and appreciation of diversity in the field.

In addition to showcasing diversity in astronomy, planetariums can also promote understanding and appreciation of different cultures and perspectives. For example, the Sheikh Abdullah Al Salem Cultural Centre Planetarium highlights how different cultures have viewed and interpreted celestial phenomena throughout history, such as how ancient civilisations used the stars for navigation and timekeeping. By providing a platform for diverse perspectives and experiences, planetariums can foster greater understanding and appreciation of the richness and complexity of the human experience.

A cultural tribute to Arabic and Kuwaiti astronomy

The Planetarium at Sheikh Abdullah Al Salem Cultural Centre offers an informative and entertaining tribute to Arabic, Islamic, and Kuwaiti astronomy. Arabic astronomy has a rich history dating back to ancient times, and this planetarium experience offers a comprehensive exploration of this fascinating field of study.

The journey through the Planetarium's exhibits is a comprehensive exploration of Arabic astronomy's historical and scientific significance. Visitors can learn about the various scientific discoveries made by Arabic astronomers, including the use of mathematical principles to chart the movements of the planets and stars.

Furthermore, the Planetarium and Space Museum experience delves into the various instruments used by Arabic astronomers to make their observations. These include the astrolabe, a device used to measure the altitude and azimuth of celestial bodies, and the sextant, used to determine the altitude of the Sun and stars. Among these remarkable instruments, the exhibition also highlights the Celestial Globe crafted by the renowned Arabic astronomer Abdulrahman al Sufi, offering visitors a glimpse into the intricate celestial mappings and astronomical knowledge of the past.

One of the most compelling aspects of the Sheikh Abdullah Al Salem Cultural Centre Planetarium experience is its presentation of Arabic astronomical achievements in the context of broader cultural and scientific movements. Visitors learn about the significant contributions Arabic astronomy has made to the scientific community, as well as the impact it has had on the broader culture of the region.

In addition, the Planetarium and Space Museum at Sheikh Abdullah Al Salem Cultural Centre play a vital role in promoting the astronomy legacy of Kuwait by serving as a tribute to the rich astronomical history of Kuwait, showcasing the achievements of Kuwaiti astronomers and scientists through its exhibits and programmes. The Centre's exhibits, especially the Galaxies Traveller Exhibit, include a comprehensive history of astronomy in Kuwait, highlighting the contributions of Kuwaiti astronomer, Saleh Al-Ojairi, to the field. Through these exhibits, visitors gain an appreciation for the significant role that Kuwait has played in advancing astronomical research and knowledge.

Throughout the Space Museum and Planetarium experience, visitors are encouraged to engage with the exhibits and ask questions about the rich history and scientific discoveries of Arabic, Islamic, and Kuwaiti astronomers. The planetarium experience is designed to be an interactive and engaging exploration of astronomy that leaves visitors with a newfound appreciation for the field.

The Sheikh Abdullah Al Salem Cultural Centre Planetarium is important to Kuwait's cultural heritage, promoting the country's rich astronomical legacy to local and international audiences. The Centre's commitment to providing visitors with an immersive and interactive experience is a testament to Kuwait's ongoing dedication to promoting scientific education and exploration. As such, the planetarium serves as a tribute to the past achievements of Kuwaiti astronomers and scientists while inspiring the next generation of scientists to continue pushing the boundaries of astronomical research and knowledge.

Honouring contributions and empowering women

Sheikh Abdullah Al Salem Cultural Centre, represented by the Space Museum, extends its dedication to celebrating women's achievements by actively participating in the United Nations' International Day of Women and Girls in Science. On this significant occasion, the Centre devotes an entire programme to enlightening young girls about the

remarkable contributions of women scientists from the past and present. Through engaging workshops and insightful talks, young minds are immersed in the inspiring stories and accomplishments of these prominent figures, such as the First Female Astronaut, igniting their curiosity and enthusiasm for scientific pursuits. Furthermore, the Centre takes pride in its commitment to highlighting the enduring role of women in Islamic history with a series of workshops and discussions that shed light on the invaluable contributions of women throughout the ages. By nurturing young talents and fostering an appreciation for women's accomplishments, Sheikh Abdullah Al Salem Cultural Centre continues to champion the role of women in Kuwaiti society and beyond.

The power of planetariums in inspiring future generations

Research has shown that planetariums significantly impact science education and engagement. Various studies have found that planetariums are effective in increasing students' understanding of astronomical concepts and improving their attitudes towards astronomy and science (e.g., *Plummer, 2009; Türk et al., 2016; Slater & Tatge, 2017*).

Planetariums are thus a powerful tool for inspiring the next generation of scientists and researchers. By offering immersive and interactive learning experiences, planetariums can engage visitors of all ages and backgrounds and spark curiosity and interest in STEM fields. Through cutting-edge technology and innovative programming, Sheikh Abdullah Al Salem Cultural Centre Planetarium creates an educational and inspiring environment, encouraging visitors to explore the wonders of the universe and discover new possibilities for scientific discovery and exploration.

Furthermore, planetariums can also play a crucial role in promoting space exploration. With the increasing interest in space travel and the growing importance of space-based technologies, planetariums can help to educate the public about the potential of space exploration to address some of our world's most pressing challenges, such as climate change and resource depletion. By providing immersive and interactive learning experiences, planetariums can spark curiosity and interest in STEM fields, inspiring the next generation of space explorers and scientists.

Moreover, planetariums can also serve as a platform to raise awareness about the need for greater diversity and inclusivity in science education and careers, which can help to ensure that the benefits of space exploration and scientific advancements are available to everyone, regardless of their background or abilities.

For Example, the Astronomers Diwaniya, a monthly rendezvous at the Planetarium and Space Museum, is a testament to the potent influence of knowledge and shared passion. This monthly gathering brings budding astronomers and seasoned stargazers into the Planetarium and Space Museum. Participants of all ages and backgrounds gather to discuss celestial wonders, planetary phenomena, and space exploration's latest updates. Expert insights and spirited discussions enrich each gathering, stimulating a profound appreciation for the mysteries of the Universe. Through the Astronomers Diwaniya, the Planetarium and Space Museum not only cultivate a robust sense of community among space enthusiasts but also propel the intellectual exploration of the cosmos, imparting a lasting impact on the next generation of scientists.

Moreover, the Planetarium orchestrated a live show that transported audiences on a cosmic journey through our Solar System. The meticulously crafted presentation shed light on the intricate details of each planet, offering a deep dive into the wonders of our local neighbourhood. Additionally, the event served as a poignant tribute to the monumental achievement of the Apollo 11 mission, a triumphant landing on the Moon's surface that etched itself into humanity's history. This immersive experience illuminated the remarkable past and kindled an insatiable curiosity about the boundless prospects of future space exploration.

Therefore, the Sheikh Abdullah Al Salem Cultural Centre Planetarium offers a unique and immersive learning environment that inspires visitors to explore the universe and pursue careers in science and technology. It is crucial in promoting science education and engagement, space exploration, and diversity and inclusivity in science education.

Planetariums as a tool for addressing global challenges

Planetariums are critical in addressing global challenges such as climate change, biodiversity loss, and light pollution (e.g., *Wyatt, 2013; Yu et al., 2013; Kamal, 2022*). These challenges pose significant threats to the planet and its inhabitants, and planetariums can raise awareness and inspire action to mitigate their impact. Through immersive experiences and educational programmes, planetariums can help visitors better understand the complex systems that govern the natural world and the impacts of human activities on the planet. As institutions that promote science education and engagement, planetariums can raise awareness and inspire action on these pressing issues.

Awareness and advocacy of environmental issues

The Sheikh Abdullah Al Salem Cultural Centre encourages advocacy to promote awareness and inspire action on critical issues by collaborating with organisations and initiatives focused on environmental sustainability. The Planetarium serves as a platform for dialogue and discussion, bringing together stakeholders from diverse backgrounds to collaborate and find solutions to these challenges.

In its unwavering commitment to addressing pressing global challenges, the Sheikh Abdullah Al Salem Cultural Centre Planetarium takes a proactive stance by hosting enlightening lectures dedicated to shedding light on climate change and renewable energy. These lectures offer a platform for experts and scholars to delve into essential topics such as the Al-Sarayat season in Kuwait, the local thunderstorm season during Spring, and the underlying reasons behind climate fluctuations. With a primary objective of raising awareness and promoting informed discourse, the Centre collaborates with distinguished institutions such as the Directorate General of Civil Aviation in the State of Kuwait to ensure the highest calibre of expertise. Through these sessions, the Planetarium enables a deeper understanding of the intricacies of our changing climate and the pivotal role of renewable energy in securing a sustainable future. These lectures inform and inspire a collective commitment to addressing the environmental challenges of our time.

Adapting to the Covid- 19 pandemic

The Covid- 19 pandemic has profoundly impacted cultural institutions worldwide, and Sheikh Abdullah Al Salem Cultural Centre has not been immune to these challenges. With the closure of physical exhibition spaces and restrictions on public gatherings, the Centre had to adapt quickly to new modes of engagement with its visitors, including virtual tours and online resources allowing visitors to explore the exhibitions from the safety and comfort of their homes.

One of the key strategies that Sheikh Abdullah Al Salem Cultural Centre adopted during the pandemic was virtual calls to engage with visitors in real-time. These calls allowed visitors to connect with the Centre's educators and curators, who could guide them through the exhibitions and answer any questions. The team used various multimedia resources to support these virtual tours, including high-resolution images, videos, and 3D models that provided a comprehensive and immersive experience. The virtual tours also featured detailed information panels that provided context and historical background, making the exhibitions visually engaging and intellectually stimulating. Virtual calls also allowed the Centre to connect with visitors from around the country, making the exhibitions accessible to a broader audience than ever before.

Amid the challenges posed by the Covid-19 pandemic, Sheikh Abdullah Al Salem Cultural Centre embarked on a pioneering initiative by introducing a virtual summer camp run by the Space Museum, tailored to engage children in exploring the wonders of space and space exploration. The camp was structured to accommodate children of varying ages and backgrounds, ensuring a customised learning experience. Young participants delved into captivating topics, including the *International Space Station (ISS)* and the Solar System, under the guidance of the Centre's educators. While the transition to a virtual format came with unique challenges, notably requiring parents to prepare certain items for their children to participate in the interactive workshops, the summer camp maintained its success by closely measuring engagement levels and the knowledge acquired by the young participants. By actively involving children and evaluating their learning experiences, Sheikh Abdullah Al Salem Cultural Centre sustained the annual tradition of inspiring and educating young minds, even during the trying times of the pandemic.

The importance of planetariums as dark sky oases

Light pollution is a severe issue worldwide that hinders astronomical observations and negatively affects the natural environment and human health. In addition to serving as a venue for scientific education and outreach, planetariums also play an essential role in preserving the natural beauty of the night sky. Thus, the role of planetariums as dark sky oases is vital, as they provide an unobstructed view of the night sky, free from the interference of artificial light. This allows visitors to experience the beauty of the Universe while learning about astronomy in a controlled environment.

Moreover, planetariums can play a crucial role in raising awareness about global challenges and the fight against light pollution. They provide a perfect venue to educate the public about the negative impact of light pollution, raise awareness among visitors and promote sustainable lighting practices. Sheikh Abdullah Al Salem Cultural Centre, represented by the Space Museum and Planetarium, collaborates with local communities to encourage implementing policies and regulations that reduce light pollution. The Centre has formed strategic partnerships with several prominent local organisations (discussed below) to promote responsible lighting practices and increase public awareness regarding the detrimental effects of light pollution and other global challenges. We also host regular stargazing events and workshops to help people better appreciate the night sky and develop a deeper connection to the cosmos.

In a dedicated effort to combat the pervasive issue of light pollution and its detrimental effects on the night sky, Sheikh Abdullah Al Salem Cultural Centre has initiated an enlightening lecture entitled 'Light Pollution and its Dangers to the Night Sky.' This illuminating session, curated for children aged 6 to 14, is a platform for education and awareness. We called upon the expertise of the IAU National Outreach Coordinator for Bahrain, Myriam Alqassab, as the key speaker, ensuring the highest quality of information dissemination. Such lectures not only empower the younger generation with knowledge about the importance of preserving the natural beauty of the night sky but also illuminate the perils of light pollution, thereby instilling a sense of responsibility towards sustainable lighting practices from an early age.

Additionally, the Centre organises special trips outside the city's light-polluted areas, providing visitors with a firsthand experience of starry night sky unencumbered by light pollution. These experiences leave a lasting impact, deepening the connection between visitors and the celestial wonders above while emphasising the urgency of preserving the night sky for future generations.

Collaborations with local organisations and international participation

Sheikh Abdullah Al Salem Cultural Centre has formed a strong collaboration with local organisations to enhance its Planetarium's educational outreach and provide the public with an immersive and interactive learning experience, including the Youth Public Authority, which aims to provide the youth of Kuwait with opportunities for personal and professional growth through educational and cultural programmes. Kuwait University, a leading institution of higher learning in Kuwait, has been actively collaborating with the Centre, represented by the Space Museum and Planetarium, to provide scientific and technical expertise in astronomy and related fields.

The Kuwait Institute for Scientific Research, which focuses on scientific research and development, has partnered with the Centre to provide valuable scientific insights and data for the Planetarium's educational programmes. This collaboration extends to programmes such as "Renewable Energy in Kuwait" and "Introduction to Nanotechnology and Its Applications," offering visitors a comprehensive understanding of cutting-edge scientific advancements. The Kuwait Meteorological Department, the government agency responsible for monitoring and forecasting weather and climate conditions in Kuwait, has also played an active role in the Space Museum and Planetarium by providing relevant meteorological data and research.

Furthermore, the Ministries of Education and Information in Kuwait have supported

the Space Museum and Planetarium by promoting educational programmes and providing valuable resources to enhance the public's learning experience. The Space Museum initiative has forged a significant partnership with the Kuwait Foundation for the Advancement of Sciences (KFAS), a revered non-profit organisation propelling scientific research and development in Kuwait. This collaboration has birthed a transformative youth volunteering programme to transcend traditional roles. Beyond mere volunteerism, this initiative offers young enthusiasts a platform to actively engage with the museum's profound mission, infusing their journey with meaningful contributions. The program immerses them in the captivating realms of science and culture, imparts hands-on experience, and enriches their understanding. In alliance with KFAS, the initiative strives to cultivate a new generation of scientific enthusiasts and cultural champions, instilling a profound appreciation for the boundless world of knowledge and exploration.

In addition to its local collaborations, the Planetarium has also engaged with international organisations, such as the International Astronomical Union (IAU). Sheikh Abdullah Al Salem, Cultural Centre Planetarium, participated in the NameExoWorlds 2022 competition organised by the IAU — the event aimed to involve the public in naming new planets outside our solar system.

Furthermore, the Centre's active participation in prestigious international events underscores its commitment to fostering scientific literacy and astronomical appreciation. Notably, the Planetarium and Space Museum organised a captivating evening dedicated to Moon observation, aligning with the global celebration of the International Observe the Moon Night. During this event, visitors were taken on a journey, delving into the mysteries of our celestial neighbour, the Moon. They gained insights into lunar observation techniques, the Moon's rich history, and the remarkable saga of human space missions to lunar landscapes.

As part of its collaborations with these organisations, the Planetarium and Space Museum has been able to organise and participate in various educational events, workshops, and exhibitions, all aimed at increasing public awareness and understanding of astronomy and related fields. These events are tailored to cater to different age groups and backgrounds, ensuring that everyone can learn and explore the wonders of the Universe.

The relationships the Planetarium and Space Museum have built with local and international organisations demonstrate the Centre's commitment to promoting public engagement in astronomy and space exploration. The Planetarium's collaborations have also enabled it to develop educational programmes and resources tailored to Kuwait's unique cultural and environmental context. Through these collaborations, the Centre's planetarium has become a valuable resource for the local public, providing a platform for science communication and public engagement and promoting scientific literacy and critical thinking skills.

Conclusion

As we look to the future, many exciting opportunities and challenges face planetariums worldwide. From advancing technologies to changing social and cultural norms, there is no shortage of factors that will shape the future of planetariums and their role in society. However, whether through innovative programming, cutting-edge technology, or community partnerships, planetariums will remain an important source of inspiration and wonder for people of all ages and backgrounds.

As we celebrate the Centennial of the Planetarium, we reflect on the rich history and continued relevance of planetariums in contemporary society. The planetarium at Sheikh Abdullah Al Salem Cultural Centre in Kuwait is an exemplary model for planetariums, showcasing innovative technology, a cultural tribute to Arabic, Islamic, and Kuwaiti astronomy, and promoting diversity and inclusivity. However, planetariums face global challenges, such as combatting light pollution. They must continue to be dark sky oases — recent advancements in planetarium technology promise to further enhance the field's ability to engage and educate audiences. As we look towards the future, planetariums will play a vital role in shaping the next generation's understanding of the cosmos and our place within it.

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Biographies

Fatemah Salem has a computer science and information systems degree from the American University of Kuwait and has been the Planetarium Operator at Sheikh Abdullah Al Salem Cultural Centre since 2018.

Khaled Al-Jamaan is the Museums Manager at Sheikh Abdullah Al Salem Cultural Centre and the IAU National Outreach Coordinator for Kuwait.

Column

Unisphere after three years of operation

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Keywords
Astronomy Education, Case Study, Immersive, Planetarium, Public Outreach, Visualisation

This article summarises the experience from the first three years of operation of the Unisphere spherical projection at Silesian University in Opava, Czech Republic. In addition to our operational experience, we describe our creative activities and future plans for the Unisphere Studio.

Who are we, and where are we?

Silesian University is located in Opava, a historic city in Silesia, Czech Republic. The University includes the Institute of Physics, which is focused mainly on relativistic astrophysics and is one of the top scientific institutions in Europe. In addition, the Institute focuses on science communication using immersive media.

History of the Unisphere

The idea of building a planetarium at the University was under consideration for many years, but in 2015, it was decided to use a large empty space in the attic of the main building of the Institute for this purpose. The suspended projection dome has a diameter of 8 metres, can accommodate 50 spectators and is equipped with a projection system with stereoscopic projection capability. We additionally built a studio to create shows for spherical projection and secured funding through the use of the EU Structural Fund programmes. The inauguration ceremony took place in November 2019.

The planetarium's name was not only intended to declare that it would be a spherical projection with a wide range of uses but also allude to its connection to the university and academic environment. Therefore, the name Unisphere consists of the prefix UNI (e.g., university, universe, uniqueness) and then the first letters of the phrase: **S**cience **P**opularisation **H**ub for **E**ducation, **R**esearch and **E**ntertainment.

Operation of Unisphere

In 2021, the Institute of Physics was spun off from the original Faculty of Arts and Sciences as a cutting-edge research facility; the Unisphere was completed under the auspices of the Faculty but is now operated by the Institute of Physics.

Since the Unisphere is intended as an academic planetarium, its main purpose is to teach university students and produce spherical shows. The initial shows were all rectangular projections onto the dome but shifted to include spherical shows in 2020. As a secondary function, we also operate the planetarium for high school students and the general public. Also, the content focuses not only on astronomy and astrophysics but also on other natural sciences, in addition to history, art, photography and music, all in 2D or stereoscopic form.

After the inauguration and the launch of the first shows, which included four of our own shows, the Covid- 19 pandemic began in March 2020. It has been two challenging years, but our small team at Studio Unisphere has kept going, creating a new visual style and a website[1]. Tickets for public shows are sold through the university e-shop.

Some relevant parts of the undergraduate and graduate courses are also run in the Unisphere, such as Astronomy Proseminar, Fundamentals of Astronomy and Astrophysics, Practical Astronomy, Popularising Astronomy, Communicating Science, as well as courses on Planetarium Shows and Fulldome Shows.

Shows for high school students are run according to their demand; these groups can book tickets online via the form on the Unisphere website.

Figure 1: *The audience during the opening ceremony of the Unisphere in November 2019. Image Credit: Ondřej Smékal*

Figure 2: *General view of the projection dome and auditorium of Unisphere. Image Credit: Ondřej Smékal*

Overview of shows

The shows offered consist of several types of performances:

- Purchased classical or stereoscopic shows, such as *Dream to Fly*; six shows in total.
- Shows that are distributed for free, for example, through the Fulldome Database[2] (e.g., *Two Small Pieces of Glass* and *From Earth to the Universe* by ESO and others); about 15 shows in total.
- In addition to the classic fulldome shows, the Unisphere also hosts live lectures that take advantage of spherical projection. A total of about 10 lectures have taken place under the dome.

Figure 3: *An example of a poster promoting an event (in this case, a lecture) in the Unisphere. Image Credit: Adam Hofer*

We prepare posters for public events for the month's programming and individual lectures. The posters employ our own visual style. Since 2023, our activities for the general public are also supported by city grants.

Overview of other activities

Among the non-traditional events in the Unisphere, we must also mention the Astronomy Olympiad. This culminates here each year in a national three-day finale, partly held in Unisphere. The national finals are held in March for the top 20 students in years 3 and 4 of secondary school and in May for younger secondary school students. In the Unisphere, the finalists always solve practical astronomy and night sky orientation problems.

The operation of the Unisphere has been possible for three years thanks to the "Lifelong Learning" project, and within its framework, we have started official cooperation with some domestic and foreign universities.

We have also become experts in the field of non-formal education and have produced distance learning texts, including *How to create spherical projection for (non-)formal education*, a 270-page text that focuses on acquiring the skills needed to create different types of informal education shows in relation to the individual needs of the target audience. In addition, we created how-to texts for other topics, ranging from creating an exhibition to creating an AV show for (non-)formal education. Currently, these resources are only available in Czech[3].

Studio Unisphere and in-house production

The core team of the Unisphere consists of eight people with a complimentary variety of expertise. Unfortunately, none of the positions at the Unisphere are full-time. This makes producing shows significantly more difficult.

From the beginning, in addition to our core team, we have employed trained university students on a freelance basis to help with the day-to-day operations for high school students and the general public.

The first projects

The first independent projects included the creation of four shows about night sky orientation during the year.

The next projects[4] of the creative group were the production of 10 short fulldome shows on very advanced astrophysical topics, from black holes to space missions and exoplanets.

Although these are very demanding topics in terms of content, for financial reasons, the visual aspect of these shows was very simple. We made the most of the capabilities of our projection system's environment and the rectangular image composition onto a sphere.

In the following production stage, we decided to rework one of these shows into a better fulldome format with the original graphics. We chose a script about binary stars and created a new visual design. The show, *Journey to the Binary Stars with AIDA*[5], takes place aboard a fictional spacecraft during a journey to the Alpha Centauri system. The basic properties of the different types of binary stars are communicated through a conversation between the astronaut and the onboard artificial intelligence, AIDA.

Figure 4: *Members of the Studio Unisphere team at FFB 2022 in Brno. The festival included the premiere of the fulldome show Journey to the Binary Stars with AIDA. Image Credit: Unisphere*

Figure 6: *The new terrace for astronomical observations for students and the public. The dome of the automated telescope, WHOO!, is visible in the left part of the image. Image Credit: Tomáš Gráf*

Future plans

The Studio Unisphere team is currently developing a family show with the working title *Wannabe Spider*, about an opilione that wants to be a spider, which will be completed during 2023. Another developing idea is a show about geology with the working title *Journey to the Center of the Earth*. However, we are still early in the development stages of this project and are still working to prepare a script.

Figure 5: *Poster of the show Journey to the Binary Stars with AIDA. Image Credit: Patrik Bałon*

It is important to remember that one of the primary functions of the Unisphere is to be a digital planetarium to discuss astronomical and astrophysical topics. For this reason, the University constructed an observing terrace for students and purchased a new telescope. We intend to take advantage of the combined capabilities of both facilities, the WHOO! (**W**hite **H**ole **O**bservatory **O**pava) and the Unisphere, and offer the possibility to observe the sky after the show or possibly to broadcast images from the observatory's telescope directly onto the Unisphere dome.

In the future, we hope to present topics through multiple forms of media, including the fulldome show, a VR experience, and a video game.

Acknowledgements

The core team of Unisphere currently consists of Viky Kurečků (D6 programming, modelling and VR), Lucie Dospivová (operations logistics, administration, translations), Patrik Bałon (artist, animator, creative), Adam Hofer (projection technology, D6 programming), Ondřej Smékal (filmmaker), Jan Novotný (astrophysicist, scriptwriter), Jan Hladík (astrophysicist) and Tomáš Gráf (astronomer, group leader, production manager, scriptwriter).

Thanks to all the members of the Studio Unisphere team, all the supporters of Unisphere activities and last but not least, the management of the Institute of Physics. The activities of Unisphere would not be possible without financial support from EU funds and a grant from the City of Opava.

The studio used to create shows for spherical projection was built using funds from the EU Structural Fund programmes (CZ.02.2.67/0.0./0.0/16_016/0002503).

Notes

[1] Learn more about the Unisphere at their website: https://unisfera.slu.cz/index_eng.php

[2] The Fulldome Database can be accessed at this link: https://www.fddb.org/

[3] For access to the resources created by Unisphere, follow this link: https://www.slu.cz/fpf/cz/layout/3442.

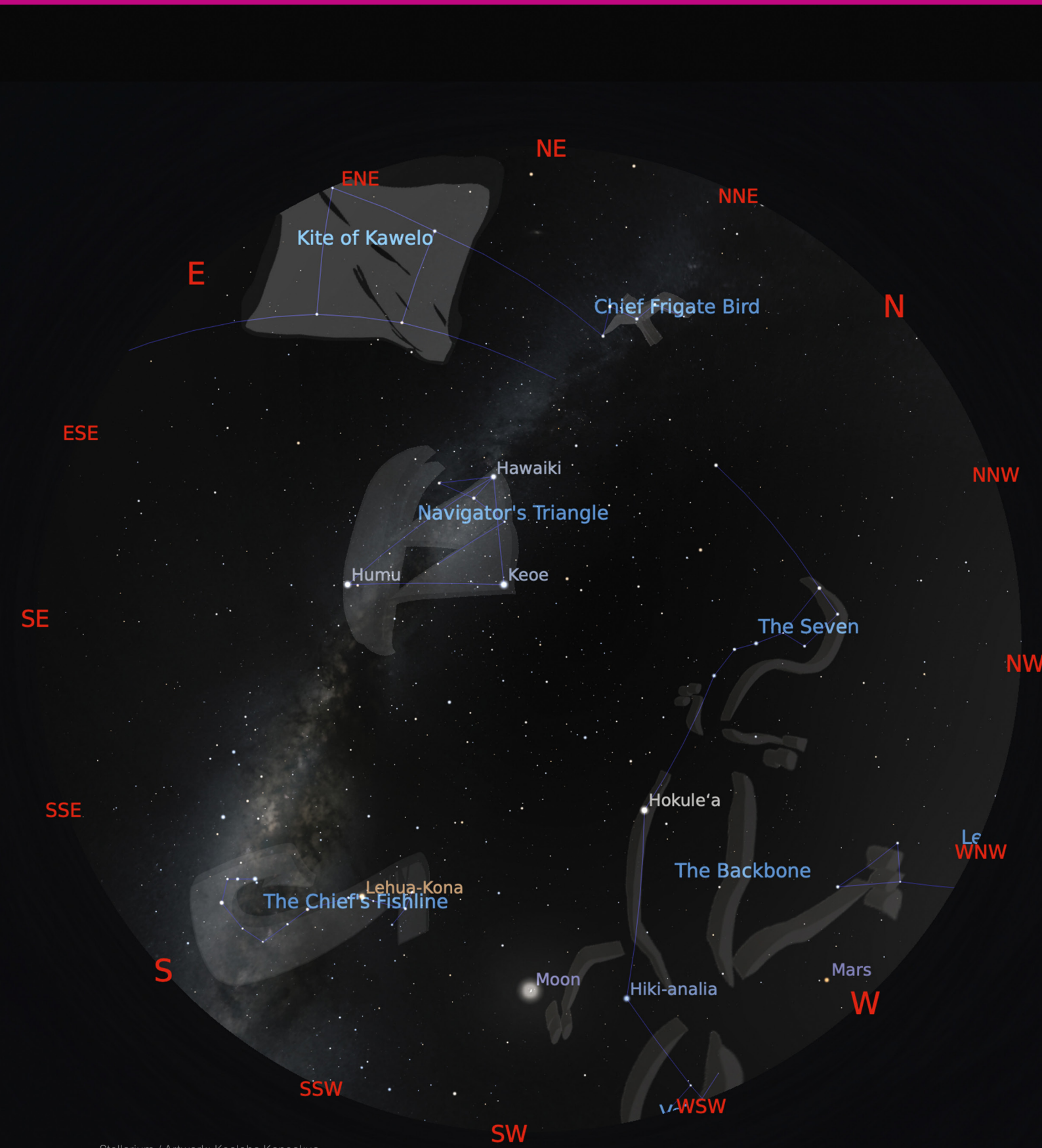
[4] The shows are available in Czech, but the script texts are also available in English upon request. For more information, contact the lead author at tomas.graf@physics.slu.cz.

[5] *Journey to the Binary Stars with AIDA* is available in Czech and English upon request. For more information, contact the lead author at tomas.graf@physics.slu.cz.

Biographies

Tomáš Gráf is a Czech astrophysicist, astronomy populariser and university teacher. Since 2015, he has been working at Silesian University in Opava, and since 2017, he has been the Vice Dean for Strategy and Development at the University's Faculty of Philosophy and Sciences. In addition, Gráf is the head of the WHOO! observatory and the Unisphere.

Did you know that Stellarium, the free planetarium software, allows you to experience the sky with the star lore of more than 30 cultures? These include educational information, traditional names, and artwork from the Aztec, Maori, Dakota/Lakota/Nakota, Sami, and Tupi-Guarani cultures, and many more. Pictured here are the starlines developed by Nainoa Thompson to navigate Polynesian canoes across the world's oceans using traditional navigational practices. The accompanying information is based on the teachings of Mau Piailug, the work of Nainoa Thompson and Kālepa Baybayan, and was compiled by Darren Kamalu and Christopher Blake, Students Jonah Apo, Nicholas Koanui, Brenden Aila and the Celestial Navigation class at Kamehameha Schools Kapalama in Honolulu, Hawai'i.



Stellarium / Artwork: Kealoha Kaneakua

Case Study

The Infini.to planetarium: One tool, many ways to make the most of it!

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Keywords
Accessibility, Best Practices, Immersive, Live Performance, Public Engagement, Visualisation

Infini.to is a science center devoted to astronomy and space that contains a digital planetarium. Since its opening in September 2007, the planetarium has been one of the most essential tools for audience engagement and science communication at Infini.to. After more than fifteen years of trial and error, we have learned many lessons and identified several best practices, which we relay in this article.

Introduction: Infini.to, a brief presentation

Infini.to is the first pioneering Italian science centre devoted to Astronomy and Space, thanks to the visionary idea of its first President and Founder, Professor Attilio Ferrari. It was inaugurated in September 2007 on top of the panoramic hills surrounding the city of Turin, next to the Astrophysical Observatory (Figure 1), with the mission of communicating the most advanced results of scientific research on astronomical topics. The participating institutions of Infini.to are the National Institute of Astrophysics, the University of Turin, the National Institute of Nuclear Physics, the Piedmont Region, the Metropolitan City of Turin, and the Township of Pino Torinese.

Infini.to combines one of the most technologically advanced planetariums with a 1,000-square-metre exhibition area and more than 40 interactive exhibits. Infini.to has hosted more than 600,000 visitors and students, not only from the neighbouring cities of the Piedmont Region but also from Italy and abroad. Infini.to offers guided tours, laboratory activities, shows in the planetarium, conferences, seminars, workshops for educators and teachers, and stargazing events aimed at its many visitors.

In 2020, with the start of the Covid- 19 crisis, Infini.to launched Infini.to@home, a digital project to enrich educational programmes. With this, Infini.to opened up new opportunities to reach out to and engage with audiences, increasing the visibility of its multimedia digital assets for edutainment. The new offering considers current transformations in formal education, in which new learning models are overcoming the boundaries of traditional schooling.

In this panorama, Infini.to will be an instrumental part of the learning ecosystem – a bridge between formal, non-formal and informal learning. Recognising digital technologies as part of the museum's educational mission will strengthen its public value by providing inspiring and engaging lifelong learning opportunities for all, as well as empowering culture in society with a particular focus on youth.

Infini.to has gathered a strategic network of partners and collaborators to help it achieve its goals. These include scientific institutions,

Figure 1: *Infini.to entrance.*

space agencies, aerospace corporations, educational institutions, philanthropic organisations, publishing partners, and other science centres and planetariums.

The importance of a dedicated production team for content creation

Planetariums can be a powerful visualisation tool. However, their effectiveness relies heavily on the contents displayed and how they are presented. Today, hundreds of great shows are on the market, covering a variety of topics. Even so, we felt the need to tell our stories and to tell them in our way.

To achieve this, we built a dedicated content creation team of physicists and astrophysicists with computer graphics and storytelling expertise. The team began creating planetarium shows in 2008, less than a year after the opening. However, in a small-to-medium-sized planetarium such as the one at Infini.to, it is not always possible to have resources dedicated solely to content creators. This means the content creation team also serves as part of the explainer team, conducting guided tours inside the museum and as planetarians under the dome. This constraint turned out to be a strength. Creating your own show and immediately testing it with the audience as a planetarian is a valuable tool and can speed up the refinement process. Live audience feedback during and after shows helped us make critical improvements, leading to fast and efficient development along the entire content creation pipeline.

Moreover, producing custom content enabled us to develop a personal style: a trademark that differentiates our planetarium from others.

The process has been gradual. Initially, we started exploring the planetarium's capabilities regarding objects, databases and pre-built scripts. In this way, we encourage our visitors to engage in the same learning by engaging in processes we employ in our content creation.

There is an excellent community of planetariums, and many resources are available online, including cloud-based databases that facilitate learning from the community. After some time, we started to create our own 3D models, 2D graphics and animations. In this way, we have found that learning from the experiences of others, modifying existing materials, and challenging yourself with complex tasks is an efficient way to learn.

As pre-rendered shows require a significant amount of rendering time, the Infini.to planetarium typically uses the real-time engine already used by the system. There are some limitations typical of many real-time engines, but the gain in speed and flexibility is massive – both of which are particularly important for a small team. These limitations must be well understood to produce the best possible products and get both good performance and visual effects.

The market also offers many different solutions for software, both for 3D modelling, 2D graphics rendering, and video editing. Many great open-source software are available and cover all the necessary aspects of content creation. This is an excellent option for a small team with a low budget. As with any new software, the learning curve can be steep. However, investing time in learning and developing new skills is an opportunity for growth and progress in the future.

A planetarium's audience can be diverse, from schools of any order to families, amateur astronomers and casual visitors. By creating custom shows dedicated to specific topics or peculiar events and specific audience targets, we can meet many of the audience's needs and peculiarities. Throughout our more than 15 years of operation, many shows have been produced at Infini.to, some of them are for a particular audience or topic, and others are more flexible and can be used for general audiences. Moreover, a considerable fraction of the guests may be frequent visitors who visit the planetarium several times yearly, hoping to have a unique experience each time. Our planetarium stories are constantly evolving as discoveries and challenges step onto the horizon.

Real-time interaction and the active audience

All the shows produced internally are live shows. By interacting with the audience, we can create a unique experience at each show, accommodating the scenes according to the visitors' needs. In this way, we can answer questions, foster ongoing dialogue, and create an engaging environment for the visitors, who often continue the conversation after the show has ended.

Additionally, this interactive and friendly show creates a more relaxed environment where everyone can feel free to express themselves, transforming the traditional passive experience into an active one.

Open and real-time shows built on demand

In addition to our pre-scripted shows, we have had success in giving the audience drive the show according to their preferences and curiosity. To this end, we have special events for which we rely entirely on the visitors' requests, building the show in real-time.

These kinds of improvised shows need a lot of preparation, both from a technical and astronomical point of view. In order to be able to fly to any location requested by the audience, we have created many custom button boxes. These allow the planetarium operators to quickly load models, images, sounds, visual effects and more while maintaining a smooth narrative. Content creators must pay special attention to building scripts open enough for use in many different situations but can still achieve the desired result. Our custom-built archive of scripts, organised in buttons and pages, is constantly growing. When we began producing real-time shows, we needed two planetarium operators to run the show: one flying and the other talking, collecting requests and answering questions. Now, with more experienced staff and a more streamlined and refined system, our planetarians can run these shows individually.

Although there are some downsides to this show style, such as not being able to use a proper soundtrack synchronised to what is shown, building the show together with the audience is a unique experience, both for the planetarium operators and for the guests. Visitors feel more engaged and perceive the planetarium as welcoming, attentive, and capable of creating a unique show every time.

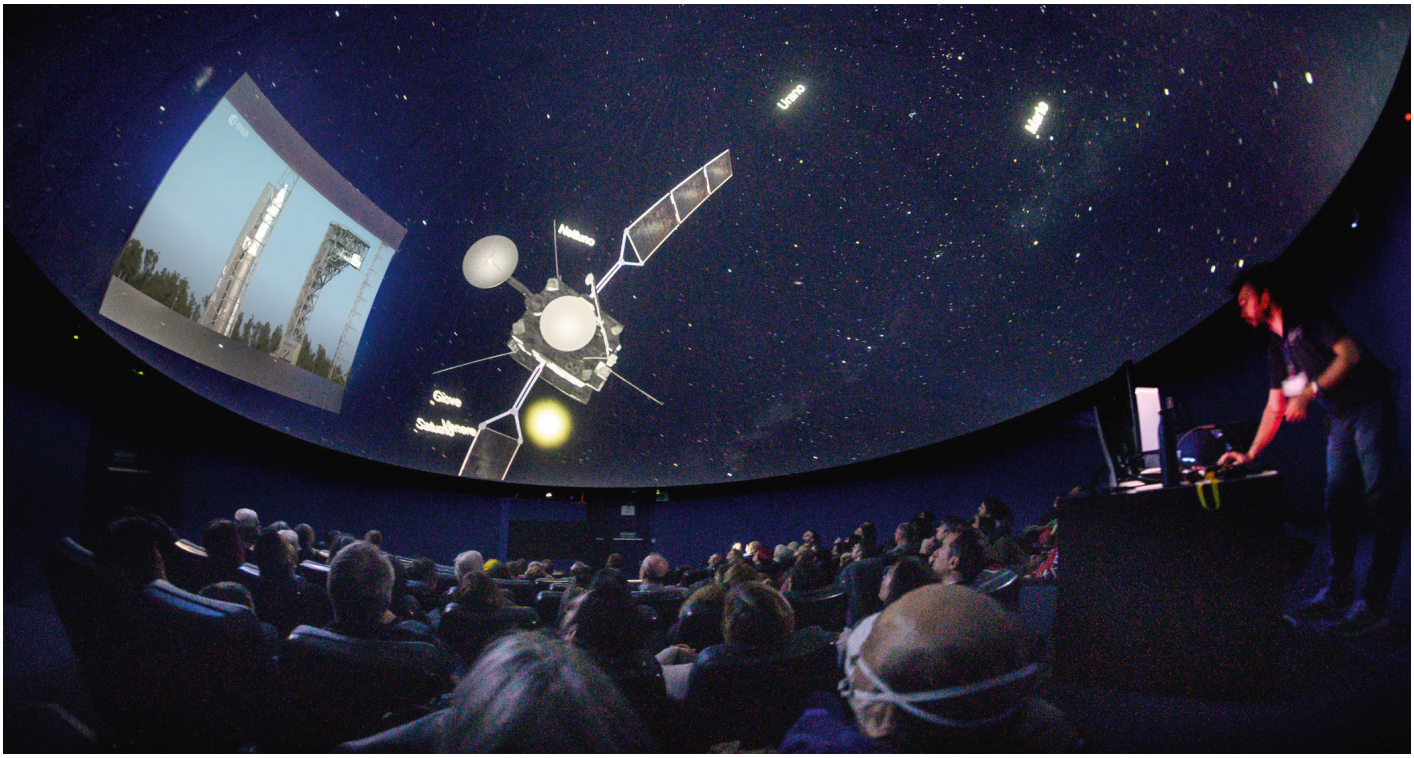

Figure 2: *A dedicated show on the ESA Solar Orbiter launch. Image Credit: Infini.to*

Create dedicated shows for current astronomy events

Astronomy is a living science. We have discoveries, publications and news almost every week – many of which make it to the public's attention. Keeping pace with these publications can be an incredible advantage, and planetariums are an excellent tool to bring these discoveries to life.

To achieve this result, we have many custom-made events during the year. Some are preprogrammed, such as commemorating a spacecraft launch (e.g., Figure 2); others are scheduled to run if a discovery arises. The expertise earned from the live events enables us to quickly create small shows for each event. Sometimes, a new spacecraft or object is featured in the news, and a 3D model does not already exist in the planetarium library. In that case, we construct a custom 3D model with dedicated textures that can be imported inside the real-time engine. To display trajectories correctly, real data is downloaded from dedicated web archives, such as JPL or ESA datacentres, and, if necessary, converted and rewritten in a readable format to be displayed and used under the dome.

Teacher training using the dome

The planetarium is a powerful educational tool, representing the sky and offering a model that is difficult to reproduce in a school environment. It is not an accessory but rather complementary to traditional teaching tools. Through its representation of the sky, the planetarium is an effective resource that allows students to change their perspective and have sensory experiences that may be difficult to replicate in real life or within a school setting.

For this reason, Infini.to has implemented several teacher trainings using the dome. Almost yearly since 2014, Infini.to has hosted a workshop on astronomy and science, reaching about 450 teachers globally. Though astronomy is not mandatory in Italy, it is part of the national science curriculum, and due to students' typical fascination with astronomy, it is a great way to introduce many other scientific disciplines, such as chemistry, physics, math, and coding. For this reason, the dome has been used not only to train teachers on specific topics and update them about astronomical discoveries but also to spread the beauty of space and share hints on how to use it in their classrooms.

Researchers under the dome

Infini.to is proud to be part of a network of scientific institutions with important technological partners. As part of this network, we invite researchers and engineers under the dome to showcase the latest discoveries and milestones in the space industry. These "Astrotalks" take place at least once a month. The idea is to use the planetarium to support the talk, giving a powerful visualisation tool to the speaker and an immersive experience to the audience. Working with the planetarium operators, the speaker has freedom of movement inside the digital universe projected on the dome. Custom 3D models, images and videos are prepared in advance and can be pulled anytime during the talk. This flexibility is fundamental to engaging the audience as they interact with engineers and researchers, asking questions and requesting more information. These events are for the general audience and usually occur on Saturday afternoons. We developed a similar format for schools, called "Ask it to the astronomer", in which all interactive elements of the original are maintained. Still, the complexity of the talk is adjusted to fit the audience's age.

Visualising scientific data sets for a general audience and researchers

The amount of scientific data coming from the research world is constantly increasing. So, too, is the frontier of space probes, and their journies are monitored continuously. Much of this data, regarding both science and the technology of the instruments used, are open source. Although the data can be challenging to visualise, the planetarium is a powerful tool for visualising this data in a virtual 3D space.

One of Infini.to's significant efforts in research and development activities has been to bridge the gap between data and the full-dome projection system of the planetarium. To achieve this, we have developed and experimented with software for data processing that can collect, filter, reprocess, and convert data from external databases into a format understood by the software that manages the planetarium projection. These software are continuously updated and improved, enabling us to visualise raw and filtered data from current and past space missions and immerse them in the 3D space of the digital planetarium. Our ongoing research and development allow Infini.to to propose cutting-edge themes, working closely with researchers in the field to create planetarium shows that benefit general audiences. In addition, through our many programmes at the planetarium, we provide unique opportunities for data visualisation and analysis for professional astronomers.

Artistic collaborations with music, visual arts and theatrical performances

Planetariums are places dedicated to astronomy, space and science in general. However, the planetarium can also showcase works and collaborations with non-STEM fields. In Infini.to's fifteen years, we have hosted many different art forms under the dome. For example, in 2015, we created a summer live music festival under the dome called "Songs for Stars" (Figure 3). During this event, now scheduled every year, the beauty of music and the wonders of the Universe play together to create a visual and acoustic immersive experience. Typically, we ask the performer to improvise their music while we, as planetarians, improvise the flight. We do not give astronomical explanations during the show: visitors are free to enjoy the beauty and fascination of the sky, driven by the live soundtrack. The interaction between musician and planetarian is unique: sometimes we follow the music, and at other times, the musician gets inspiration from the sky, steering their compositions accordingly.

Figure 3: *"Songs for stars": live music under the dome with real-time travel through the Universe.*

In addition, planetariums can be a suitable venue for theatrical performances. The dome can become the show's scenery, and a new set of interactions between actors and the dome can be explored. Since 2010, we have tested this format at Infini.to, adapting existing shows to be performed under the dome and even creating and producing our own show, "Cosmic Snapshot". Special attention must be dedicated to the lighting setup: the dome works better in darkness, but the actors need light. To accommodate these opposing requirements, we adopted a custom lighting system which can be controlled in real-time from the planetarium control panel.

Finally, as a visual system, the planetarium naturally lends itself to the digital arts. In 2016, we hosted "Words and Stars", a collaboration between the artist Grazia Toderi and the Nobel Prize for Literature recipient Orhan Pamuk. The dome became a drawing board for images and poetry inspired by the starry sky over Istanbul.

We have found that such events are ideal for meeting different audiences, fostering their creativity and imagination.

Planetarium design for all

As astronomers heavily rely on light to gather information, planetarium shows mainly consist of visual displays. Unfortunately, this can make standard shows less accessible for individuals with blindness or low vision. At Infini.to, we recognise this challenge and have been actively working to design and develop shows that everyone can enjoy, regardless of their abilities.

"Un cielo per tutti" (A sky for all) is an Infini.to project aimed at improving museum accessibility and promoting inclusion and equal participation in astronomy for people with disabilities, including those with blindness or low vision, Deaf or hard of hearing people, and those with cognitive disabilities. The project was co-funded by the Fondo di Sviluppo e Coesione PAR FSC 2007- 2013 and supported by Fondazione Compagnia di San Paolo. It was launched in 2016 to find innovative strategies and solutions to make astronomy

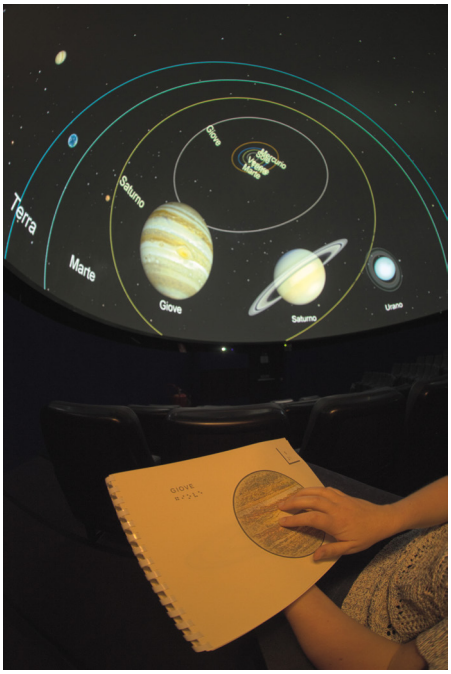

Figure 4: *The tactile book developed by Infini.to for people with blindness and low vision to use as a storyboard during planetarium shows.*

more accessible to people with disabilities and to address the challenges they face in enjoying museum exhibits and the planetarium. The project was the result of collaborative work that involved several institutions in different phases, including the Fondazione Nazionale delle Istituzioni Pro Ciechi, Servizi per Disabili Sensoriali della Città di Torino, and Unione Ciechi di Torino. Through collaboration with the scientific communicators at Infini.to, we developed a suite of flexible and modular activities and tools (consisting of physical materials) that enable customised visits and workshops for different audiences and disabilities. We preferentially focused on tools rather than standard-issued objects to help autonomous equipment production and to modify or update production on demand.

The outcomes of "Un cielo per tutti" are numerous. For example, shows for the planetarium were explicitly created for blind and low-vision visitors, featuring tactile tables that act as storyboards and allow the public to follow live talks about the sky in the planetarium (Figure 4). Some of the planetarium shows were also subtitled for Deaf and hard-of-hearing visitors. We conducted several educational activities using tactile materials and 3D models for different disabilities. Additionally, we developed SpazioApp, an application to support visits to the museum that integrates geolocation and virtual reality and allows the user to zoom in and vocalise text. This app provides a digital guide that enables visitors, including those with disabilities, to easily move around the exhibition space and enjoy the museum content. Although the project has concluded its pilot phase, it continues to evolve and improve every day. Groups and individual participants can contribute their experiences, evaluations, and feedback to promote continuous improvement for future visitors.

Building on the experience gained through "Un cielo per tutti" (A sky for all), in 2022, Infini.to was awarded a grant from the Italian Ministry of Culture to further improve accessibility. The approved project named "OPEN SKY", currently being implemented, includes interventions to enhance access to the museum structure and significant actions to make the planetarium experience more inclusive. Thanks to commercially available software, planetarium shows will feature audio descriptions for those with blindness and low vision and shows in multiple languages to cater to non-Italian speakers.

Conclusions

In many years of astronomy and science dissemination using the dome, we have learned some good practices worth sharing that we will summarise here.

- It's essential to communicate and to know how to communicate. That's why it's helpful to create custom content, tune them for each specific audience, and use them as a tool to engage. The dome can be a place for dialogue, not only monologues.
- While doing so, it is also important to create a community as large and diverse as possible. A planetarium can be a place for students, teachers, researchers, artists, and more. We can foster mutual influence by inviting this wide variety of experience and expertise under the dome. This flexibility and creativity have been vital to expanding our reach.
- Different audiences also include other ways of perceiving the Universe. By providing opportunities to explore the Universe with more senses than just sight, we build an inclusive and rewarding environment for our visitors. We are now developing shows for everyone, including tactile and sound experiences, to offer a show for everyone.

Planetariums will increasingly focus on fostering active engagement with their audiences. Recent years have shown that, for our visitors, live shows conducted by engaging and interactive experts are the most popular, and this mode of presentation should be developed and expanded as much as possible. In this context, we are exploring new ways to involve audiences, such as participatory planetarium experiences that leverage technology to create immersive and interactive environments.

Biographies

Marco Brusa is a Physicist of Advanced Technologies and has been working at Infini.to since 2007. He is the coordinator of the Multimedia Office, which deals with planning educational activities, workshops and training courses for the general public and teacher training. In addition, Marco creates shows for the planetarium and develops virtual environments to disseminate astronomy and science.

Eleonora Monge is an astrophysicist and science communicator. Since 2014, She has been the Director of Infini.to, responsible for managing activities and coordinating the staff. She coordinates and directs institutional activities and contributes to developing and implementing programmatic and strategic plans in agreement with the President and the Board of Directors.

Emanuele Balboni is an astrophysicist and has worked as a science communicator at Infini.to since 2008. As Planetarium Coordinator, he creates shows for the digital planetarium. He has combined his passions for astrophysics and photography in the blog *Cosmos and Surroundings*, where he publishes his suggestive shots and deals with scientific dissemination.

Simona Romaniello is an astrophysicist and science communicator and has been the Education Manager of Infini.to since 2014, where she is responsible for managing and projecting educational activities.

The first planetarium in an astronomy department in Turkey

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Keywords
Public Outreach, Astronomy Education, Training, Science Communication

Among many planetariums in Turkey, Istanbul University hosts the first planetarium in an astronomy department run by professional astronomers and graduate and undergraduate astronomy students. In this work, we present the design and some technical aspects of the planetarium, as well as our experiences since its opening in 2018.

A brief history of Turkey's planetariums

The first planetarium in Turkey was established in the Naval Academy in İstanbul in the 1980s and was used for training naval students to navigate in the open ocean using the stars.

In contrast, undergraduate astronomy students from Istanbul University have been brought to the Naval Academy Planetarium in Tuzla to obtain experience with artificial sky projection.

Since then, several planetariums have been established in Turkey. Today, fixed, installed planetariums are mostly found in science centres, schools, and museums throughout the country. Interestingly, most of the largest planetariums in Turkey are not in İstanbul but rather in cities such as Eskişehir, Gaziantep, İzmir, Konya, Kayseri, and Denizli with 14-metre dome diameters and approximately 100 seats each.

Figure 1: *The Department of Astronomy and Space Sciences complex at Istanbul University. The historical and modern domes for telescopes and the planetarium (marked with a red arrow) are noticeable. Image Credit: Istanbul University*

Mobile planetariums are also popular as they are very flexible. Public outreach events such as science festivals, telescope viewing events, open nights, and star parties are suitable for portable planetariums. Even though their image quality is not as sharp as fixed planetariums, it is possible to bring a celestial cinema to many schools in rural areas and places without significant infrastructure.

Common issues with planetarium operations in Turkey

Since 2000, the number of planetariums in Turkey has increased over 30. Istanbul has the most planetariums (9) in the country (*Kartal, 2019*). In the left and right-hand panels of Figure 2, respectively, we show the distributions for planetariums established by year and the number of planetariums in various cities in Turkey.

According to the Turkish Astronomical Society (TAD), the main issue with planetarium operations is human resources. People working in planetariums who are in direct contact with the public do not necessarily have an astronomy and space sciences background. However, we believe that in order to have effective outreach, improve the Turkish general public's general knowledge of astronomy, and combat misinformation, training in astronomy is essential for the planetarians.

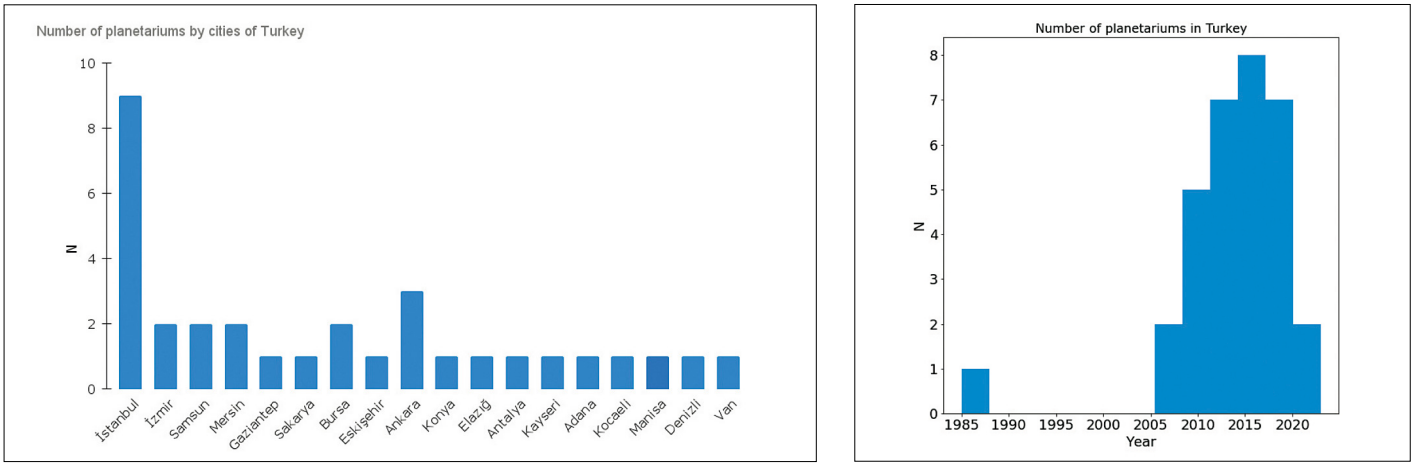

Figure 2: *Left: The number of planetariums in Turkish cities. Right: The distribution of Turkish planetariums as a function of when they were established. The oldest planetarium is the Tuzla Naval Academy Planetarium.*

For this reason, professional astronomers, especially the heads of astronomy departments and the Turkish Astronomical Society, have been trying to convince the administrations of science centres and museums to employ astronomy graduates.

In the past, establishing a planetarium in Turkey was a significant endeavour. However, today, infrastructure such as domes, seats, projectors, computers and sound systems are affordable for many institutions in Turkey. However, there remains a major issue: producing quality planetarium shows. Thanks to the European Southern Observatory, we can access pre-made and license-free shows[1]. However, relying purely on these free sources is not sustainable for most planetariums. Usually, annual fees for planetarium shows are beyond the annual budgets of museums and science centres. Annual budgets are largely driven by entrance fees, which institutions attempt to keep relatively low to introduce astronomy to as much of the general public as possible. Some planetariums operate on an appointment basis and do not request any payment.

The managing team of the Istanbul University Astronomy and Space Sciences Planetarium translated shows provided by ESO and narrated them. Turkish translations and narrated versions of *From Earth to the Universe*, *The Hot and Energetic Universe*, and *Journey to the Center of the Milky Way* were made available to the planetarium community[2].

Planetarium in an astronomy institution

For a long time, astronomers at Istanbul University struggled to find funding for a planetarium. In that period, a historical Ottoman bath was considered a suitable location for a planetarium, but ultimately not realised. In 2013, Istanbul University decided to rebuild many of the old and unsafe buildings of the astronomy department. The department's administration seized this opportunity to convince the university administration and architects to include a place for a planetarium (see Figure 1).

The new building has a 7-metre dome for a planetarium and was constructed to host 39 audience members (Figure 3). It took over four years to accrue the necessary funds to furnish the planetarium with the main projection and operation systems. The Elginkan Foundation agreed to donate some of the missing systems for the planetarium, but we were forced to

Figure 3: *View of the planetarium from the operation desk. Image Credit: Istanbul University*

Figure 4: *A close-up view of projectors and planetarium seats. Image Credit: Istanbul University*

accommodate a more affordable and sustainable solution.

The planetarium architect devised a plan to use multi-projectors based on image mapping techniques. The projectors used for this purpose are much more affordable than common brands' special planetarium projectors. To reach a 4K resolution with the merged image on the fulldome, we needed to incorporate 10 projectors. We employ a powerful computer to combine the images transferred via HDMI cables and efficient video mapping software to create the 4K dome image. This was the first planetarium in Turkey with 4K resolution and located within an astronomy institution (*Saygac & Alis, 2018*). Figure 4 shows three of the projectors and their placement in the dome.

Istanbul University Planetarium[3] started its operations in February 2018. By 2020, the planetarium has completed nearly 1500 shows with a total attendance of more than

Figure 5: *A scene from the show From Earth to the Universe during a screening. Image Credit: Istanbul University*

23000 people. These shows were organised by a team of undergraduate and graduate students with close supervision by a faculty member of the astronomy department. For each visit, we introduce the department's history as it is the first astronomy department in Turkey, established in 1933. The audience then visits the historical telescope, as well as the small museum of astronomical equipment that had been used in the department throughout its lifetime. Finally, a typical visit (Figure 5) ends with the planetarium show.

Due to Covid- 19, visits were suspended in March 2020. We are still in the recovery period after the pandemic, with an increasing number of visits.

Planetariums have a wide range of uses and are not limited to public outreach events. At Istanbul University, the planetarium is used in many courses of the curriculum of the astronomy programme, including lectures on spherical astronomy and celestial mechanics. The planetarium has additionally been used for teacher training events at the astronomy department. Under a special protocol, Istanbul University cooperates with the Directorate of National Education, which is the local authority of the Ministry of Education in the city of Istanbul. Teachers selected mainly from the branches of physics, science, and geography are trained for a 12-week program by the faculty members of the department.

Conclusions

Planetariums are crucial for the communication of science, impacting the public's perception of space and instilling a deep understanding of topics in astronomy and other STEM topics that are difficult to visualise. However, the cost of establishing the planetarium and maintaining its operations makes it a challenging investment. From our experience, the major expenses of the planetarium after its establishment are planetarium shows. Particularly, high-quality shows with a well-defined plot and high image quality can be prohibitively expensive.

Planetarians should follow special training for public outreach besides a comprehensive astronomy curriculum. In this regard, a planetarium in the astronomy department of Istanbul University is unique in Turkey, where the planetarians are professional astronomers and astronomy students.

Installing planetariums with multiple projectors is more affordable than many well-known brands' most common projector systems. However, attention should be paid to the selection of projectors. We should emphasise that not all projectors are suitable for use in planetariums. The most important factor here is the black levels of projectors.

The Istanbul University Planetarium is unique in its design and application of the projection system, in addition to its operational distinction. The experience gained with this planetarium led to the establishment of a larger planetarium in the Karsiyaka district of Izmir, with a dome radius of 14 metres and a capacity of nearly 100 people.

Acknowledgements

The authors are grateful to the public outreach team at the Department of Astronomy and Space Sciences of Istanbul University and acknowledge the strong support of the Department Head, Professor Dr Tansel Ak, and the university administration. The Planetarium in the Astronomy Department at Istanbul University was established with the generous donation of the Elginkan Foundation.

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Notes

[1] European Southern Observatory pre-made and license-free shows are available at: https://supernova.eso.org/for-planetariums/

[2] Turkish translations of the titles listed above can be found at: https://www.eso.org/public/videos/archive/category/fulldome/. For more planetarium shows in Turkish, see this website: https://astronomi.istanbul.edu.tr/bilimtoplum/gosteri.html

[3] For more information on the Istanbul University Planetarium, visit this website: https://astronomi.istanbul.edu.tr/bilimtoplum/index.html

Biographies

Sinan Alis is an assistant professor at the Department of Astronomy and Space Sciences of Istanbul University. His main research field is extragalactic astronomy, but he also extensively conducts and coordinates public outreach events, teacher trainings, and astronomy and astrophysics olympiads for high-school students. Sinan is also the IAU National Outreach Coordinator for Turkey.

A. Talat Saygaç is a professor at Istanbul University who studies cataclysmic variables and novae. He is also the co-author of a popular astronomy book in Turkey, *Gökyüzünü Tanıyalım* (or, in English, "Get to Know the Sky").

F. Korhan Yelkenci is an astronomer at Istanbul University working on galaxy evolution. He is an expert on spectroscopic observations and reductions and contributes to several follow-up programmes. In addition, he gives speeches at public outreach events, as well as teacher and high-school trainings in different cities across Turkey.

Archival research in a planetarium: The first projector at Armagh Planetarium

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Keywords
Observatory, History of Astronomy, Interdisciplinary

This paper will examine how a simple archival research project in a planetarium can uncover competing narratives and forgotten figures. We set out to uncover how a Goto "Mars" projector was selected for the Armagh Planetarium in 1965 by looking at the remaining archival material from the period. The projector was the centrepiece of a new planetarium that had been in the planning stages for over twenty years when the first stones were laid. The projector would occupy a pivotal place in the mythology of the Armagh Planetarium, and its short seven-year reign saw the establishment of an institution that would survive significant internal and external turmoil. Contrasting the narrative and mythology around this central piece of equipment with the evidence uncovered in the archive reveals important considerations for how planetariums can research their own history.

Introduction

The star projector lies at the heart of any planetarium in the post-Second World War period, as the dome became the focal point and linchpin of planetarium architecture. The futuristic vision of the planetarium was centred on the technological device that sat in the dome and merged the spectacle of cinema with a booming interest in the cosmos. The first projector for any institution is loaded with significance, not just as an object by which the public can be shown the stars, but also on a personal level to the staff who use it. Especially in institutions that go on to have multiple generations of projectors, the first projector enters its own mythology.

In this case study, we conducted a simple archival research project on the story of the first projector purchased and installed at the Armagh Planetarium in Northern Ireland, as seen in Figure 1. At first glance, the story was relatively straightforward; a projector was needed, and the Goto "Mars" was selected by a committee following a visit to America and Japan to meet the designers. Archival research revealed a more nuanced story of vying corporations and technological competition and, most importantly, highlighted the contrast between the story as told decades later and the material held in the archives. Part of this contrast is the result of the institutional history of Armagh Planetarium, which was in constant flux from its opening in 1968 to the appointment of its

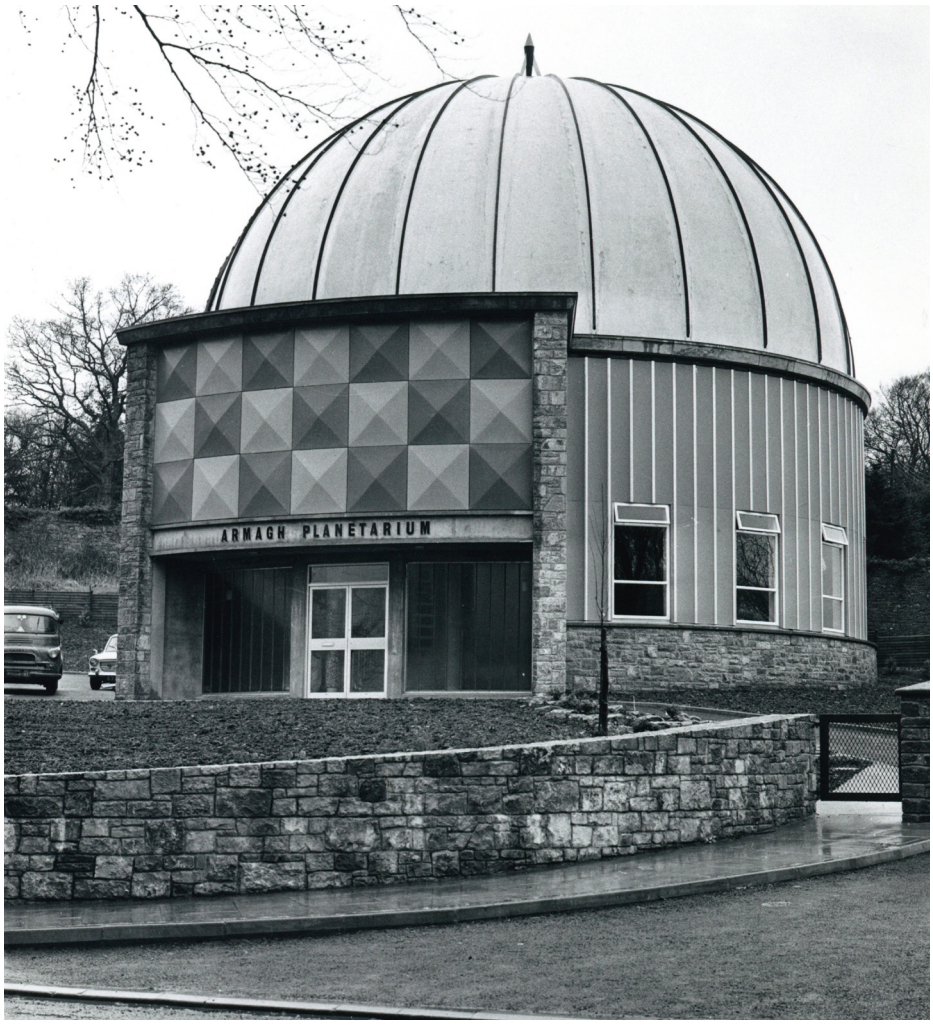


Figure 1: *The completed Armagh Planetarium in 1968. Image Credit: Armagh Observatory and Planetarium*

fourth Director in 1971. The rotation of Directors, assistant directors and lecturers created a perceived sense of increased chronological distance between the events in the spring and summer of 1965 that surrounded the purchasing of the projector and 1971, when the story had to be condensed into a readable guide to the planetarium.

Historical context

Armagh Observatory and Planetarium occupy the site of College Hill, Armagh, in Northern Ireland. The Hill was given to the Armagh Observatory in 1790 when it was founded by Archbishop Richard Robinson. After over 150 years of continuous research in astronomy, it came under the leadership of the seventh Director of the Observatory, Dr Eric Mervyn Lindsay, who spearheaded the efforts to build a planetarium in Armagh.

The Armagh Observatory and Museum Act 1791 – the Act of Parliament that officially established the Observatory – also established a museum in the same building under the same Director who would be known as the Keeper of the Museum. Between the 1840s and the 1930s, this aspect of the Director's responsibility had been quietly ignored in pursuing uninterrupted scientific research. Upon appointment in 1937, Lindsay immediately petitioned for resources from the Northern Irish Government to create an entirely new display room. This restored the building's dual purpose as a place of scientific research and public education, for which he was a passionate advocate.

The creation of the exhibition space also proved that there was an appetite at a governmental level for initiatives supporting public science education. This new display proved immensely popular. By the 1940s, Lindsay personally guided a peak of 4,500 visitors per year through the exhibition and showed them the night sky, weather permitting. This created mounting pressure on several fronts. The new exhibition space was positioned in the 1827 extension of the observatory. However, Lindsay and his family lived in the observatory, and as the institution expanded, visitors and staff encroached on the domestic space. Joined by a student, Moria L. Meredith, for a year in 1942 and undertaking plans to recruit additional astronomers, Lindsay sought to replicate the futuristic planetariums he had seen in the early 1930s while studying in the United States. This purpose-built project would become the new centre for communicating astronomy to the public and relieve the pressure on the observatory building.

The Planetarium Archive effectively began in 1943. Lindsay began to correspond with government ministers, civil servants and his newly formed "Planetarium Erection Committee" to build a planetarium in Northern Ireland. The initial plan is summarised on the front page of the Committee's minute book: "Committee of Project for the erection of a Planetarium as a memorial of the stay of American Troops in Ulster" (*Planetarium Erection Committee, 1944*). The Second World War saw thousands of American servicemen stationed in Northern Ireland. Lindsay knew plans were already underway to build a memorial at Derry-Londonderry. It was hoped in Northern Ireland that by linking such projects, the United States might be persuaded to fund them both. After these unsuccessful efforts, the plan for a planetarium would be reignited in fits and starts, aided by fundraising efforts, for the next twenty years. In the 1960s, the Northern Irish Government hoped to alleviate growing social tensions through economic investment in cultural and educational projects. In 1964, meetings with the Department of Finance put the possibility of a planetarium in Armagh back on the table, and every effort was made to secure a projector.

Armagh Planetarium archives

The archives available at Armagh Observatory and Planetarium are incomplete. Like many planetariums worldwide, the archive was not viewed as historically important; in the 1990s, a significant portion of the collection was deaccessioned. A lack of cataloguing, combined with the deteriorating environmental conditions in the building before major renovations in the early 2000s, also contributed to the loss of material. However, key elements have survived, forming the foundation of ongoing research by both internal and external researchers. When the Armagh Planetarium and the Armagh Observatory merged into a single organisation in 2016, the collections began the slow process of integration and cataloguing.

The primary collections for this research are the uncatalogued binders of letters to and from Lindsay that survived in the collection of Armagh Observatory but were not accessioned with the rest of his material because it was stored separately, and the contents were not explored until this project. In addition, photographs from the Eric Mervyn Lindsay Collection (collection code: ARM EML) and documents from the Armagh Administration Collection (collection code: ARM ADM) were considered. We addressed the research question chronologically, looking at the chain of letters as they arrived at their destination and grouped them by sender. We then began to examine the associated documentary sources that could corroborate the information in the letters. These sources ranged from an official minute book of the Board of Governors and Guardians (archival code M 136.1) and the visitor book of the Armagh Observatory (archival code ARM ADM 14) to a photograph album assembled by Lindsay after the opening of the Armagh Planetarium in 1968 (archival code P 34)

This case study examines a short chronological period from December 1964 to August 1965. The research question was: "How was the Goto 'Mars' projector selected as the first projector system?"

The myth

In 1971, three years after the Armagh Planetarium had opened to the public, the Planetarium published a short guidebook to give viewers an idea of what awaited them. The Goto "Mars" Projector appears on the front cover and then greets the reader again on the third page. However, it is explained only in function until the sixth page, where it is formally introduced.

"The Goto projector is the heart of the Planetarium. This complex machine is an intricate optical device which enables us to project a complete view of the sky, at any time past, present or future on to the 40' inner dome. This equipment is the last word in the visual presentation of our Universe and the fascinating sky shows projected on the celestial dome have earned it the title of 'The Theatre of the Stars' and incidentally the trophy for the outstanding new attraction in British Tourism." (*Murtagh, 1971, p. 6*)

Figure 2: *A Guide to Armagh Planetarium by Terence Murtagh (1971) featuring the Goto "Mars" Projector. Image Credit: Armagh Observatory and Planetarium*

This description was written by the newly appointed Director of the Armagh Planetarium, Terence Murtagh. He was the fourth Director in the post since the planetarium opened. He positioned the Goto front and centre of the Planetarium's advertising efforts, seen in Figure 2 and pitched it in futuristic terms as a "great black machine which sits in the middle of the Theatre looking as if it had just arrived from Mars" (*Murtagh, 1971*).

The other primary source for the origin of the Armagh Planetarium is a short fifteen-page booklet published by the Armagh Observatory in 1968. *The Story of the Armagh Planetarium* (*Lindsay, 1968*) is a remarkable document primarily concerned with the efforts of the author, Lindsay, to raise funds for the construction of the Planetarium. It does not dwell on how a projector was chosen, perhaps because, as we will see, the story is convoluted.

The Spitz letters

Armand Neustadter Spitz was a titanic figure in the history of planetariums globally. His first appearance in the historical record at Armagh Observatory is a letter he wrote to Lindsay in September 1947. Lindsay was on a trip to the United States and had been invited to visit Armand and view the brand-new Spitz Planetarium Projector. The letter references prior communications about the possibility of a planetarium in Armagh, and in the final paragraph, Spitz promises "[his] help in any way in furthering [Lindsay's] plans for the promotion of astronomy" (*Spitz, 1947*). Lindsay had many connections to the United States: his wife, Sylvia, was an American, and he frequently visited many American astronomers and lifelong collaborators that he met in the 1930s while at Harvard University and the Harvard Observatory station in South Africa, which later became the Boyden Observatory. His connections to America and his own experience of seeing the futuristic planetariums in the United States added to his vision of the planetarium that would be built at Armagh.

Their communication picked up again in November 1952 when Armand sent Lindsay a letter enquiring how the planetarium project was coming along (*Spitz, 1952*). It took over six months for Lindsay to respond, in part because he had been in South Africa at Boyden working with the newly completed Armagh-Dunsink-Harvard Telescope (funded in a model he envisioned repeating with a planetarium by contribution from both governments on the Island of Ireland). In his eventual response, Lindsay requested the approximate cost for an entire Spitz projector system (*Lindsay, 1953a*).

The response from Spitz was much more prompt, hurtling back across the Atlantic eleven days after Lindsay got in contact. Spitz offered to assist as he could. He requested further information from Lindsay on exactly what type of projector was required in Armagh (*Spitz, 1953a*). Just as quickly, Lindsay had responded in another letter, enquiring as to the optimal size of the dome required, indicating that at this point in 1953, the Armagh Planetarium was planned to be a 50-foot dome, seating 250 guests (*Lindsay, 1953b*). Again, Spitz responded promptly, confirming his own approval of a 50-foot dome and recommending the Spitz Model B for such an installation. During this period of planetarium building in the United States, the interest was in 60-foot domes to seat up to 400 people. Lindsay had hoped to save costs by building the smaller 50-foot dome, and Armand added a handwritten line, "I prefer a smaller dome because of its

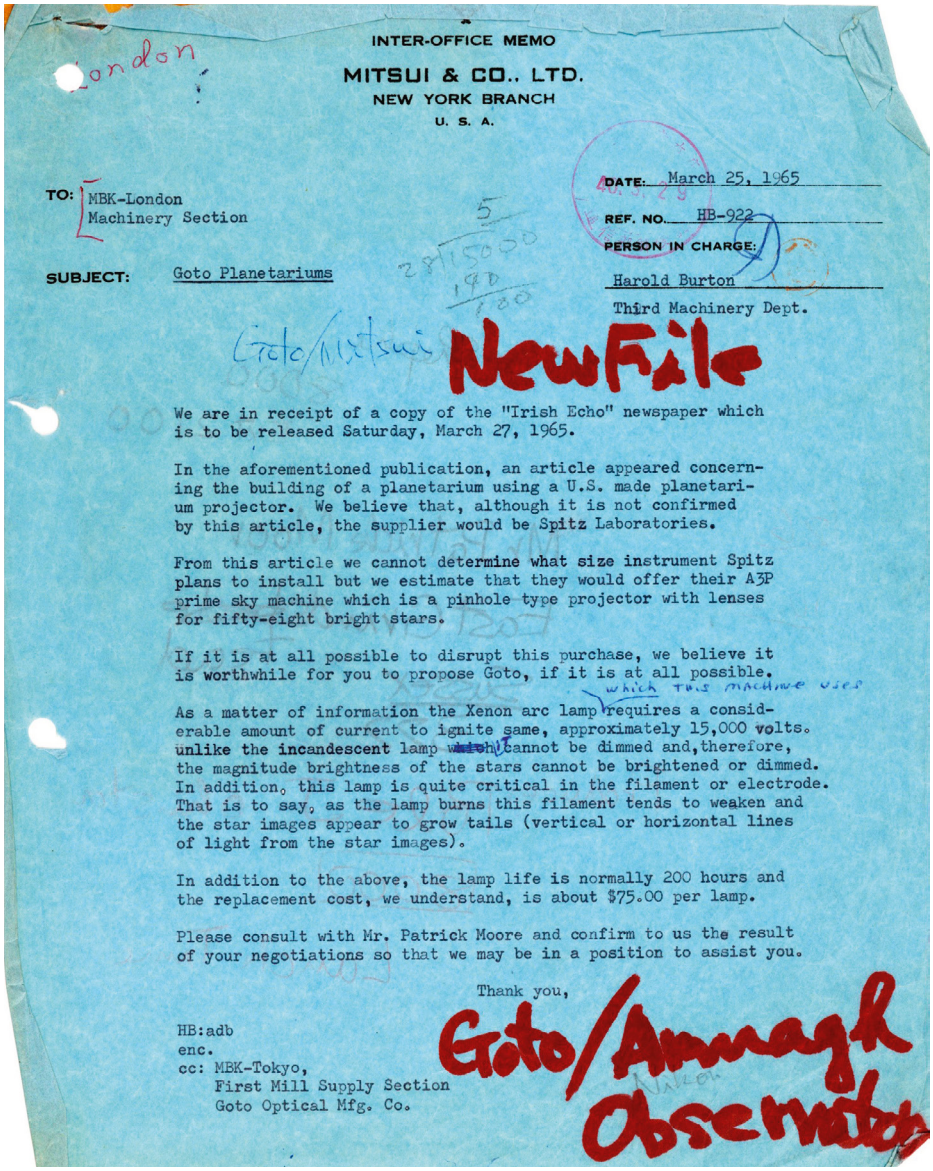
comparative informality" (*Spitz, 1953b*). He does, however, caution that a smaller dome will not be proportionately cheaper, as the plans required for a 50-foot dome were not on hand.

A period of relative calm follows in the archives: over six weeks pass without a letter between the men, and on 20 July, Spitz reached out tentatively to enquire how progress fared with the planetarium (*Spitz, 1953c*). Months came and went without a response, and the plan to build a planetarium in Armagh once more went dormant. At the end of 1953, the two again exchanged a flurry of letters attempting to coordinate a reunion but were ultimately unable to do so.

Once more, the correspondence between the two men ceased, only to restart a few years later in 1961, along with the efforts to get a planetarium built in Armagh. The vision of the planetarium was changing from a dome seating 250 people to one that seated under 100. Lindsay named the Spitz Model A- 1 as a potential instrument (*Lindsay, 1961a*) and wrote to Spitz requesting "all the information possible… cost of projector, size, and type of dome required" (*Lindsay, 1961b*). Within a month, Spitz responded and wrote candidly on the issue of a projector for Armagh: "My friend, let us face the facts of life: the cost of such an instrument, if you get the best, is far more than it was in the days when you and I were planning hopefully" (*Spitz, 1961*).

Spitz recommended a Model A- 3-P and claimed it was as versatile as any Zeiss or Goto instrument on the market. He lists the cost of $13,000 for the projector system and $10,000 for the dome and suggests that the seating and sound systems be sourced in the United Kingdom to save on expenses (*Spitz, 1961*). This cost was not what Lindsay had anticipated, and in a letter to his old friend and mentor, Harlow Shapley, he expressed his shock at the price and requested advice on potential funds or trusts in the United States that might assist with the purchase, mirroring his original plans from 1943 (*Lindsay, 1961c*). In a letter to Spitz, Lindsay outlined his plan for financing his proposed planetarium but highlighted that it was entirely dependent on funding from an external source (*Lindsay, 1961d*).

By 1964, Spitz had withdrawn from the day-to-day operations in Spitz Laboratories, but



INTER-OFFICE MEMO

MITSUI & CO., LTD.
NEW YORK BRANCH
U. S. A.

London

TO: MBK-London
Machinery Section

DATE: March 25, 1965
REF. NO. HB-922
PERSON IN CHARGE:
Harold Burton
Third Machinery Dept.

SUBJECT: Goto Planetariums

Goto/Mitsui

NewFile

We are in receipt of a copy of the "Irish Echo" newspaper which is to be released Saturday, March 27, 1965.

In the aforementioned publication, an article appeared concerning the building of a planetarium using a U.S. made planetarium projector. We believe that, although it is not confirmed by this article, the supplier would be Spitz Laboratories.

From this article we cannot determine what size instrument Spitz plans to install but we estimate that they would offer their A3P prime sky machine which is a pinhole type projector with lenses for fifty-eight bright stars.

If it is at all possible to disrupt this purchase, we believe it is worthwhile for you to propose Goto, if it is at all possible.

which this machine uses

As a matter of information the Xenon arc lamp requires a considerable amount of current to ignite same, approximately 15,000 volts. unlike the incandescent lamp which cannot be dimmed and, therefore, the magnitude brightness of the stars cannot be brightened or dimmed. In addition, this lamp is quite critical in the filament or electrode. That is to say, as the lamp burns this filament tends to weaken and the star images appear to grow tails (vertical or horizontal lines of light from the star images).

In addition to the above, the lamp life is normally 200 hours and the replacement cost, we understand, is about $75.00 per lamp.

Please consult with Mr. Patrick Moore and confirm to us the result of your negotiations so that we may be in a position to assist you.

Thank you,

HB:adb
enc.
cc: MBK-Tokyo,
First Mill Supply Section
Goto Optical Mfg. Co.

Goto/Armagh Observato

Figure 3: *The Goto Memo. Image Credit: Armagh Observatory and Planetarium*

his personal friendship with Lindsay remained strong. He was informed that a new Director was appointed to the planetarium project: Patrick Moore, a rising star in the world of popular astronomy in Britain (*Spitz, 1964*). Moore was already a presenter on 'The Sky At Night', a regular television show on the British Broadcasting Corporation schedule, which informed the public of basic astronomical concepts and the most cutting-edge developments in the Space Race. Herb Williams, the Vice President of Spitz Laboratories, reached out to both Moore and Lindsay in a letter dated 3 December 1964. He confirmed the earlier assessment that the Spitz Model A- 3-P would be ideally suited to a dome of the type envisioned by Lindsay (*Williams, 1964*). The response to his letter came four months later, on 5 March 1965. The funding for the planetarium had been secured through the Northern Irish Government, and the letter opens, saying, "We are now definitely going ahead with our Planetarium, and we propose to purchase the Spitz A- 3-P Prime projector" (*Lindsay, 1965a*).

The next day, he sent a letter to Spitz, declaring, "At last success!" (*Lindsay, 1965b*) and confirming that they had firmly decided upon the Spitz projector. At this point, it appeared that the efforts that had begun in 1947 were about to be completed. The final step was to clarify the size of the

dome that would be built in Armagh, and to do so, Patrick Moore would travel to the United States to view various Spitz installations. As Lindsay explained in a letter to Spitz, their priority was to produce the best display on the dome. Patrick Moore would arrive in the United States on April 13, 1965 (*Lindsay, 1965c*).

April to June saw a considerable change in the planning, and by June, nothing was to be as simple as it had appeared only a few months earlier.

The Goto letters

Goto was established in 1926 in Tokyo, Japan, by Seize Goto. Originally established as an entry-level telescope manufacturer, the business grew steadily until the 1950s. In 1954, the Japanese government passed the "Enactment of the Science Education Promotion Act", which saw massive investment in scientific equipment in schools across Japan. Taking their expertise in optical manufacturing, the company began to provide planetarium projectors for the school market, and by the end of the decade, they had acquired over ninety per cent of the industry market share in Japan.

The end of the 1950s also saw the release of Goto's flagship planetarium projector, the Model M. The Goto company intended this projector system to catapult them into the global planetarium market. The second Model M to be constructed was installed overseas, in the Museum of Art, Science and Industry in Connecticut, in the United States.

Lindsay had originally contacted Goto in early 1962, requesting that the company present a projector to the Armagh Planetarium Board as a gift to provide advertisement for the company and a flagship installation in the United Kingdom. This request, and an additional one later made to the Japanese Government, were both met with silence until March 1965.

Figure 3 shows an inter-office memo from the New York to London branch of Goto, with the Tokyo office in copy. The memo concerns an article in The Irish Echo that mentions that the Armagh Planetarium will install a projector in the United States. The memo's author, Harold Burton, an employee of the Goto branch in New York, speculates that the supplier will be Spitz Laboratories and instructs the Goto London branch to contact Patrick Moore immediately. The memo outlines the aggressive campaign: "If it is at all possible to disrupt this purchase, we believe it is worthwhile for you to propose Goto" (*Burton, 1965*).

Following a series of correspondences in April 1965, Goto flew a representative to Belfast to meet with Lindsay in Armagh (*Mitsui & Co, 1965a*).

After a trip to the United States to tour the various Spitz installations, Patrick Moore was excited about the possibility of using a Spitz instrument in Armagh. Goto representatives met with Moore shortly after their rendezvous with Lindsay and offered to sponsor another trip to the United States to view their projector installations. Before his trip, Moore received a letter from a prominent planetarium consultant, George Lovi, praising the Goto export Model M, the "Mars" model, and comparing it to the Spitz Model A- 3-P installation in Connecticut (*Lovi, 1965*). This sequence of events represents a curious set of coincidences that began to push the Armagh Planetarium towards a Goto instrument.

Moore wrote to Lindsay upon his return, reporting his impressions of the Goto instruments. The praise he had earlier heaped on Spitz was now focussed on the Goto, and his report put his feelings on the matter in no uncertain terms:

> …I am rather sorry to have to say that the Goto is not only better, but infinitely better. There is, I fear, no doubt in my mind that we should be making a crass error to have the Spitz, which is clearly less rigid, less reliable, less well serviced, has less performance, and doesn't produce a better sky in any case (*Moore, 1965, p. 1*)

This starkly contrasts the reports he wrote to Lindsay after his trip to meet Spitz and see the Spitz A- 3-P. The Board of Governors and Guardians of the Armagh Observatory established a sub-committee of astronomers and physicists to determine which instrument they should purchase. This sub-committee was established just days after the report by Patrick Moore. They aimed to "deal with such technical matters as the type of projector and outer dome" (*McCann, 1965a*).

The rationale for this decision was briefly outlined by Lindsay; the primary deciding factor was that the dome provided by Goto was significantly cheaper, allowing them to purchase the more expensive projector system, the Goto "Mars". He stressed that the sub-committee would make the final decision, but the committee members with the most subject matter expertise were Lindsay and Patrick Moore. Whilst no minutes of this sub-committee's deliberations survive, they decided in under

Figure 4: *Patrick Moore with the installed Goto "Mars", 1968. Image Credit: Armagh Observatory and Planetarium*

a month. The decision would be made quickly and unanimously. By mid- 1965, Goto wrote to confirm they would supply Armagh with a "Mars" model planetarium (*Mitsui & Co, 1965b*).

Word of the decision had reached Spitz Laboratories by local channels. Herb Williams sent a letter to Patrick Moore on 30 June 1965, informing him that he had heard Armagh would have a Goto and expressing his disappointment (*Williams, 1965*). In July 1965, Goto wrote to confirm the agreement to supply the projector, and Patrick Moore held a press conference to announce the purchase. On 5 August 1965, the agreement was formally signed by the Archbishop of Armagh in his role as the Chair of the Board of Governors and Guardians (*McCann, 1965b*)

Conclusion

When the planetarium opened to the public on 1 May 1968, as shown in Figure 4, the public was introduced to the night sky by the projector and the lectures delivered by Patrick Moore. There was no mention of the role played by Armand Spitz over the previous two decades in the planning of the Armagh Planetarium.

The last letter that was sent by Spitz to Lindsay is undated, but from the contents, it seems to have been sent at some point between late May and the end of June 1965. This letter, which was rediscovered in 2020 during the COVID- 19 pandemic, sparked the current research into the history of the projector systems at the Armagh Planetarium. The letter illustrates the optimism and spirit of the planetarium as it was embodied in the 1960s and, we hope, to the present day:

> Maybe I'm an incurable idealist, but methinks that planetariums and all they stand for should bring people together and should not be separative in effect.
> Any planetarium, Goto, Zeiss, Spitz or any other, that is well conceived and operated will do an acceptable job. Its [sic] all dependent upon the spirit of its sponsors and operators.
> One thing I emphasize to you… and I told this to Patrick when he was here: I believe in planetariums as an educational and cultural asset to any community. I have offered to lend him and you any support within my power, whatever instrument you buy, and I mean time. Naturally I'd be happy if it bore my name, but my interest in your success is not predicated upon this. (*Spitz, 1965, p. 1*)

What appeared at the outset to be a simple story of acquiring the first projector for the Armagh Planetarium has turned out to be a complicated process, reflecting the realities of buying a planetarium projector in the 1960s. The intricacies of funding from multiple bodies, shipping from overseas and the technological hurdles that had to be overcome all deserve further research in their own right. This case study highlighted the changing nature of the planetarium projector from the 1940s through to the 1960s. The 18-year period examined here saw a global explosion in the number of planetariums and the rapid development of intercontinental networks of supply, collaboration, and competition. This trend was boosted by the Space Race, which, in turn, increased competition in the market.

Competition in the planetarium industry was increasingly fierce in the 1960s, and the entry of Goto to the deliberations around Armagh Planetarium was a well-coordinated project. All three company branches approached Lindsay and Moore to sell them on a Goto system. It presents a stark contrast to the sales tactics employed by Spitz Laboratories over the previous years, which relied upon personal connections and well-established networks.

As more planetariums across the globe join the Centennial celebrations, attention will shift to their own histories. Many planetariums, like the Armagh Planetarium, contain rich historical archives that can provide excellent material for exhibitions. Guests who attended the planetarium in their childhood may now be returning with grandchildren, and they are particularly interested in seeing images of the projectors, exhibitions, and architecture they remember from their first visit.

This archival research project was conducted with a simple chronological methodology, focused on letters and their senders. But even in this, it must be noted that people have been left out of the story for brevity. Whilst the archives cannot tell us who was responsible for posting, editing, and typing the letters sent from Goto and Spitz, we know that in the Armagh Observatory, that role fell to the Secretary, Sheelagh Grew. Her role as counsel and editor for Lindsay cannot be understated, and she was certainly regarded at the time as instrumental in the complex decision-making that occurred in the Observatory.

As we have seen, the history of an institution as relatively young as the planetarium is often only considered when it needs to be streamlined into a few paragraphs for a brochure, an exhibition, or a website. This, however, can obscure important events and individuals from institutional history, even if they were crucial for the existence of the institution as it stands today. The full story has yet to be unearthed and presented in its full complexity. Perhaps the Centennial of the Planetarium will encourage institutions to dig into their own history and present it to visitors alongside their astronomy.

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