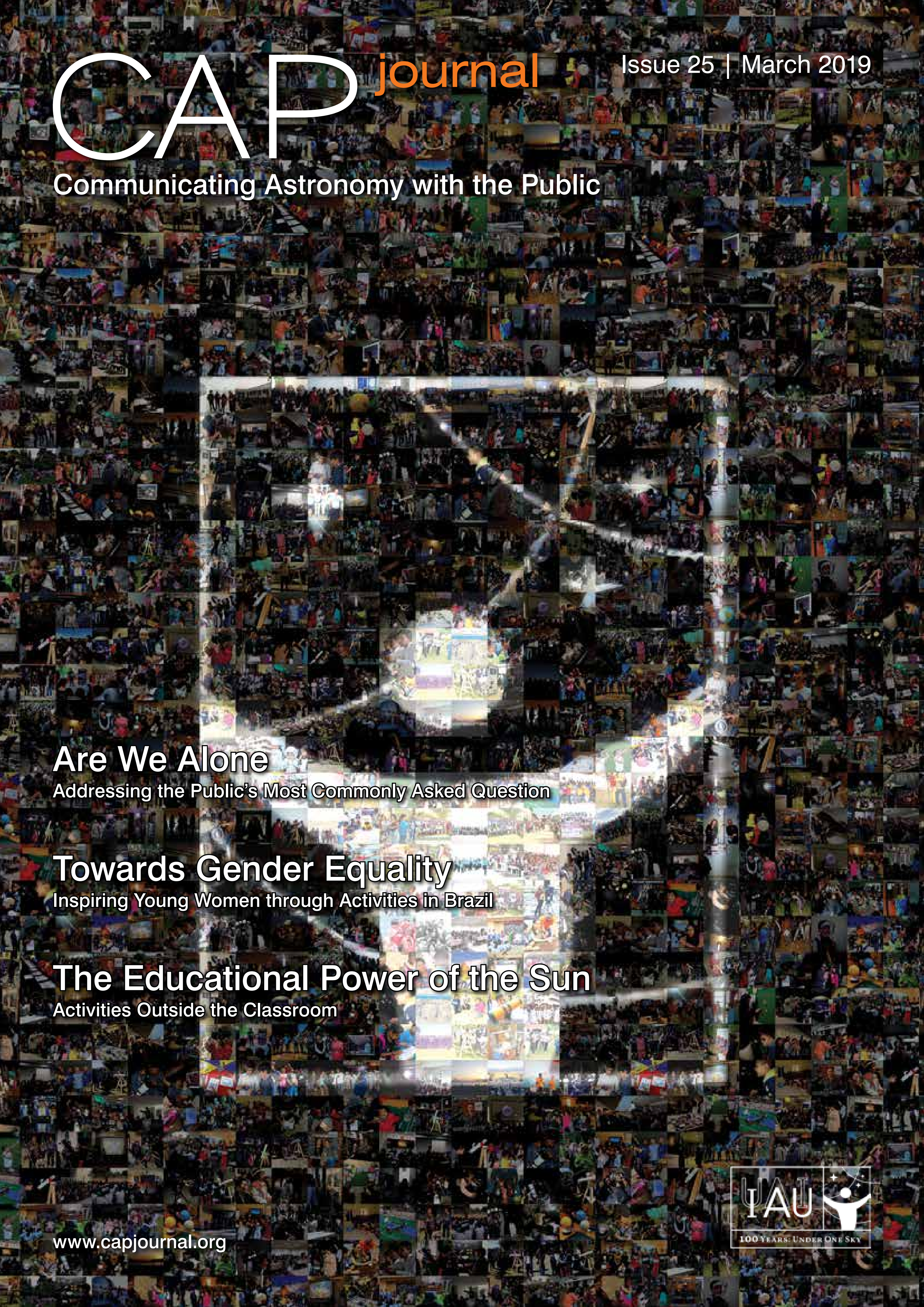


Issue 25 | March 2019

CAP journal

Communicating Astronomy with the Public

Are We Alone

Addressing the Public's Most Commonly Asked Question

Towards Gender Equality

Inspiring Young Women through Activities in Brazil

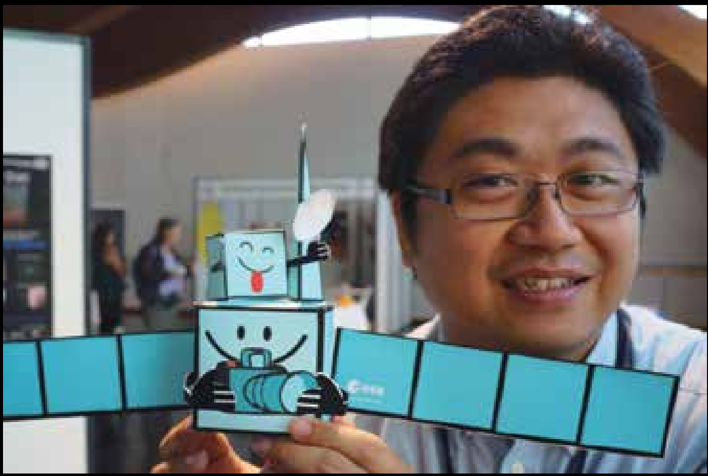
The Educational Power of the Sun

Activities Outside the Classroom

www.capjournal.org

IAU 100 Years: Under One Sky

For only the second time, astronomers have discovered a set of repeating fast radio bursts (FRB), given the name FRB 180814. J0422+73. FRBs are very brief but powerful radio flashes originating from the deep space, but their source is still a mystery. The new Canadian Hydrogen Intensity Mapping Experiment (CHIME) detected the six bursts from the same location, about 1.5 billion light-years away. Credit: Andre Renard/Dunlap Institute/CHIME Collaboration.



Contents

Cover: A mosaic of the 100 Hours of Astronomy activities around the world which marked the beginning of the IAU centennial celebrations. This mosaic was assembled using images submitted to the IAU Office for Astronomy Outreach Flickr account. Credit: CAPjournal.

Editorial

Finally, the IAU centenary celebrations have arrived. The 100 Hours of Astronomy event took place 10 - 13 January 2019 with more than 1200 astronomy activities taking place in more than 85 countries worldwide! Following this, set of events the Women and Girls in Astronomy Day took place on 11 February, and more celebrations are still to come. These upcoming events include the Dark Skies event around the International Day of Light on 16 May, the 100th anniversary of the Eddington solar eclipse, the 50th anniversary of the Moon Landing, the national campaigns of NameExoWorlds, and many more. I recommend everyone checks the IAU100 website so as not to miss the chance to promote astronomy in your community this year.

The originally planned issue on solar eclipse is in the progress. In this issue of CAPjournal you can find papers reflecting on the IAU100 themes, such as gender equality, inclusion, exoplanets and the big question, are we alone? We hope you will enjoy reading.

On a final note, I am stepping down as editor-in-chief as my term as the IAU International Outreach Coordinator comes to an end, but I will continue to be a guest editor. During the year, we have improved the peer review process, and published a new peer review guideline to help both the authors and peer reviewers to increase the quality of the publications. I am also glad to say the submission rate has increased over the year. Many astronomy communicators are do-ers, but we hope more people will continue to submit learnings and share with the larger community. This is the purpose of CAPjournal.

Sze-leung Cheung
Editor-in-Chief of CAPjournal

News
Announcement
Interview
Opinion
Resources
Best Practice
Review
Research & Applications
Correspondence
Column

Explained in 60 Seconds: The Diversity of Distant Worlds

Natalie Batalha
Project scientist, Kepler mission
natalie.m.batalha@nasa.gov

To date, astronomers have discovered almost 4,000 exoplanets by observing stars and watching for a slight reduction in their brightness as a planet passes in front of them. Although planets are merely specs against their parent stars, we now have telescopes sensitive enough to detect them.

The diversity of the planets found outside the Solar System far exceeds that within it. Beyond our seven closest neighbours, there are all kinds of fascinating worlds.

There are planets orbiting dead stars and ocean worlds entirely enveloped by water. We see planets orbiting binary stars. On these worlds, if we could visit them, we would find two suns rising and setting. On other planets, where the host star is one of many in a gravitationally bound cluster, the night sky would be awash with bright stars. We see worlds with surfaces covered in molten lava and planets that orbit so close to their host star that they are disintegrating, boiling away like comets too close to the Sun and leaving a trail of material behind them.

Among this startling diversity, we also find many planets that resemble our own. These Earth-like planets are relatively small, rocky and much harder to detect. When a planet the size of Jupiter passes in front of its star, the observed dip in brightness is 1%. For an Earth-like planet this percentage plummets to 0.01%, a difference so minute it is very difficult to detect. It is the equivalent of looking up at a building 80 stories tall and noticing one person lowering their window blind by just a centimetre. This is the change we have to detect to find a planet like Earth.

Other than being rocky and small, it is the positioning of a planet in the habitable zone of its parent star that makes it Earth-like. This positioning has to be just right, not too close that liquid water will boil away and not too far that water is locked into ice. NASA's Kepler spacecraft has discovered almost five dozens of such Earth-like planets, but they are not all as similar as the name may suggest. Some of them are super-Earths, many times the size of ours, while others are covered in a thin layer of liquid water.

Figure 1. *(from left to right) Artist rendering of (a) dead planet, (b) lava world, (c) photo-disintegrate planet, (d) ocean worlds, (e) planet orbit binary stars and (f) planets in a star cluster. Credits: (a) David A. Hardy, (b) NASA/Kepler Mission/Dana Berry, (c) NASA/JPL-Caltech, (d) NASA, Jose-Luis Olivares/MIT, (e) Lynette Cook / extrasolar.spaceart.org, (f) Michael Bachofner.*

Survey of IAU Members' Outreach Activities and Save the Date for CAP2020

Richard Fienberg
American Astronomical Society
rick.fienberg@aas.org

Sze-leung Cheung
IAU Office for Astronomy Outreach
cheungszeleung@iau.org

Oana Saudu
European Southern Observatory
osandu@partner.eso.org

Under the umbrella of the IAU Commission C2 working group, Science Communication Research in Astronomy, a study of outreach activities has been published in the journal *Nature Astronomy*[1]. The study presents results from a survey of 2587 IAU members, and the results show that astronomers have a remarkable drive for public engagement.

The Science Communication Research in Astronomy working group was established in 2015 to address the need for more science and research around science communication[2]. The working group's triennium report articulated its purpose in the following words:

Science communication has long existed as a field of practice, but the academic field of science communication is rather young. Yet, one of the biggest challenges facing science communication is the polarization between practice and scholarly. Empirical evidence in astronomy communication is scarce, nonetheless necessary to improve public engagement with science. This WG emerged in this context and as an attempt to contribute to this ambitious goal. The IAU membership and its dynamic com-munity in research and outreach represent a unique opportunity to make this a reality. The mission of the WG is then to create a space for reflection and discussion about the needs in astronomy public communication, to produce empirical evidence on astronomy communication, and to serve as a platform to strengthen the boundaries between the fields of science communication research and practice. As a deliverable by the WG, a global study of the outreach practices of the IAU membership was accomplished (Entradas, 2015).

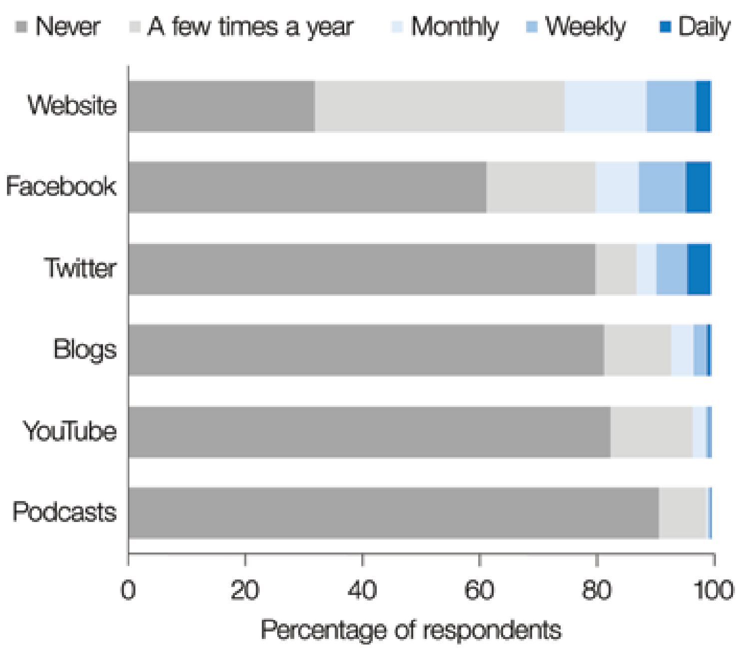


Figure 1. *The frequency of participation in different online channels among the 2587 astronomers who responded to the survey. Credit: NATURE/M. Entradas (LSE, ISCTE-IUL).*

The IAU issued a press release[3], reporting that the study, which surveyed a record-breaking 2587 professional astronomers in early 2016, found that as many as 87% participated in scientific outreach activities, both by taking part in events and by engaging with representatives of the media. Those astronomers who reported participating in outreach activities had participated in an average of eighteen activities in the preceding year. Because of the ubiquitous nature of its questions and the stunning insights into the nature of the Universe, astronomy has often been thought of as the natural science with the most far-reaching popular appeal. The study has shown that professional astronomers may be engaging with the public more than scientists in any other field.

The study also showed high activity by astronomers working in less developed regions. The vast majority of astronomers prefer to interact with the public in traditional ways, through lectures and school talks, and fewer than 20% use social media and digital platforms for outreach activities. Most engagements with news reporters are conducted by senior astronomers, while junior scientists prefer face-to-face interactions. The outreach activities in which IAU astronomers participate tended to be self-organised. Despite 86% astronomers being in contact with communication experts at their institutions, only 43% of those use the available outreach structures. The rest prefer instead to organise their own activities.

Save the date for CAP2020

The IAU Commission C2 working group Communicating Astronomy with the Public

Conference has received fourteen applications from six continents to host the CAP 2020 conference. The working group has shortlisted five proposals for a second-round evaluation, following which the proposal to host CAP 2020 was awarded to Sydney, Australia.

CAP 2020 will take place 21 - 25 September 2020. Please save the date and more details will be published soon on the Commission C2 website[2]. We look forward to seeing you there.

Notes

[1] Research paper: https://www.nature.com/articles/s41550-018-0633-7

[2] Commission C2 website: https://www.communicatingastronomy.org

[3] IAU Press Release: https://www.iau.org/news/pressreleases/detail/iau1813/

Reference

Entradas, M. et. al. 'IAU Commission C2 Science Communication Research in Astronomy WG triennium report' [online report] (2015-2018), http://www.iau.org/static/science/scientific_bodies/working_groups/261/wg-triennial-report-2015-2018-science-comm-research.pdf

Biographies

Richard Fienberg is the President of the Commission C2 Communicating Astronomy with the Public.

Oana Saudu is the Vice President of the Commission C2 Communicating Astronomy with the Public, and the chair of the CAP conference WG.

Sze-leung Cheung is the IAU International Outreach Coordinator and the former co-chair of the CAP conference WG.

Best Practice

Behind the Scenes of CAP2018 Japan: Producing the Largest Astronomy Communication Conference to Date

Lina Canas
National Astronomical Observatory of Japan
lina.canas@nao.ac.jp

Hitoshi Yamaoka
National Astronomical Observatory of Japan
hitoshi.yamaoka@nao.ac.jp

Hidehiko Agata
National Astronomical Observatory of Japan
h.agata@nao.ac.jp

Shigeyuki Karino
Kyushu Sangyo University, Japan
karino@ip.kyusan-u.ac.jp

Keywords
Conference; outreach; astronomy communication

The 2018 Communicating Astronomy with the Public Conference is the largest and most diverse astronomy communication conference organised to date. In this article, the local organisation committee in Japan presents an overview of the implementation strategies and the lessons learned, focusing specifically on the needs of the region and the international impact of the conference.

Introduction

The CAP conference series is organised by the International Astronomical Union (IAU)[1], through its Commission 2: Communicating Astronomy with the Public[2]. The IAU has more than 12 000 active members in nearly 100 countries worldwide. The IAU's mission is to promote and safeguard the science of astronomy through international cooperation. Since 2005, CAP meetings[3] have facilitated a global exchange of ideas and best practices in informal education and astronomy and space communication. The conference helps to strengthen the local community of professionals by connecting them to a global network of astronomy communicators and giving them access to the latest trends, lessons learnt and ongoing projects.

Figure 1. The official group photo for the conference, capturing the diversity and enthusiasm of the 446 participants who attended CAP2018. Credit: CAP2018 LOC.

The eighth conference, held in March 2018[4,5] was hosted and organised by the National Astronomical Observatory of Japan (NAOJ) and Fukuoka City and supported by a very strong team of national and local astronomy communicators, city officials and other partners. A scientific organisation committee designed the conference programme, and the local organisation committee prepared the logistics.

The conference hosted 446 participants from 53 different countries (Figure 1).

Fukuoka City Science Museum was the venue for the conference. Opened in October 2017, the museum aims to bring all of Fukuoka's citizens and visitors closer to science. It aims to make science accessible to the public and to provide an environment where children can express their creativity through fun and engaging science experiences.

Conference Content and Participants

Between the 24 and 28 March 2018, the conference hosted five plenary sessions with a total of 24 plenary talks. These included five invited speakers; 22 parallel sessions, including a planetarium session; 24 workshop sessions; 20 unique workshops; four unconference slots; 111 posters; and a special session dedicated to the 100 Year Anniversary of the IAU.

Japan was selected to host this edition of CAP to fulfil the goals of reaching the Asia-Pacific region and promoting an exchange between professionals with different backgrounds, strengthening collaboration and increasing diversity within the community. The numbers demonstrate its success, with 89 participants from the Asia-Pacific region and 198 participants from Japan. There was also a good gender balance: 47% male and 33% female (20% data not available).

Implementation

To complete the various organisational tasks that hosting an event like the CAP conference entails, the local organising committee divided its action groups into different teams: financial, public relations, operations, social events and proceedings. The finance team focused on gathering sponsors to fund participants from the Asia-Pacific region to attend and contribute to organisation costs. The public relations team focused on building dissemination networks and the visual identity of the conference. The operations team focused on providing the best onsite volunteers to facilitate registration and the smooth running of the conference. The social programme team assured an intercultural exchange and provided a warm and welcoming environment for the guests. The proceedings team focused on collecting submissions and compiling a book of the conference proceedings.

Financial

The local organising committee was particularly active in acquiring the external means for funding and for finding sponsors. Nearly 30 avenues for support were acquired in total, in addition to the grants provided by the IAU.

For the organising committees, the CAP2018 conference was a unique opportunity to promote the development and professionalisation of science communication in the Asia-Pacific region. Joint efforts between NAOJ and Japanese crowdfunding campaigns supported the attendance of participants from Asia-Pacific countries. Twelve grants were awarded to participants from eight countries and regions: Indonesia, India, Bangladesh, Philippines, Nepal, Malaysia, Taiwan and Singapore. NAOJ and crowdfunding donors rewarded the next generation of science communicators and provided them with an opportunity to attend the CAP2018 Conference. Winners were chosen based on their

Figure 2. *CAP2018 artwork influenced by iconic astronomy projects depicted in Japanese style drawings. Credit: CAP2018 LOC.*

potential to make a difference in science communication in their region and their impact on the future of astronomy dissemination and informal outreach in their local communities.

For the first time, one- and two-day tickets were made available, which facilitated and encouraged national participation.

Public Relations
The priority of the public relations team was to reach out to the international astronomy communication community. This work began with a proposal, in 2016, explaining the strong desire of the local organising committee to host the conference.

The team identified vital potential partners through their own extended networks at the international, regional and national level to support and disseminate CAP2018. Instead of the usual media partners, the focus here was to seek out the most active community leaders in outreach, informal education and astronomy communication. This strategy proved to be effective: nineteen dissemination partners were identified and participants from 53 different countries attended the conference.

The team also had a strong presence on social media, particularly Facebook[6] and Twitter[7]. They focused not only on the scientific potential that a conference such as CAP could offer but also on the opportunity to know more about Japan's cultural multiplicity – the beautiful surroundings of the conference, the vibrant city of Fukuoka and the island of Kyushu. The organisers believed that immersing CAP participants in Japanese culture would forge a closeness that would reflect in future collaborations and strengthen the bonds between Asia and participants from other regions.

During the conference, the scientific organising committee's regular posts kept the international community informed about the sessions taking place and the topics discussed. #CAP2018 was trending in Japan, the Netherlands and the United Kingdom.

The public relations team was also responsible for key deliverables, including a programme book. Far more substantial than a printout of digital data, this publication required the support of a full publishing team and contained essential information for the participants not only about the scientific programme but also about other events and logistical information about Fukuoka. Other deliverables included conference bags, badges and onsite signs.

Figure 3. *The logo of CAP2018. Credit: CAP2018 LOC.*

All CAP2018 artwork was influenced by iconic astronomy projects depicted in Japanese-style drawings (Figure 2). The artwork blended the deep astronomy roots of Japanese culture with its state-of the-art astronomy endeavours.

The process of creating the CAP2018 artwork started in January 2017, under the artistic direction of Adachi Design Laboratory. The CAP2018 logo followed the concept of previous CAP conferences, with sidereal motion as a motif; however, customised elements such as the stellar trail and cherry blossom petals were added in reference to the conference's location and season – Fukuoka in March 2018 (Figure 3).

The main visual graphics were illustrated by Chamooi, a young emerging illustrator who represents Japanese pop culture without straying too much into 'Japanimation nerdy'. Many items reflect both modern astronomy and Japanese traditions. The main image resembles a Hakata Gion Yamakasa, a characteristic festival car of the Fukuoka area. Individual rabbits represent people gathering from all continents and were featured on the various deliverables, including the programme book, name tags and conference bags. This well-received visual welcomed participants to the Fukuoka City Science Museum.

Operations
Onsite, one of the biggest operational concerns was managing the registration of around 400 guests on the first day. As a solution, registration was opened a day earlier, and tickets to the museum or to the planetarium show were offered as incentives to those who registered earlier. This strategy worked: around 200 registrants enrolled in the pre-onsite-registration, and this significantly decreased the burden on staff.

Other concerns were ensuring a good flow of the participants between sessions, good time keeping and strong communication between the volunteers and organisation committee members to ensure that issues were immediately addressed and resolved.

Capacity for people and posters was also a challenge. Although CAP2018 is an international conference and takes place in English, Japanese-speaking participants could listen to the Japanese translations through receivers at a satellite venue via simultaneous interpretation during the first three days. This allowed for participants to be spread across multiple rooms and solved capacity issues. Owing to the large number of session submissions, the posters were also separated into two sections.

Social Events
The focus of the social events was to share with the participants a bit of the Japanese culture and offer the local community a chance to interact with the invited participants. On the first day, the participants attended a Noh play, traditional Japanese theatre, at Ohori Park Noh Theatre. This special performance was followed by

Figure 4. *For the five days of the conference, participants from all over the world shared their know-how and diverse expertise in science and astronomy communication. Credit: CAP2018 LOC.*

a star-gazing session with local amateur astronomer groups and a welcome cocktail. On the evening of the second day, Professor Murayama from the Kavli Institute for the Physics and Mathematics of the Universe gave a lecture to the public as a satellite event.

The conference banquet was held at Hotel New Otani Hakata on the evening of the third day. The Japanese drum performance and Tsugaru Shamisen (three-stringed traditional musical instrument originated from Tsugaru) at the dinner were particularly well received by the foreign participants.

Proceedings
The main conference theme was Communicating Astronomy in Today's World: Purpose and Methods. The theme compelled the community to reflect on the many challenges communicators face in the post-truth era and on the role of astronomy communication in this era. At the same time, the conference was an opportunity to seek recommendations from communicators worldwide as they came together to share insights and the lessons learned.

A book was compiled containing works presented during CAP 2018, from the community, for the community. The submitted works were collected from 21 plenary talks, 106 talks and 72 posters. The book also features special contributions from invited speakers Norio Kaifu, Wanda Diaz-Merced, Hitoshi Murayama, Dominique Brossard, and the IAU 100 years session contributors.

Lessons Learned

In addition to having a strong programme, culturally linked social events and a team structure, the organising committee has put together a set of other practical lessons that led to the successful completion of the project (Canas, 2018; Canas, 2019).

Proposal
Present a clear and (nearly) complete plan within the proposal. If the conference is not funded by the central organisation, make it your priority to find sponsorship for the venue. Link the scientific goals to regional needs: why do you want to organise the conference? How will your country/region benefit? Establish a global network at an early stage and seek letters of endorsement from the community.

Network
Partner with international and global institutions in the field to increase visibility and reach within the community. The local organisation also set up a national committee to strategically link to other institutions and widen the reach of the conference and engagement within Japan.

Invited Speakers
Draw on the expertise of the scientific organising committee to choose the guest speakers. Pay attention to the diversity and representation of your chosen panel: it will make a difference in inspiring the next generation in your audience.

Participant Support
Identify early needs and possible struggles participants might face. You can lower the registration fee by getting full sponsorship for the venue. Provide grants to regional participants and promote workshops tailored to the needs of the region.

Satellite Events
Take advantage of the country's other astronomy assets. Connect with other groups in the country who might want to host related events. For us, this included an astronomy education meeting in Kagoshima and a visit to the JAXA Tanegashima Space Center.

The conference required a great deal of hard work but the returns were much more. Hidehiko Agata, chair of the local organising committee, summarised it in his opening speech:

'With CAP2018 Japan we hope we can provide you with the tools and inspiration as to when upon your return to each of your communities you can actively work towards building a better society through science communication. May CAP2018 lay the road ahead and let us walk together!'

Acknowledgments

CAP 2018 would not have been possible without the hard work and enthusiasm of the many people on the scientific organising committee, national organising committee and local organising committee. We also thank the National Astronomical Observatory of Japan for inviting CAP to Japan and the Fukuoka City Science Museum, the student volunteers and all members of Team Fukuoka representing the host city of Fukuoka for their "omotenashi" (Japanese style unlimited hospitality) spirit. Finally, we thank all of our sponsors.

Notes

[1] IAU Commission C2: https://www.iau.org/science/scientific_bodies/commissions/C2/

[2] IAU Official Website: https://www.iau.org/

[3] Communicating Astronomy with the Public: https://www.communicatingastronomy.org/

[4] CAP 2018 Edition: https://www.communicatingastronomy.org/cap2018/

[5] NAOJ Article Report: https://www.nao.ac.jp/en/news/events/2018/20180423-cap.html

[6] CAP Conferences Facebook: https://www.facebook.com/CAPconference/

[7] CAP Conferences Twitter: https://twitter.com/capconference

References

Canas L. et al., 'Communicating Astronomy with the Public 2018: Efforts on Bringing Together the International Astronomy Communication Community', Proceedings of the Communicating Astronomy with the Public Conference 2018: NAOJ, IAU, 2018, p. 284

Canas L., et al., 'Communicating Astronomy with the Public 2018: Efforts on Bringing Together the International Astronomy Communication Community', Astronomy in Focus, Proceedings of the International Astronomical Union, Cambridge University Press, 2019, in press.

Biographies

Lina Canas is the IAU Assistant Outreach Coordinator of the IAU Office for Astronomy Outreach, based at the National Astronomical Observatory of Japan (NAOJ) in Tokyo, Japan.

Hidehiko Agata is the Chief of Education and Outreach Office of NAOJ and is the IAU Office for Astronomy Outreach Supervising Director.

Hitoshi Yamaoka is an Associate Professor and Chief of Public Relation Office of NAOJ. Born in Shikoku Island, Japan, where a beautiful night sky is available.

Shigeyuki Karino is a faculty staff at Kyushu Sangyo University, who is interested in neutron stars, science educations, and UNESCO World Heritages.

Opinion

The Use of Picture Postcards in Disseminating Astronomy

László Szabados
Konkoly Observatory,
Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences
szabados@konkoly.hu

Keywords
History of astronomy; telescopes; Solar System; space; deep sky objects

Picture postcards on astronomy are a good means of delivering information to the public. In this paper, the author – a professional astronomer, lecturer, science writer and postcard collector– reflects on the diverse use of picture postcards in bringing astronomy closer to the public.

Introduction

Collecting items is a popular hobby, and the range of collectibles is very wide – from butterflies to stamps, from beermats to postcards. I have been collecting postcards for sixty years.

Postcards are usually sent to loved ones or bought as souvenirs when travelling. An overwhelming majority of postcards have famous buildings, monuments or other places of interest from the country or city in question. You can also find postcards of paintings, sculptures and other art pieces in museums and galleries.

Just as a museum is a sanctuary of art, an astronomical observatory or a planetarium is a sanctuary of scientific knowledge. An important task of all of these institutions is to publicise their treasured collections. For an astronomy institution, this treasure may include rare books in their library collections, scientific results and spectacular photos of the Universe. These visual pieces of information can be easily captured and shared in the form of a postcard – a relatively inexpensive memento with a beautiful and meaningful photo on the face and a brief explanation of the image on the reverse.

Within and Beyond Astronomy

Astronomy-related images can be readily categorised into several (sometimes overlapping) thematic groups:

- History of astronomy;
- Observatories and telescopes;
- Planetariums;
- Celestial objects;
- Explanation of astronomical phenomena;
- Astronomy in the arts;
- Astronomical events;
- Advertisements using astronomy-related content.

History of Astronomy
Postcards related to the history of astronomy can depict any relevant object or document from ancient times to the recent past. Examples are megalithic observatories, old astronomical instruments, portraits or sculptures of famous astronomers, title pages or excerpts from classical astronomy books and obsolete instruments or historic observations from observatories that are still in service (Figure 1g).

Observatories and Telescopes
Postcards of observatories and telescopes can be divided into two main groups: ground based and space observatories/telescopes. An aerial view of a terrestrial astronomical observatory can be especially impressive. Beautiful colour postcards have been issued of the Hubble and Spitzer Space Telescopes and the Hipparcos astrometric satellite. Observatories detecting non-electromagnetic signals such as neutrino and gravity waves are also in this category. These postcards are often issued by major space agencies. NASA and ESA often publish series of postcards when a new space probe for carrying out astronomical research is launched (Figure 1e).

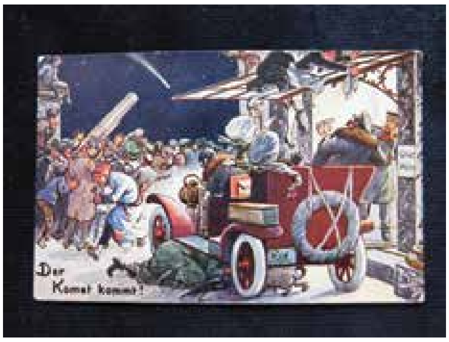
Planetariums
The main task of planetariums is to disseminate knowledge about astronomy and the Universe. Therefore, planetariums usually publish postcards not only of their own equipment and domes but also on various astronomical topics – from Solar System objects to deep-field images.

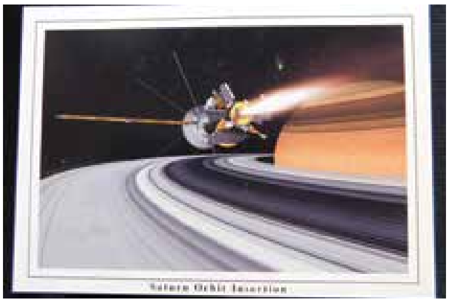
Celestial Objects
The largest group of astronomy-related postcards are probably those that depict celestial objects or phenomena. Astronomers are aware of the richness of the night sky, so there is no need to give a list here. Celestial objects and deep-sky phenomena can be visualised beyond the visible range of the electromagnetic spectrum. Impressive postcards exist, for example, of X-ray views of supernova remnants and infrared views of star-forming regions.

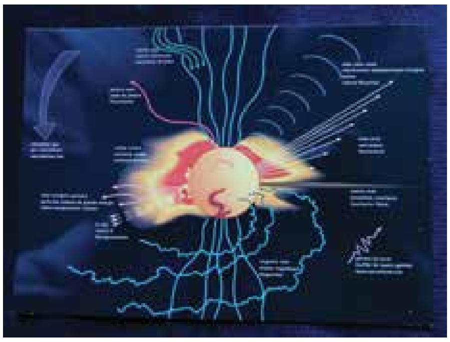
Explanation of Astronomical Phenomena
Some, very specific, postcards explain an astronomical phenomena or notion. Examples in my collection are the structure of the heliosphere issued by ESA when the Ulysses solar probe was launched and the visualisation of non-radial stellar pulsations on a postcard by the Instituto de Astrofísica de Canarias.

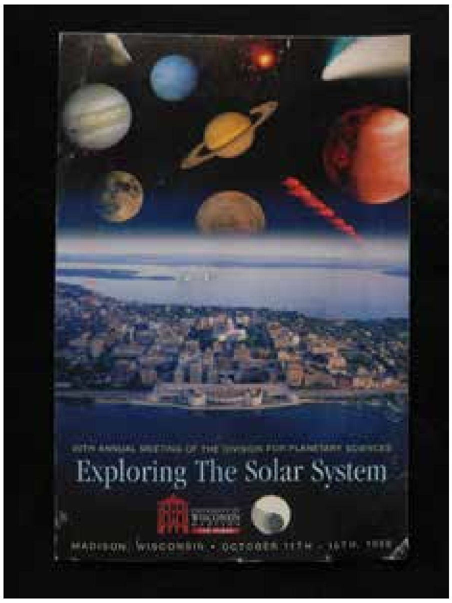
Astronomy and the Arts
Pure scientific content may not attract people completely unfamiliar with astrophysics. However, they may get closer to astronomy by staring at postcards of the 'interdisciplinary' field of astronomy in the arts. Painters sometimes draw inspiration from the night sky. The Starry Night and The Starry Night over the Rhône, famous paintings by Vincent van Gogh which are on display at the Museum of Modern Art, New York and Musée d'Orsay, Paris, respectively, have been reproduced on postcards. Another well-known example is The Astronomer painted by Jan Vermeer van Delft. The original painting can be seen in the Musée du

Figure 1. *Part of the author's postcard collections. (from top to bottom, left to right) (a) A collage of postcards; (b) Astronomical Museum postcard, (c) Comet Halley 1910 approach postcard, (d) Cassini mission postcard, (e) Ulysses mission postcard, (f) Total Solar Eclipse 1999 postcard with solar filter embedded, (g) Lick Observatory postcard, (h) American Astronomical Society (AAS) Division for Planetary Sciences (DPS) Meeting postcard. Credit: László Szabados.*









Louvre, Paris. Good quality reproductions of The Astronomer on postcards are available in many museum shops. The postcard reproduction of Jacopo Tintoretto's masterpiece, The Origin of the Milky Way, at The National Gallery, London, is also worth mentioning. Victor Vasarely's many works of art also have astronomical titles, such as, Vega-blue and Quasar-dia (which are on exhibit in Vasarely Museum, Pécs, in the native town of the Hungarian-born French master). These latter pieces do not resemble the star Vega or any quasar but the title itself may arouse the spectator's interest in the real Vega and quasars. Astronomy-related sculptures also include statues of famous astronomers such as Copernicus, Galileo and Ulugh Beg. Reproductions of these sculptures are often available on postcards too.

Astronomy Events

A completely different kind of astronomy-related postcard aims to advertise certain events, either celestial or terrestrial. For instance, postcards have been issued to commemorate the XIXth General Assembly of the IAU in New Delhi in 1985, the 1998 annual meeting of The Division for Planetary Sciences of the American Astronomical Society (Figure 1h), on the occasion of the International Year of Astronomy in 2009 (Figure 2) and for advertising total solar eclipses in certain geographical regions over time (Figure 1f). The diversity of the events is a key element here.

Advertising

Marketing based on astronomy is extensive. Various postcards carry an astronomy-related photo or graphics for advertising a product or service. The products and services may be completely unrelated

Figure 2. *Postcards issued during the International Year of Astronomy 2009. Credit: László Szabados.*

Figure 3. *The back of postcards usually contains information explaining the subject, therefore useful to disseminate astronomy. Credit: László Szabados.*

to astronomy or may be issued by astronomical institutions to popularise their own products and services. Examples for this kind of postcard are the online edition of the Barnard Atlas by the Georgia Institute of Technology and a series of postcards by the SIMBAD in Strasbourg, France, to popularise their Aladin Lite service.

Personal Experience Using Postcards to Disseminate Astronomy

The beauty of astronomy-related postcards is only one part of their value. They are also very useful for disseminating astronomical knowledge in various forms.

During public lectures, I can pass around postcards with topics related to the title of the talk. This requires careful selection of about a dozen postcards.

When I am to appear on television, some of my postcards always accompany me. Editors usually agree to show close-ups of the postcards during our conversation to illustrate certain points. On the occasion of the Cassini Grand Finale, I was able to present a set of postcards issued by the NASA Cassini Team and other picture postcards on Saturn and its satellite system (Figure 1d).

In written dissemination, using postcards for figures gives a special flavour to the article. In May 2018, I published a paper about the history of astronomy from antiquity to the Extremely Large Telescope in the monthly, Természet Világa (World of Nature), in Hungary (Szabados, 2018). All twenty figures were reproductions from genuine postcards.

Another possibility is to arrange an exhibition of postcards. I mention two examples: one from the past and one yet to take place. In 1992, I presented a poster during the IAU/ICSU/UNESCO Meeting Adverse Environmental Impacts on Astronomy in the UNESCO Headquarters in Paris. In this poster about a dozen picture postcards were used for visualising how pollution destroys the night sky.

A plan for the near future is to organise an astronomy postcard exhibition on the occasion of the centenary of the International Astronomical Union. This event will take place in the headquarters of the Hungarian Academy of Sciences in the second half of 2019.

Conclusion

With this brief article, my intention was to draw attention to the usefulness of postcards as tools for communicating astronomy with public. In addition to leaflets, brochures and booklets, astronomical institutions must publish postcards to showcase their own activity, history, scientific results and the beauty of the Universe.

I am grateful to my colleagues for gifting me numerous picture postcards and thus contributing to the enrichment of this unique collection.

Reference

Szabados, L., “Rendhagyó szemléltetés,” Természet Világa, 2018, p. 217-222.

Biography

László Szabados research professor emeritus has been a staff member of the Konkoly Observatory, Hungary, since 1971. His main field of interest is astrophysics of variable stars, especially Cepheid variables. In addition to 170 research papers, he has published 285 popular articles and edited ten conference proceedings. He has been the co-editor of the IAU Information Bulletin on Variable Stars and a natural science editor of Magyar Tudomány, the monthly periodical of the Hungarian Academy of Sciences, for decades.

WOMEN & GIRLS in Astronomy

Organize or join an event worldwide to celebrate women and girls in astronomy!

inclusive-astronomy.org

#IAU100
#WomenInAstronomy
#WomenInSTEM

IAU 100 Global Partners

Are we Alone? Discussing the Public's Most Asked Question with Professor Martin Rees

Sze-leung Cheung
IAU Office for Astronomy Outreach
cheungszeleung@iau.org

Keywords
Interview; astrobiology

In this column Sze-leung, editor of CAPjournal, interviews Professor Martin Rees, a well known astronomer and author of many public-facing astronomy and science books, on one of astronomy's most popularised questions: Are we alone?

Interviewer: Martin, you spend a great deal of time speaking to the public, what are the most fascinating questions you get?

Martin: Science is a truly global culture. It spans all barriers of nationality and faith. That's especially true of astronomy. Throughout history, people have gazed up at the same night sky and wondered about it. It's the one feature of our natural environment that all of us have in common.

It attracts the young and old from around the world and the scope for amateurs is now far larger thanks to the Internet. The discoveries being made can be appreciated by anyone, like close-up pictures of planets and moons in our Solar System, not to mention the remarkable realisation that billions of stars in our Galaxy are, like our Sun, orbited by retinues of planets, many like the Earth.

When I talk to general audiences about these discoveries or when I casually meet someone and tell them I'm an astronomer, the first question they are likely to ask is 'are we alone?'. This is, for me, the most fascinating question of all. It's also the one I enjoy talking about, even though it's a question that nobody knows the answer to yet. But searches are now being carried out.

Interviewer: So, from your point of view, compared to other disciplines, do you think communicating astrobiology with the public is particularly important nowadays?

Martin: I think astrobiology is clearly a very important subject, but it has had a fairly low profile in the past. Even though scientists know it's important, people thought it was too difficult and didn't work on it because they didn't think they could make progress. But, so much progress has been made in the past decade that it has become a much more vibrant subject. Most importantly, of course, is the discovery of the exoplanets. We now know that there are literally billions of stars in our galaxy and yet, we have observed life only on Earth. People care about how life began here on Earth, but no one actually knows. We understand evolution as explained by Darwin, evolution through bio-selection and into the biosphere. But, the actual transition from non-living to living, from complicated chemistry to the first metabolized reproducing structure, remains a mystery. No one understands that but people have been working on it. There were the Miller–Urey experiments 60 years ago, but now, years later, we have a lot serious chemists working on it.

Figure 1. *Interviewer with Martin Rees. Credit: Sze-leung Cheung.*

So, I think there is every hope that there will be progress in understanding the origin of life, and this is very important, obviously, for anyone who is interested in the evolution of life on Earth. It will also tell us two other important things. First, it will tell us whether it is a rare accident or if we should expect it to happen in other places, in environments and on planets beyond Earth. Secondly, it might tell us whether there is actually something very special about the chemistry of DNA and RNA. This would imply that other life is going to be of the same chemical basis. If it isn't special, it might just be one of many building blocks. We could even have life without water.

I am hopeful that in ten years we will understand the origin of life, have a better feel for how likely it is to find biospheres on other planets like the Earth, and what the chemistry of those biospheres might be. Now, of course, that does not mean any kind of intelligent life, which is the most fascinating question.

Interviewer: Yes, it is! So what about intelligent life? Are there aliens out there?

Martin: We don't really know because biologists who study evolution on Earth disagree on whether it was inevitable that simple life would evolve into complex life as in our case or whether it happened through a series of lucky accidents. But, the other issue is if intelligence has emerged, will it be in people like us? Or, will it be quite different? I think it is unlikely that we will settle this question, but I think it is worthwhile to look for evidence of intelligent life. And, there are several projects looking for this evidence. It could be some peculiar transmissions in radio observations or oddly shaped objects in the asteroid belt—we are looking for all of these things.

Interviewer: These kinds of major discoveries seem important to draw public attention. Do you think these are important topics for professional communicators to share with the public?

Martin: These are the most fascinated topics for the public and that's why it's a topic that should be funded, should be developed. Most funding for the search for intelligence life comes from private individuals like the SETI institute[1].

Interviewer: So you think that making the public understand the potential of this area could help with government funding?

Martin: If I was making a case to the government, irrespective of the country, I would feel more comfortable making a case for the search for intelligent life than for a big particle accelerator. I would feel that way because if you were to take an opinion poll of people coming out of science fiction movies, it's likely that a lot of them would be happy if their taxes were used in that way. I am not sure that as many would be happy with their money being used for the accelerator. So, I'm surprise there is no public money going into the search. But, the good news is there is enough private money going into this programme.

Interviewer: You mentioned there has been significant change in the past decade. What do you think might change in the next decade?

Martin: Well, I think in the next decade we will have a better understanding of how life began and of exoplanets. We will have the next generation of telescopes like the European Extremely Large Telescope with a 39-meter mirror to take a spectrum of Earth-like planets and perhaps, we will have evidence of their atmosphere and biosphere. We can't do this with the existing telescopes. But, I think with the next generation this will be possible and getting some good evidence will be very exciting indeed.

Interviewer: Yes, that would be very exciting! Thank you so much for your time.

Interview by Sze-leung Cheung.

Notes

[1] SETI is a not-for-profit research organisation whose mission is to explore, understand and explain the origin and nature of life in the Universe.

Biography

Martin Rees has been the Astronomer Royal since 1995 and was the President of the Royal Society from 2010 to 2015.

Sze-leung Cheung is the IAU International Outreach Coordinator based in the National Astronomical Observatory of Japan.

Astronomy for All Senses

David Gruber
Planetarium Südtirol Alto Adige
david.gruber@planetarium.bz.it

Keywords
Astronomy exhibits; planetarium; sensory communication; tactile astronomy

In this article, we describe the content of a small and cost-effective exhibit at Planetarium Südtirol in northern Italy, in the hope that other science centres can benefit from it and reproduce it. The exhibit is called Astronomy for All Senses, and it interacts with all five human senses to facilitate learning about the Universe.

Introduction

Planetarium Südtirol is a small education centre in the Italian Dolomites. As the nearest settlement to this centre is located at some distance, we wanted to offer the public more than a standard planetarium show to make their journey worthwhile. So, we planned an exhibit that added to their visit.

Together with a student apprentice, we developed Astronomy for All Senses, a free-of-charge exhibit consisting of astronomy-related experiments, ideas, articles and illustrations that engaged with all five human senses: taste, smell, sight, hearing and touch. Many such multi-sensorial astronomy-related activities are already available, such as the g-astronomy project (Trotta, 2018)[1]. Most often, tactile ideas and activities developed are for the visually impaired[2]. For our exhibit, we combined these existing activities from different science communicators around the world into one special exhibit.

The exhibit was self-explanatory, as the planetarium had only two staff members who were usually busy with planetarium shows and not available as tour guides. Using off-the-shelf products from hardware stores and supermarkets, some LEGO bricks and a little bit of creativity, we were able to prepare a didactically entertaining and worthwhile exhibit for under 1000 euros. The exhibit was open to the public from 10 October 2017 until the end of September 2018.

Here, we describe the various stations, so as to enable other planetaria and science centres to do something similar.

Taste

Drink a Planet
To help our visitors visualise the sizes of the planets in our Solar System, we modelled them using various types of fruit. Because it is almost impossible to find real fruit in the exact shapes and sizes needed to make everything to scale, we printed the fruit on paper and used fruit juices for the taste component.

We selected the following juices: black currant (Mercury), small strawberry (Venus), cherry tomato (Earth), bilberry (Mars), large pineapple (Jupiter), large grapefruit (Saturn), apple (Uranus) and peach (Neptune). The determining factor for the selection was not only scientific accuracy, but also the availability of the juices. For instance, a watermelon would have been a

Figure 1. *Drink a planet exhibit. Credit: David Gruber.*

Box 1. Connection between objects and its smell

- Using the radio telescope IRAM in Spain, scientists discovered the chemical ethyl formate in Sagittarius B2, a dust cloud in the center of the Milky Way. This chemical is the dominant flavour in raspberries, as well as an important one in rum.
- Astronauts on the Moon reported that as soon as the lunar dust reacted with the atmosphere in the lunar module they were reminded of the smell of spent gun powder.
- Several studies report the existence of ammonia in comets.
- The atmosphere of Venus consists, among other things, of sulphur dioxide with clouds consisting of sulphuric acid.
- On Europa, the moon of Jupiter and Enceladus, a moon of Saturn, we discovered liquid oceans underneath their icy crust, hence the smell of water.

Figure 2. *Glass bottles with different contents. Credit: David Gruber.*

better choice for Jupiter, but it was not possible to source the juice. An Austrian beverage company Rauch was kind enough to sponsor the juices for this specific exhibit.

Smell

What's That Smell?
In the first of our two smell stations, we had five small glass bottles – one each for sulphur, water, raspberry spirit, ammonia (diluted with water) and some gun powder from fire crackers to resemble black powder (its possession is illegal in Italy). The bottles were labelled with the letters A to E. The goal for the audience was to smell the contents of each bottle and assign each scent to a given astrophysical object, printed on a sheet of paper

The correct matches were as follows: Venus with sulphur, which should really be sulphur dioxide (Marcq, 2013); Europa with water; Sagittarius B2 with raspberry (Belloche, 2009); a comet with ammonia (Wyckoff, 1989); and the Moon with black powder[3]. On the back of the paper, we listed the correct solution, with a short explanation on why the objects smell like they do.

Eau de Comète
The scent firm The Aroma Company crafted a mixture to mimic the odour of comet 67P/Churyumov Gerasimenko, as reported by the ESA lander Philae. According to Philae's findings, 67P smelled like rotten eggs, cat urine and bitter almonds[4]. The cometary odour was captured on post cards which

Figure 3. *Postcard with 67P/Chury's scent. Credit: David Gruber.*

we displayed at our exhibit, together with an explanation.

Sound

The Sounds of Space

The first sound exhibit consisted of a desktop computer and a set of headphones. Using interactive buttons, our visitors could click through various slides that contained six astrophysical phenomena and their respective sounds.

Among the sounds used were winds recorded by the ESA lander Huygens during its descent through the atmosphere of Saturn's moon Titan[5], the sound of the oscillation of 67P's magnetic field[6], the sound of the aurora[7,8] and the sonification of stellar oscillations by the Sun, a White Dwarf, a Red Giant and a pulsar. In addition to allowing visitors to play back the sounds, we included a very short description on each slide.

Even though most of our visitors generally understood the concept of sonification, an elementary school student was confused, as she (correctly) assumed that because of the absence of air (or another medium), space should be quiet. We updated our slides with a statement that all the presented oscillations were shifted to the audible spectrum and that a carrier medium would be required.

Your Voice on Another Planet

The second sound station was a mathematica computer programme called soundmorph, which was created by Prof Timothy Leighton from the Institute of Sound and Vibration Research, University of Southampton (Leighton, 2016). This software can modify the speech of a visitor in accordance with the underlying physics to reproduce those vocalisations as if they had been produced on Mars, Venus and Titan. In addition, it contained sounds of other natural phenomena on the aforementioned planets, for instance thunder and cryovolcanoes.

Touch

How Much Do I Weigh on…

In this exhibit, visitors could compare what it felt like to lift a bottle of a certain weight here on Earth and on a planet with a different gravitational acceleration. We filled one half litre bottle with about 0.3 kilograms of fine beach sand; this served as the reference bottle on Earth. We then used another set of bottles filled with sand to show how the weight would change under the gravitational acceleration on other planets. In addition, we put an image of the planet in question on the lid of the bottle. As gravitational acceleration is very similar on Venus, Saturn, Uranus and Neptune, we also used a small kitchen scale to make it easier for our audience to see the differences in weight. In the description, we explained the difference between mass and weight and provided a multiplication factor with which a visitors could calculate their weight on each planet and on the Moon.

Touching the Moon

NASA has an archive of open source 3D models[9], which everyone can download and print with an appropriate 3D printer. Using a 3D printer from computer solutions company IDM[10], we printed the landing site of Apollo 15[11] and the Aristarchus plateau[12], the highest reflectance feature on the Moon.

Using an LED reading lamp, visitors could play around with different incident illumination of the Sun to see how craters and mountains cast shadows.

Figure 4. *Desktop PC with headphones to listen to space. Credit: David Gruber.*

Figure 5. *A microphone, speakers and a laptop running soundmorph to let visitors listen to their own voice on another celestial object. Credit: David Gruber.*

Figure 6. *Various bottles filled with beach sand. Credit: David Gruber.*

Sight

Landing on the Moon
At the Touching the Moon exhibit, we provided visitors with the means to see the Moon in 3D using anaglyph (blue/red) glasses. Stereoscopic images shot by the Lunar Reconnaissance Orbiter (LRO) are widely available online to make this possible[13,14].

In addition, we used Google cardboard[15] and the smartphone app Apollo 15 VR[16] to let our visitors experience the lunar landscape through virtual reality. Visitors downloaded the app on their own smartphones. Note that not all smartphones support a virtual reality mode.

LIGO with LEGO®
The University of Osnabrück built a Michelson interferometer using LEGO® bricks, a couple of small mirrors and a class II laser. The building instructions (both pdf and video), including the list of necessary bricks, are available online[17]. We bought the bricks on bricklink.com, the largest online marketplace to buy individual LEGO® parts. The prices of the bricks depend highly on the chosen colours, which is why our version of the interferometer is rather colourful. We ordered a 650 nm, 1 mW laser 20 (laser class II)[18], which is sufficient to show the interference pattern. Assembling the interferometer was relatively easy. We refrained from building the breadboard as it would have been too expensive given the large number of bricks. Without the breadboard, which dampens unwanted noise, small vibrations (talking or walking next to it) were picked up by the interferometer and were visible in the interference pattern.

A Lycra Universe
To illustrate the bending of spacetime by a massive body, we used a large sheet of Lycra, which we bought from a local tailor. We stretched the sheet over four PVC tubes forming a square and secured it to the tube with twelve plastic clamps. We loosely followed the building instructions given in a YouTube video called *Gravity Visualized*[19]. We used small rocks, marbles of different sizes and Chinese stress balls to further illustrate Einstein's view of the Universe. A word of warning: without supervision, children tended to misuse the Lycra universe as a trampoline for the marbles, which led to many missing balls over the course of the exhibit.

Discussion

Because of the lack of personnel, we were not able to robustly evaluate whether our visitors understood astronomical concepts better after their visit and/or how much time they spent at each station. However, we know that visitors usually come to the planetarium on average thirty minutes before a show to buy their tickets, and this is the time they spent at the exhibit. Verbal feedback from visitors has been positive. Children seemed to like the voice changer and the juices (especially after a long planetarium show) while adults were more interested in Lycra Universe and the LEGO interferometer.

In this article, we have presented a very cost-effective, reproduceable and easily realised multi-sensorial astronomy exhibit for audiences of all ages. The exhibit does not require extra security personnel or guides and can therefore be implemented

Figure 7. *Two 3D printed sceneries, together with anaglyph pictures of the Moon. Credit: David Gruber.*

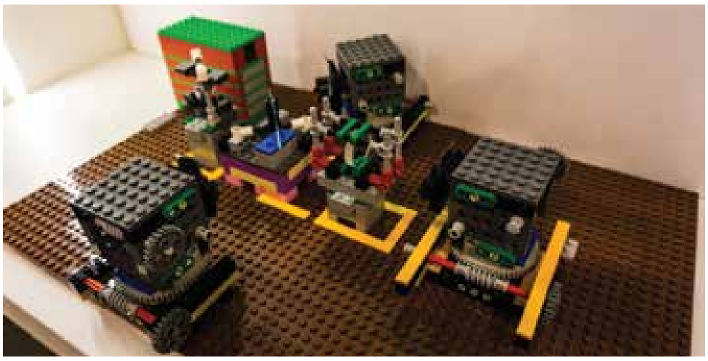


Figure 8. *LEGO interferometer. Credit: David Gruber.*

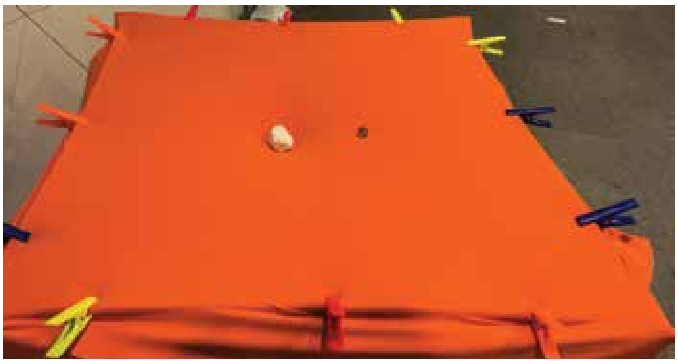


Figure 9. *Two-dimensional version of a universe, created with Lycra. Credit: David Gruber.*

in planetaria with limited human and financial resources.

References

Leighton, T. et al., 'Extraterrestrial Sound for Planetaria: A Pedagogical Study', The Journal of the Acoustical Society of America, vol. 140, no. 2, 2016, pp. 1469-1480.

Trotta, R., 'The Hands-On Universe: Making Sense of the Universe with All Your Senses' Communicating Astronomy with the Public Journal, vol. 23, 2018, p. 20.

Marcq, E. et al., 'Variations of Sulphur Dioxide at the Cloud Top of Venus's Dynamic Atmosphere', Nature Geoscience, vol. 6, 2013, pp. 25-28.

Belloche, A. et al., 'Increased Complexity in Interstellar Chemistry: Detection and Chemical Modeling of Ethyl Formate and N-propyl Cyanide in Sgr B2(N)', Astronomy & Astrophysics, vol. 499, no. 1, 2009, pp. 215-232.

Wyckoff, F. et al., 'Ammonia abundances in comets', Advances in Space Research, vol. 9, no. 3, 1989, pp. 169-176.

Notes

[1] More information on the g-astronomy project: www.kitchen-theory.com/g-astronomy-the-universe-at-the-tip-of-your-tongue/

[2] Examples of experiments for the visually impaired: http://sion.frm.utn.edu.ar/iau-inclusion/?page_id=75

[3] A first-hand account of the likeness of the moon's smell to that of spent gunpowder: https://science.nasa.gov/science-news/science-at-nasa/2006/30jan_smellofmoondust

[4] More information on the aroma company: http://www.aromaco.co.uk/portfolio/the-open-university/

[5] More on the sounds of Saturn's moon, Titan: http://www.esa.int/Our_Activities/Space_Science/Cassini-Huygens/Sounds_of_an_alien_world

[6] More on the sound of 67P's oscillating magnetic field: https://rosetta.jpl.nasa.gov/news/rosettas-singing-comet

[7] More information on the sounds of the aurora: https://www.gresham.ac.uk/lectures-and-events/the-sounds-of-the-universe

[8] Video content on the sounds of the aurora: https://www.youtube.com/watch?v=Zcef943eoiQ

[9] NASA's open-source 3D models can be found here: https://nasa3d.arc.nasa.gov/

[10] More information on IDM's 3D printer: https://www.idm-suedtirol.com/en/eu-projects/innovation/69-makerspace.html

[11] 3D model of Apollo 15: https://nasa3d.arc.nasa.gov/detail/Apollo15-Landing

[12] 3D model of the Aristarchus plateau: https://nasa3d.arc.nasa.gov/detail/aristarchus

[13] Stereoscopic image of the moon: http://lroc.sese.asu.edu/posts/733

[14] More information on the Lunar Reconnaissance Orbiter: https://www.nasa.gov/mission_pages/LRO/news/3d-moon.html

[15] Google cardboard: https://vr.google.com/cardboard/

[16] Smartphone app Apollo 15 VR: https://play.google.com/store/apps/details?id=com.ThomasKole.Apollo15VR&hl=de

[17] Building instructions for a Michelson interferometer using LEGO® bricks: https://www.ufp.uni-osnabrueck.de/en/education/myphotonics.html

[18] Laser built was the a 650 nm, 1 mW laser 20 (laser class II): https://www.laserfuchs.de/de/punktlaser/lfd650-1-4-515x68

[19] Video on YouTube demonstrating the bending of spacetime: https://www.youtube.com/watch?v=MTY1Kje0yLg

Biography

David Gruber studied gamma-ray bursts and other high-energy transients at the Max Planck Institute for Extraterrestrial Physics in Munich, Germany. After his PhD, he worked for five years at the Planetarium Südtirol in Italy as a science and astronomy communicator. Currently, he is Director of the Museum of Nature, South Tyrol, Italy. You can find him on Twitter (@antisophista) and Instagram (@dj_of_the_universe).

Towards Gender Equality: Girls' Day at the Museum of Astronomy and Related Sciences

Patrícia Figueiró Spinelli
Museum of Astronomy and Related Sciences, Brazil
patriciaspinelli@mast.br

Sandra Benítez Herrera
Museum of Astronomy and Related Sciences, Brazil
Institute of Astrophysics of the Canary Islands
sandra.benitez.herrera@gmail.com

Ana Paula Germano
Museum of Astronomy and Related Sciences, Brazil
ana.germano@gmail.com

Keywords
Women in STEM; women in science; astronomy education; science museums; gender equality

It is widely recognised that women are underrepresented in science, technology, engineering and mathematics (STEM). The United Nations Educational, Scientific and Cultural Organisation (UNESCO) is encouraging worldwide efforts to overcome gender disparities, and the Girls' Day at the Museum of Astronomy and Related Sciences (MAST) in Rio de Janeiro, Brazil, is one such initiative. The event stimulates discussion on inequality in science, brings female scientists and young people together and inspires young women to pursue astronomy through communication and engagement activities.

Introduction

Science is a powerful institution for the development of humankind, but as with any other human endeavour, it is not neutral but subject to the social constraints and norms that exist in society at the time and place it is developed. Several social studies of science have concluded that science is value laden (Bronowski, 1956). The underrepresentation of women in science, technology, engineering and mathematics (STEM) careers is part of the social context of science and how it has developed.

Gender segregation in this context refers to the unequal distribution of men and women in careers and may occur in two forms: (1) horizontal segregation or gender tracking, meaning that men and women cluster in different jobs and (2) vertical segregation or a glass ceiling, meaning that men occupy the top-tier jobs whereas women are concentrated in the less powerful, prestigious and lowest-grossing positions in the workforce.

As with other sciences, astronomy is subject to this gender imbalance. Many factors have been cited as potential contributors to this and affect female professionals in the field (Flaherty, 2018; Reid, 2014). Strategies to address these issues include the inclusion of more young women in discussions about STEM careers. Girls' Day at the Museum of Astronomy and Related Sciences (MAST) is oriented towards this and attempts to tackle the horizontal segregation problem in STEM careers.

A recent study showed that Brazil is a global leader in terms of the participation of women in the sciences (Elsevier, 2017), with nearly half of the country's scientific scholarly articles written by female authors. This is an important step towards equity, but stratification across research fields shows that Brazilian female scientists are predominantly clustered in the fields of social science, education, biology and medical sciences. The percentage of Brazilian women in physics, geology, engineering, computer sciences and astronomy careers is far lower.

Data from the Brazilian National Council for Scientific and Technological Development Census indicate that the percentage of PhDs in STEM subjects held by women is 31%[1]. A study by the International Astronomy Union (IAU) (Cesarsky & Walker, 2010) that analysed the percentage of women from countries with at least 40 IAU members, as is the case with Brazil, indicates that the increase in the number of women in astronomy-related careers has been negligible over the years. In 2009, when the study was carried out, the percentage of Brazilian IAU members who are female was 22.7%. Twelve years previously, this percentage was 16.5%. Using IAU membership as an indicator and assuming the improvement continues at this rate, Brazil will not reach gender equality in astronomy until 2070. To increase this rate, more girls need to opt for studying STEM subjects.

Another motivation for selecting girls as the target group for the engagement activity described in this paper was the results of a 2015 survey on public perception of science in Brazil[2]. The results of this survey showed that only 6.7% of the population can name a Brazilian scientist, and this percentage dropped to 2.7% among girls aged 16–24 years.

Girls' Day around the World

Initiatives aimed specifically at engaging girls with science and encouraging them to pursue STEM careers have been adopted since at least the early 90s. In the US, girls would accompany relatives working in STEM to work at certain participating companies, scientific institutions and universities. Girls' Day grew out of this movement and was first adopted across Europe in the early 90s.

Since its implementation in 2001, the Girls' Day-Mädchen-Zukunftstag in Germany, has reached over 1.7 million girls and adolescents. It has been officially implemented by the Federal Ministry of Education and Research, the German Trade Union Confederation and the D21 initiative, and coordinated by the Competence Centre for Technology, Diversity and Equal Opportunities. The number of participants increases every year, and data show that 33% of the participating institutions have later received traineeship requests from young women who had attended the Girls' Day events. A marginal increase has also been found in the number of young women pursuing STEM careers at German universities (in 2008, 21% of STEM students were female; in 2018, this value was 24.9%). More information on these results is available on the programme website[3].

In Hungary, the Girls' Day initiative took place for the first time in 2012, and now involves nearly 2000 students per year (Vámos, 2012). In Portugal, the Museu das Comunicações first celebrated Girls' Day in 2017 by launching a competition for digital art works[4].

The Girls' Day model has also taken place in the Science Museum of Minnesota, Burke Museum, Museum of Science in Boston, Nemo Museum in Amsterdam and Deutsches Museum in Munich, among others. These programmes range from single-day events to long-term programmes with activities that aim to stimulate interest in science among girls. Some museums, for example, Deutsches Museum, provide guided tours that highlight areas led by women in their exhibitions[5].

Role of Museums in Gender Equity

The described initiatives are best understood in light of the intense democratisation happening in museums worldwide. Museums have become more than mere preservation and exhibition establishments, expanding their field of action to embrace new practices and activities (Valente, 2009). They have developed broad educational programmes aimed at increasing dialogue with the public, who are increasingly seen as active participants rather than passive receivers of information (Marandino, 2008).

Marandino (2008) highlights that visiting a museum may not only stimulate a will for learning and observation but bolster the exercise of responsible citizenship through educational activities and encourage the participation of diverse groups of people from different socio-economic backgrounds. This is of utmost importance, since recent studies show that despite recent changes, science museums still pose multiple barriers for lower-income and minority groups (Dawson, 2014).

The researchers at the Science Education Department at MAST have long been aware of the potential that science museums have to promote social change and empowerment (Cazelli et al., 2018). This is particularly interesting for gender inclusion, as the museum becomes a place to question the privileged production of scientific knowledge by the male half of the population. It can be also be an arena through which role models can be provided to young female visitors. The researchers believe that museums need to grow into social institutions dealing with issues of public interest, as well as creating spaces for traditionally excluded audiences. They need to act as agents of inclusion (Gruzman and Siqueira, 2007).

Girls' Day in Brazil

Motivated by events taking place around the world, and a will to contribute to social inclusion and gender equity in science, Girls' Day at MAST began in 2015. It was promoted in March to coincide with International Women's Day. Designed to inspire a potential generation of researchers, the event connected girls with prominent female scientists from various sci-

Figure 1. *Promotional flyer from the third edition of Girls' Day in Brazil. Credit: MAST, Rio de Janeiro.*

	2015	2016	2017	2018
Theme	Women in science: Experiences and perspectives	Girls in STEM: Yes we can!	First-timer Scientists	Science is for all: gender and ethnicity matter
Research fields and areas of invited speakers	1. Astrophysicist, Maximilians Universität Munich, Germany Germany 2. Historian of Science, PUC-Rio de Janeiro, Brazil 3. Non-formal education researcher, Universidade Estadual de Campinas, Brazil 4. Physicist, Université Paul Cézanne, France	1. Astrophysicist, Technical University Munich, Germany 2. Physicist, University of Manchester, UK 3. Mobility Engineering, responsible for the traffic operations of the 2016 Summer Olympics 4. Pharmacist, Universidade de São Paulo, Brazil	1. Nuclear Engineering (winner of the international competition Nuclear Olympiad) 2. Pharmacist and innovation analyst 3. Student of Chemical engineering, member of the NASA Rover Challenge 2017 4. Student of physics	1. Astrophysicist, Caltech USA 2. Pharmacist 3. Physicist with experience in science museum theatre 4. Chemist with experience in Afro-textured hair 5. Geologist 6. Computer scientist, Apple Developer Academy
Education activities	1. Observation of the Sun with telescopes 2. Guided museum tour	1. Hands-on activities about nebulas and the interstellar medium 2. Telescope assembling and pointing 3. Theatre piece on the life of a scientist	1. Talk about female scientists forgotten by history 2. Electronic circuits workshop 3. Chat with the female competitors in the NASA Rover Challenge 2017 4. Dramatised guided museum tour	1. Hands-on activity about Mary Tharp and plate tectonics 2. Hands-on activity: Scale model of the Solar System 3. Guided museum tour 4. Observation of the Sun
Audience – Total number	122	134	170	152
Round-table on-line viewers	266	164	265	382

Table 1. *Themes, activities and audience of previous Girls' Days at MAST.*

entific institutions and universities in Rio de Janeiro, Brazil, as well as providing them with an opportunity to experience hands-on activities associated with astronomy and related sciences. To our knowledge, it was the first initiative of this kind in Brazil.

The first Girls' Day at MAST received 35% more participants than originally planned. Given this expression of interest, the event was officially included in MAST's annual agenda. In 2019, in its fifth year, Girls' Day at MAST will also be part of the IAU100-Under One Sky agenda.

The goals of Girls' Day at MAST are (1) to encourage girls to explore scientific career paths; (2) to acknowledge the contribution of female scientists and STEM professionals to scientific progress and society at large and to celebrate this with the general public; and (3) to break down social barriers and prejudices that prevent girls from pursuing STEM careers.

In all the editions of Girls' Day at MAST, we start with a round table meeting with researchers and professionals involved in science, technology and innovation. This debate is followed by a coffee break and observations of the Sun, to give the participants time to interact with the invited speakers in a relaxed atmosphere. After this, science education activities take place in small groups. The audience members can choose which activity they want to participate in beforehand. At the beginning of the event, the participants are provided a brief perspective of why gender equity in science matters. The discussion at the round table is streamed live. Table 1 summarises the activities that have taken place so far and the total number of people involved.

The first and second editions of Girls' Day at MAST focused on showcasing prestigious female STEM researchers and professionals and their contributions to the public. The invited scientists shared their personal experiences and the path they took towards a successful career in STEM.

A few months after the second Girls' Day, the coordinators of the event decided to go one step further. They launched a long-term science education pilot programme oriented toward female high school students. The programme had the goal of preparing the participants to act as science museum mediators[6], providing them not only the opportunity to learn astronomy through workshops but also to act as role models to younger visitors. To achieve this goal, three distinct phases were defined for the programme. In its first phase (July to December 2016), the participating students were trained to act as mediators during the third edition of Girls' Day at MAST. They also followed theoretical lectures and practical workshops on astronomy, science education and mediation in museums, as well as gender in science. In the second phase (February to September 2017), participants worked on the development of experiments and education activities. They also regularly acted as mediators in the education programme of the museum. The third phase of the project took place in October 2017, when the participants exhibited their experiments during the Science and Technology National Week. The results of the evaluation of the long-term project for girls are presented in Benítez-Herrera et al. (2019).

Figure 2. A dramatised guided tour through the Museum of Astronomy, former home of the National Observatory in Brazil, from the third edition of Girls' Day Brazil. Credit: MAST, Rio de Janeiro.

The first experience of the participants acting as mediators was during the third Girls' Day at MAST. We shifted the event focus from presenting renowned scientists to scientists in training, discussing the importance of exposing girls to science at a very young age. All of the invited speakers at the round-table discussion were young professionals or college students who got involved in science when they were still adolescents. The girls participating in the long-term programme at the museum led the hands-on activities that followed the round-table discussion, always accompanied by a senior scientist. This proved to be a good way to introduce junior scientists or scientists in training as role models to the girls who participated.

In the fourth edition, a wider discussion was launched. As a developing country, Brazil faces serious racism issues. The socio-economic status of the population strongly correlates with skin colour. Therefore, it is careless to discuss gender segregation and skip the segregation that Afro-Brazilians and indigenous groups face. If the presence of women in STEM careers is not adequate, the presence of black and indigenous women is almost negligible[1]. With this in mind, the Fourth Girls' Day saw multi-ethnic scientists speaking to the girls. In this edition, we held more than one round-table discussion to accommodate different topics. We also invited speakers who are currently studying topics that are of interest to black communities, such as environmental racism and properties of Afro-texture hair. Unfortunately, we found only one indigenous female scientist based in Rio de Janeiro, and even she could not accept our invitation to speak because she was doing field work in the Amazon.

The target audience of all events were teenage girls, but we have not restricted attendance to any age, or even gender. We did, however, always have a high school class (boys and girls) invited to take part. This comprised 40% of our capacity, and the remainder of vacancies were offered on a subscription basis. Nonetheless, we received spontaneous visitors who had not subscribed to the event, and we always tried to accommodate them. Interestingly, other groups of participants also showed up, namely, families with elementary school-aged children (parents brought their daughters and even their sons), groups of friends (female youngsters accompanied by male friends), activists or researchers interested in learning the pedagogical practice of the event and female university college and graduate students. In the third edition of the event, a considerable number of younger girls (6–10 years old) attended accompanied by their parents or guardians. In the fourth edition, we had a larger percentage of black teenage girls, a population usually underrepresented in science museums.

Conclusions

Gender imbalance in science is a problem that affects society as a whole. Attracting more women to science and, consequently, to astronomy is not only a matter of fairness, but a question of welcoming 50% of the intellectual capacity of humankind.

Figure 3. A great crowd of girls filled the auditorium to hear the invited speakers. Credit: MAST, Rio de Janeiro.

As institutions, science museums have the mission of expanding society's access to scientific knowledge and encouraging the excitement of discovery. They cannot be places that legitimise the exclusion of women's important contributions to science. Further, science museums must also engage diverse audiences and address the many facets of inclusion, without losing evidence of how our culture and knowledge have evolved to date. Therefore, it is fundamental to reflect on these issues and adapt the content of exhibits and activities to be gender inclusive.

Notes

[1] The Brazilian National Council for Scientific and Technological Development Census: http://lattes.cnpq.br/web/dgp/censo-atual/

[2] Public attitudes to science survey results: http://percepcaocti.cgee.org.br/

[3] Girls' Day - Mädchen-Zukunftstag Analysis Webpage: https://www.girls-day.de/Daten-Fakten/Zahlen-Fakten/Evaluation-und-Statistiken/Girls-Day-Evaluation

[4] International Girls in ICT Day (2017) activities in Europe: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Publications/International%20Girls%20in%20ICT%20Day%202017final.pdf

[5] Deutsches Museum Special Guided Tours: https://www.deutsches-museum.de/en/whats-on/guided-tours/special-guided-tours/

[6] Mediators are the professionals responsible for welcoming the public and carrying out activities in museums, such as guided tours and practical activities. They allow the visitors to deepen their understanding of the themes presented and make their experience more significant. Other terms used to describe these individuals are educators, monitors, presenters, guides and explainers.

References

Benítez-Herrera, S. et al. 'Pursuing Gender Equality in Astronomy in Basic Education: The Case of the Project "Girls in the Museum of Astronomy and Related Sciences"'. EPJ Web of Conferences. 200. 02010

Bronowski, J., 'Science and Human Values', Higher Education Quarterly, vol. 11, 1956, pp. 26–42

Cazelli, S., Falcão, D., and Valente, M. E., 'Stimulated Visits and Empowerment: For a Less Exclusive Museum', Caderno Virtual de Turismo – Rio de Janeiro, vol. 18, no. 1, 2018, pp. 66–84

Cesarsky, C., and Walker, H., 'Headcount: Statistics about Women in Astronomy', Astronomy & Geophysics, vol. 51, no 2, 2010, pp. 2.33–2.36

Dawson, E., '"Not Designed for Us": How Science Museums and Science Centers Socially Exclude Low-Income, Minority Ethnic Groups', Science Education, vol. 98, no. 6, 2014, pp. 981–1008

Elsevier, 'Gender in the Global Research Landscape - Analysis of Research Performance through a Gender Lens across 20 Years, 12 Geographies, and 27 Subject Areas', 2017, https://www.elsevier.com/__data/assets/pdf_file/0008/265661/ElsevierGenderReport_final_for-web.pdf

Flaherty, K., 'The Leaky Pipeline for Postdocs: A Study of the Time between Receiving a PhD and Securing a Faculty Job for Male and Female Astronomers', 2018, ArXiv:1810.01511

Gruzman, C., and Siqueira, V. D., 'O Papel Educacional do Museu de Ciências: Desafios e Transformações Conceituais', Revista Electrónica de Enseñanza de las Ciencias, vol. 6, no. 2, 2007, pp. 402–423

Marandino, M. et al., Educação em Museus: A Mediação em Foco, São Paulo, Geenf/FEUSP, 2008

Reid, N., 'Gender-Based Systematics in HST Proposal Selection I', 2014, ArXiv:1409.3528

Valente, M. E. A., 'Educação em Museus: A Dimensão Educativa do Museu', MAST Colloquia: Museu e Museologia: Interfaces e Perspectivas, vol. 11, 2009

Vámos, E., The Girls' Day in a Hungarian Museum, Rio de Janeiro, Cimuset, 2012

Biographies

Patrícia Figueiró Spinelli and Sandra Benítez Herrera have PhDs in Astrophysics from the International Max Planck Research School of Astrophysics, Germany. Currently, Patricia is a researcher in the area of science education at the MAST, and Sandra is a public astronomer at the Institute of Astrophysics of the Canary Islands.

Ana Paula Germano is an anthropologist and biologist. She also holds a masters in science education and is currently based at the Federal Institute of Education in Santa Catarina State, Brazil.

All authors are members of the GalileoMobile initiative and the coordinators of Girls' Day at MAST.

The Educational and Influential Power of the Sun

Alejandro Cárdenas-Avendaño
Montana State University, USA.
alejandro.cardenasa@konradlorenz.edu.co

Santiago Vargas Domínguez
Universidad Nacional de Colombia, Bogotá, Colombia.
svargasd@unal.edu.co

Freddy Moreno-Cárdenas
Centro de Estudios Astrofísicos, Colegio Gimnasio Campestre, Bogotá, Colombia.
fmoreno@campestre.edu.co

Benjamín Calvo-Mozo
Universidad Nacional de Colombia, Bogotá, Colombia.
bcalvom@unal.edu.co

Keywords
Public engagement; science and technology; science communication; developing world; research link; astronomy education; Sun.

This paper aims to encourage science educators and outreach groups to use the Sun as a tool to teach science in formal and informal education settings. We explain how the Sun can be used as a topic in this manner and share our experience across the educational spectrum in Colombia and how we have used it to drive development beyond astronomy.

Introduction

The Sun has undeniably ruled our lives since the beginning of human history, and before it began at the very birth of our planet. About 4.6. billion years ago, before planets in the Solar System were even formed, all of the matter that eventually created us was revolving around a huge disc, our early Sun. This protoplanetary disc was constantly cooling and planets emerged in areas where matter became concentrated owing to gravitational attraction. Millions of years later, conditions improved to favour the development of life.

The Sun has been the main source of energy to maintain life on Earth; it has gone from being a source of worship to an object of study for human beings.

Like its origin, the fate of our planet is strongly linked with the Sun, which will also be responsible for our planet's annihilation. There will come a day when the Sun will exhaust all its fuel, expanding into a giant red star whose size will be so large that it will swallow the Earth. There are still about five billion years until this happens, but for now, we must prepare for each solar maximum and protect the technology on which our modern civilization depends. A perfect solar storm, like the largest recorded to date which took place in 1859, could now have a huge impact on satellite technology, communications and power grids, causing losses worth millions of dollars (Moreno-Cárdenas et al., 2016)

The close relationship between the Sun and our history, present survival and future makes it a dynamic and interesting introduction to the world of science.

Colombia has experienced a scientific, technological and cultural transformation in recent years, showing considerable growth across these fields. In the midst of such important changes, it is critical to stress the importance of science and its

Figure 1. *Group of students at the Julio Garavito Armero Observatory, founded in 2000 at Gimnasio Campestre in Bogotá, Colombia. Credit: From the archive of the Gimnasio Campestre School.*

public perception and to create communication and engagement activities that will instill in society passion and admiration for what science represents and can offer. In this article, we describe our experience of creating solar astrophysics activities as part of a high school programme, for extracurricular science clubs, and at a university.

Observing the Sun at School

Gimnasio Campestre, a school in Bogota, Colombia, has been teaching basic astronomy since 1997. Its astronomical observatory, named after the prominent Colombian astronomer, Julio Garavito Armero (1865-1920), was built in 2000 (Figure 1). The observatory runs several activities and classes to involve children of all ages in science. For the youngest students, the curriculum is based on learning the fundamental positions and observations of the Sun, Moon and planets and basic knowledge about constellations. From students nine years of age (fourth grade in Columbia), the classes cover three main subjects: the origin of matter and the Universe, fundamentals of light and the Sun and impact of gravity and asteroids. For those aged eleven (sixth grade), the school offers classes on: stars and the Sun, the Earth and planetary geology, and planetary atmospheres. Older students (seventh–eleventh grade) have the opportunity to explore these topics in greater detail and do research as part of a curriculum unit called 'Jóvenes Investigadores' ('Young Researchers').

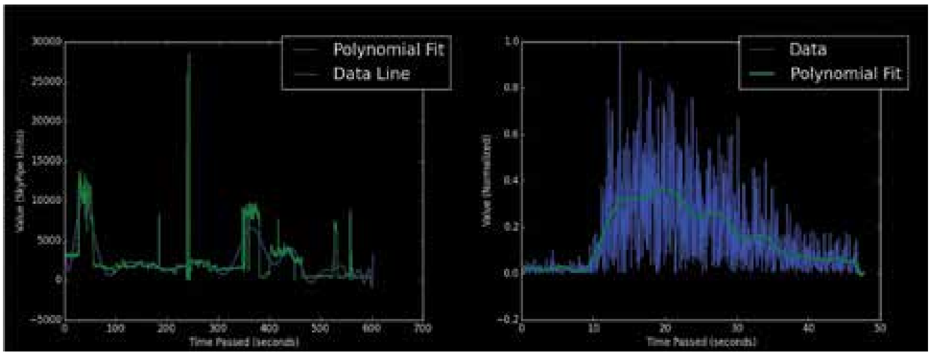


Figure 3. *An example of a scientific analysis performed on data taken on 6 September 2014 (14:10–14:20 UT) by a group of young participants that implements a polynomial fit by least squares, using Numpy (Walt et al., 2011) functions, to find a simple mathematical model that describes the data. The students used this technique to find a value for a missing data point. Credit: Julián Jiménez Cárdenas.*

Teachers have found that every year, students are particularly interested in learning about the Sun. In this academic environment, students learn about the multiple characteristics and phenomena of our star and also are trained in astrophotography. The observatory has been maintaining a record of these solar observations since 2001.

An important milestone in this project was the acquisition of an H-alpha solar telescope, which enables students to take images of filaments and solar flares. Every two years, a group of teachers and students involved in studying the evolution of the solar cycle publish an article on the subject in the school's research journal, El Astrolabio[1], and the most interesting images are sent to the SpaceWeather website[2] (Figure 2). To date, the results of the developed projects have been used to publish six articles in the school's research journal. Further, several such projects have enabled students and teachers to participate and present their research at conferences and national astronomy meetings and even publish their work in international journals. One such article in an international journal is based on a discovery report on an aurorae borealis seen in Colombia in 1859 (Moreno-Cárdenas et al., 2016).

School research projects based on observations of the Sun have been replicated in several schools in Bogotá. Currently, Gimnasio Campestre's Observatory mentors two public schools, fostering the development of scientific knowledge by involving students and teachers in interactive projects.

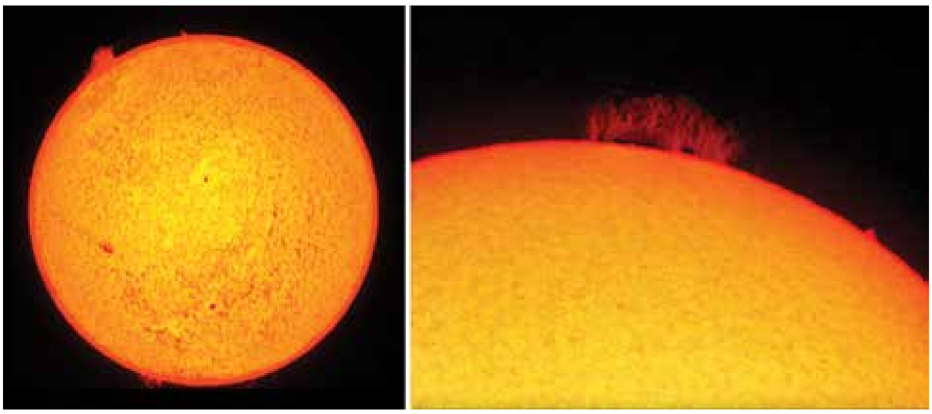


Figure 2. *Images of the Sun (H-alpha) acquired at the Observatorio Julio Garavito, Gimnasio Campestre in Bogotá, Colombia of the solar disc on 22 April 2015 (left) and detail of a prominence on 17 October 2017 (right). Credit: Freddy Moreno-Cárdenas.*

Studying the Sun before College: Seedbed Projects

Since 2010, the Young Talent Programme of Mathematics, Science and Technology has taken place each year at Fundación Universitaria Konrad Lorenz in Bogotá, Colombia. This programme is part of a non-profit project that focuses on high-school children from Bogotá and surrounding cities, including some from disadvantaged communities. The programme is designed to inspire young people and introduce them to science with astronomy as the vehicle.

Every year, 30 participants are selected from an application pool of more than 200 young people using an admission exam

Figure 4. *A group of students share their collected data and perform in open spaces where they are encouraged to show the public, especially young children, their work. Credit: Alejandro Cárdenas-Avendaño.*

that measures problem-solving abilities which do not require particular learned knowledge. The group receives one-year support by two instructors, whose purpose is, not to conduct lectures, but to answer questions and propose a main objective at the beginning of the programme.

During 2014, the team's general objective was to learn scientific computing techniques. Python was chosen as the programming language to exploit its expressive power with simple and compact syntax and third-party open-source libraries such as NumPy (Walt et al., 2011) Matplotlib (Hunter, 2007) and SciPy (Jones et al., 2014) were used to encourage the use of scientific scripting language.

To develop scientific computing techniques, the proposed objective was to measure solar activities via radio waves with NASA's Radio JOVE project antennas but without the main software provided by NASA to record, store and visualise data (Lashley, 2010; Higgins et al. 2014). Figure 3 shows an example of the data analysis performed by the participants.

In addition to the data collected by the students, the Radio JOVE Data Archive[3,4] was used to gather information and explore larger datasets. In some cases, it was possible to conduct a rigorous analysis and check if the registered phenomena were global, at least reported somewhere else or corresponded to spurious signals. Through the data collection and analysis, the participants were able to acknowledge a relationship between sunspot numbers and 20 MHz solar burst counts.

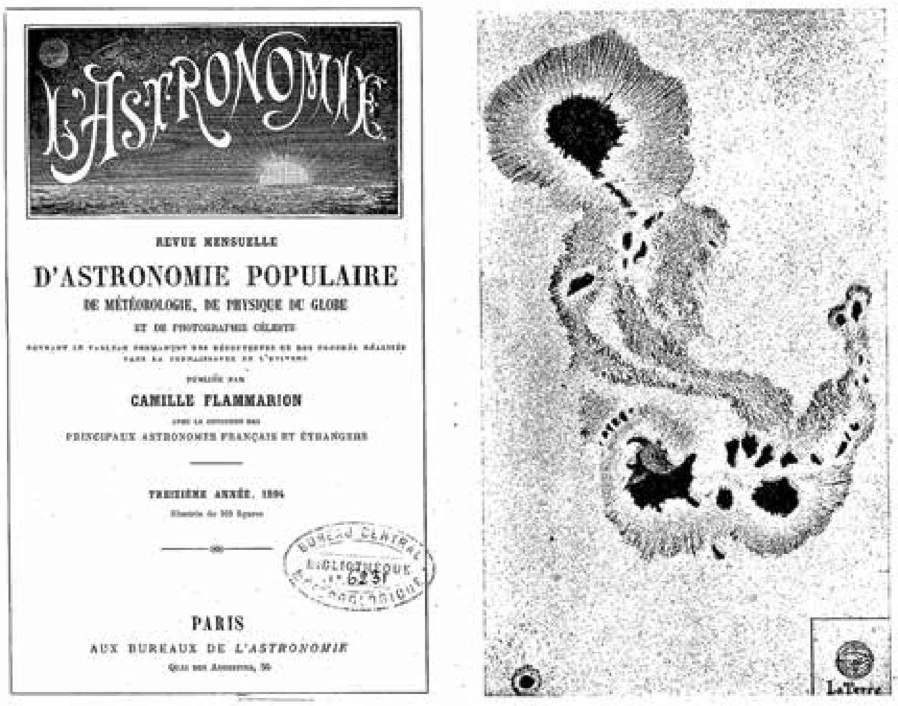


Figure 5. *Journal of the French Society of Astronomy (left panel) in which José María González Benito published a drawing of the large solar active region observed in August 1893 (right panel). Credit: From the historic archive of the National Astronomical Observatory of Colombia.*

The results were presented in regional science, engineering, technology and mathematics (STEM) fairs open to the general public and all of the data collection was conducted in public parks to engage young children and the general public (Figure 4). During the data collection campaigns, the participants shifted between collecting data and explaining the project to passers-by.

We also would like to mention that two participants performed remarkably at the Colombian Olympiad on Astronomy and, subsequently, were part of the National Team for the International Olympiad on Astronomy and Astrophysics (IOAA) and the Latin American Olympiad on Astronomy and Astronautics (LAOAA).

Solar Physics as a Research Option at Universities

The study of the Sun in Colombia dates back to observations made by José María González Benito (1843-1903) in the 19th century, when he was the director of the National Astronomical Observatory, the oldest astronomical observatory in America founded in 1803, and a member of the French Society of Astronomy. González Benito published a drawing of a large sunspot observed in August 1893 in the Journal of the French Society (Figure 5) (González, 1894). Today, Colombia offers astronomy research options in universities across the country. In this section, we will refer to our experience at the National Astronomical Observatory of the Universidad Nacional de Colombia.

The Group of Solar Astrophysics (GoSA), founded in 2011, convenes undergraduate and graduate students. The group started out with just two undergraduate students in physics who were interested in solar astrophysics. In 2012, the National Astronomical Observatory held an International Summer School entitled 'Solar Astrophysics: Modern Trends and Techniques', as a result of which, a large number of undergraduate students joined GoSA and decided to pursue their research project in solar physics. Students were trained in programming languages commonly use in the field, for example, Interactive Data Language (IDL) (Landsman, 1993), and started analysing data from cutting-edge satellite solar telescopes. Working with time series images, they explored topics ranging from the tracking of solar spicules to studying hard X-rays in solar flaring events.

GoSA members are currently exploring the challenges and opportunities of doing state-of-the-art research and are involved in multiple international collaborations. In addition, seven masters' students and twelve undergraduate students are part of a research project entitled 'Magnetic Field in the Solar Atmosphere', which comprises individual research topics on the analysis of data from ground-based telescopes, such as the Solar Swedish Tower (SST) (Scharmer et al., 2003), and space facilities like the Solar and Heliospheric Observatory (SOHO) (Domingo et al., 1995), the Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI) (Lin et al., 2002), the Solar Dynamics Observatory (SDO) (Pesnell et al., 2012), and Hinode (Kosugi et al., 2007). The group is presently developing routines for data analysis in Python as part of a Sunpy collaboration (The SunPy Community, 2015).

In 2015, the university introduced a course on solar physics, 'Foundations of Solar Astrophysics', in its official academic programme, the first of its type in Colombia. The course is intended for masters' students and can be opted for by undergraduates. Fifteen students, on average, enroll in the course every semester and a high percentage of them go on to join the research group.

More recently, the GoSA organised the International Astronomical Union Symposium 327 (IAUS327) entitled "Fine Structure and Dynamics of the Solar Atmosphere" that was held in Cartagena de Indias, Colombia, 9-13 October 2016 (Vargas Domínguez, et. al., 2017). This event strengthened the group by creating an opportunity to increase the visibility of the members and their research in the international community, therefore promoting new collaborations.

In just a few years, the group has shown rapid growth with several scientific publications, masters' theses, undergraduate research works and solar instrumentation development. Among these, the development of solar instrumentation has been one of the most noteworthy milestones in the past couple of years, with the development of three solar radio interferometers which are currently installed on the terrace of the observatory building (Figure 6, left panel). These instruments have been fully developed by the students as part of their projects and represent the commencement of the instrumentation branch at the National Astronomical Observatory. The research conducted by one of the recently graduated master student resulted in the development and implementation of the First Colombian Radio-interferometer (FiCoRi) (Figure 7, right panel) (Guevara et. al., 2017).

Further, plans are being made to use one of the interferometers in a large number of public schools to use big data (astro-

Figure 6. *Radio interferometers installed on the terrace of the National Astronomical Observatory at Universidad Nacional de Colombia. The instruments have been developed by undergraduate and masters' students as part of their research projects. The First Colombian Radio-interferometer (FiCoRi) (see the acquisition system in the middle panel of the figure) represents an important milestone in the development of radio astronomy instrumentation in Colombia. Credit: From the digital archive of the National Astronomical Observatory of Colombia.*

statistics) as a tool to promote scientific knowledge.

Former GoSA members are now pursuing their graduate studies abroad in high performance institutes including the University of California in Berkeley, Max Planck Institute for Solar System Research, Harvard-Smithsonian Center for Astrophysics, University of Graz and University of Oslo. A new generation of local students are willing to follow a promising educational road, that is, studying the multiple faces of our active star.

Our learnings from these three experiences

From a pedagogical viewpoint, we have learned that it is important that children and young people recognise the importance of long-term efforts through continuous observation. The young people we interacted with are mainly motivated by visits to astronomical observatories, star parties, STEM colleges, and career fairs and conferences.

Using the Sun as the main topic of exploration has several advantages:

- Observations can be made within a short duration to fit class schedules (approximately 1.5 hours).
- The Sun shows rapid changes which the children can see, enabling them to better visualise the potential affect it has on the planet on a daily basis.
- A Sun-related project can develop associated activities around interdisciplinary topics including the electromagnetic spectrum; stellar evolution; radio astronomy; effects of the Earth's atmosphere; scientific computing; data analysis; motors and generators; and ways to create links with biology, chemistry and even history and archaeology.
- The JOVE project offers a great opportunity to participate in scientific studies at a low costs (typically less than USD 350), which cover a receiver kit, antenna hardware, software, and tools required for instrument assembly.

The main goal of the solar-related experiences that we have developed in schools across Colombia has been to build a mechanism that can enhance creativity and allow participants to acquire and interpret data in their own ways to answer scientific questions. Instructors are meant to provide an ideal atmosphere to explore ideas, develop tools and help participants with their chosen technique, thus spreading their seeds of creativity.

The study of the Sun has gained worldwide interest in recent years because of the serious impact by solar explosive events on our technological-reliant society, particularly satellites exposed to the effects of solar activity. At the university level, and in particular within the context of the research group (GoSA), the field of solar physics has proven to be a development tool and source of motivation for students to pursue further scientific research, from the study of fundamental physics to data analysis and fostering of computational skills to simulate solar phenomena and instrumentation.

Conclusions

The important role that astronomy can play in cultural development and driving innovation tends to be underestimated, even though there is a wealth of supporting examples (Rosenberg et al., 2013).

Among the general public in Colombia, there is a distrust and even fear towards scientific areas. This is largely due to a significant gap between scientists and society. Science communicators play a fundamental role in changing public perspective about science and there is a great need for initiatives as those mentioned in this paper. Importantly, there is a need to create spaces that allow scientists, teachers and amateurs to come together and find new and better ways to bring science to the public.

Here, we have shown simple examples in which the scientific community has evolved through small and consistent efforts over time. We have seen people going through the whole education system—from primary to university—positively impacting individuals, their community and our country. We have experienced first-hand the impact these initiatives have on students and how they think about scientific areas as a future career.

As a final remark, we want to stress that although performing solar observations is relatively easy and can be done at many levels, it is important to first prepare students and the general public to avoid the potential risks this entails. This should be a major concern and implies a huge responsibility for the team involved.

References

Domingo, V., Fleck, B., and Poland, A.I., 'SOHO: The Solar and Heliospheric Observatory', Space Science Reviews, vol. 72, no. 1, 1995, pp. 81–84.

González, J. M., La Grande Tache Solaire Du Mois D'Aout in 'L'Astronomie', 1894, p. 146.

Guevara, J. C., Martínez Oliveros, J. C. and Calvo-Mozo, B. (2017, October) Fine Structure and Dynamics of the Solar Atmosphere. In IAU Symposium (Vol. 327). Edited by: Vargas Domínguez, , S., Kosovichev, A. G., Antolin, P., & Harra, L. Pags 16 -19.

Higgins, C., Thieman, J.R., Flagg, R., Reyes, F.J., Sky, J., Greenman, W., ... and Mount, A., 'Radio Jove: Jupiter Radio Astronomy for Citizens'. In American Astronomical Society Meeting Abstracts# 223, 2014 January, Vol. 223.

Hunter, J.D., 'Matplotlib: A 2D Graphics Environment'. Computing In Science & Engineering, Vol. 9, No. 3, 2007, pp. 90–95.

Jones, E., Oliphant, T., and Peterson, P., {SciPy}: open source scientific tools for {Python}, 2014.

Kosugi, T., Matsuzaki, K., Sakao, T., Shimizu, T., Sone, Y., Tachikawa, S., ... and Tsuneta, S., 'The Hinode (Solar-B) mission: an overview', in The Hinode Mission, New York, Springer, 2007, pp. 5–19.

Landsman, W.B., 'The IDL Astronomy User's Library'. In Astronomical Data Analysis Software and Systems II, Vol. 52, January 1993, p. 246.

Lashley, J. 'Beyond the Solar System'. In The Radio Sky and How to Observe It, New York, Springer, 2010, pp. 57–70.

Lin, R.P., Dennis, B.R., Hurford, G.J., Smith, D.M., Zehnder, A., Harvey, P. R., ... and Csillaghy, A. 'The Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI)'. Solar Physics, Vol. 210, No. 1-2, 2002, pp. 3–32.

Moreno-Cárdenas, F., Cristancho-Sánchez, S.C., and Vargas Domínguez, S. 'The Grand Aurorae Borealis Seen in Colombia in 1859'. Advances in Space Research, Vol. 57, No. 1, 2016, pp. 257–267.

The Sunpy Community: Mumford, S. J., Christe, S., Perez-Suarez, D., Ireland, J., Shih, A. Y., ... & Hughitt, K. (2015). 'SunPy-Python for Solar Physics'. arXiv preprint arXiv:1505.02563.

Pesnell, W.D., Thompson, B.J., and Chamberlin, P.C., 'The Solar Dynamics Observatory', Solar Physics, Vol. 275, No. 3, 2012, https://doi.org/10.1007/s11207-011-9841-3

Rosenberg, M., Russo, P., Bladon, G., & Christensen, L.L. 'Why is astronomy important?', arXiv preprint arXiv:1311.0508, 2013.

Scharmer, G.B., Bjelksjo, K., Korhonen, T., Lindberg, B., and Petterson, B., 'The 1-Meter Swedish Solar Telescope', Proceedings of SPIE, Vol. 4853, pp. 341–350.

Vargas Domínguez, S., Kosovichev, A.G., Antolin, P., and Harra, L., 'Fine Structure and Dynamics of the Solar Atmosphere', In IAU Symposium, Vol. 327, October 2017.

Walt, S.V.D., Colbert, S.C., and Varoquaux, G., 'The NumPy Array: A Structure for Efficient Numerical Computation', Computing in Science & Engineering, Vol. 13. No. 2, 2011, pp. 22–30.

Notes

[1] School research journal, El Astrolabio, http://www.revistaelastrolabio.com

[2] Spaceweather website: http://spaceweather.com

[3] Radio JOVE Data Archive: http://radiojove.org/archive.html

[4] Radio JOVE Data Analysis: http://radiojove.gsfc.nasa.gov/data_analysis/

Acknowledgements

We thank Juan Camilo López-Carreño, Sebastián Castellanos-Durán and Pedro Russo for reading a preliminary version of this manuscript and providing us useful feedback.

None of what has been discussed here would have been possible without engaging the administrative and educational heads of the schools and universities, who provided the necessary instruments and created spaces for us to talk about science in their classrooms.

Biographies

Alejandro Cárdenas-Avendaño is a graduate student at the eXtreme Gravity Institute (USA) and a research fellow at Fundación Universitaria Konrad Lorenz (Colombia). He is a theoretical physicist studying the impact of Einstein's theory of general relativity, and many of its extensions.

Santiago Vargas-Dominguez is an assistant professor at the Observatorio Astronómico Nacional de Colombia - Universidad Nacional de Colombia, and has spent the last 15 years doing research in solar physics at different institutions in Europe and America. He is currently the research coordinator at the Observatorio Astronómico Nacional de Colombia, leading in particular the study of the Sun within the Group of Solar Astrophysics (GoSA).

Freddy Moreno-Cárdenas is the director of the Observatorio Julio Garavito Armero at Gimnasio Campestre school in Bogotá (Colombia). Since 2001 he has worked as an astronomy teacher and led several initiatives to engage student towards science, in particular astrophysics.

Benjamín Calvo-Mozo is an associate professor at the Observatorio Astronómico Nacional de Colombia - Universidad Nacional de Colombia where he has spent almost 40 years teaching and doing research in astronomy. In 2011 he started the research branch in solar physics to mentor graduate students, and has promoted the development of the area in Colombia from the Group of Solar Astrophysics (GoSA).

Column

The World at a Glance - Highlights from IAU National Outreach Coordinators

Editor's note: The IAU National Outreach Coordinators (NOCs) network[1] was created by the IAU Office for Astronomy Outreach (OAO) by volunteers with extensive experience in public outreach to facilitate communication and actions between the IAU and its national communities.

Brazil

Eduardo Penteado: Brazil embraced the IAU100 celebrations by engaging in activities during 100 Hours of Astronomy and will now focus on engaging girls and women in science.

Colombia

Carlos Augusto Molina: Public observations, workshops and music were enjoyed by more than 4000 people in auditoriums, public squares and planetariums as part of 100 Hours of Astronomy. The next focus will be women in science.

Algeria

Jamal Mimouni: Algeria is starting IAU100 by bringing science, cosmic perspectives and beauty to humanity.

Ethiopia

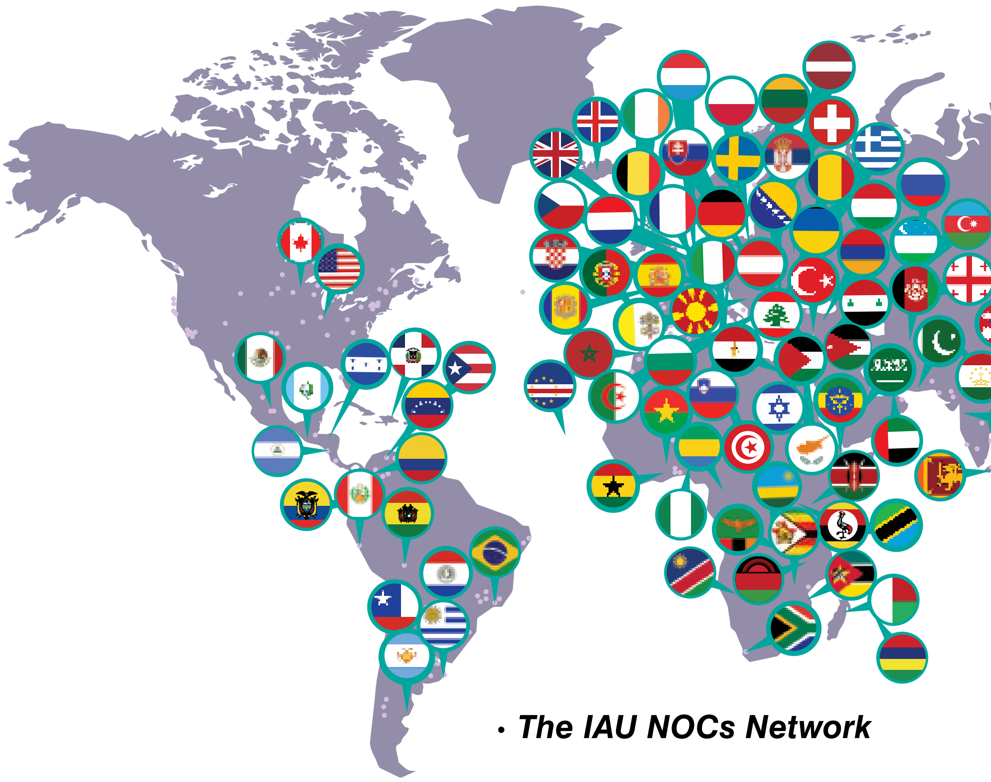
Alemiye Mamo Yacob: Ethiopia is celebrating IAU100 with 15 major nation events[15].

Mauritius

Nadeem Oozeer: Mauritius started celebration of IAU100 with a series of activities spanning the whole year[16].

Mozambique

Claudio Paulo: A public telescope-viewing event for 100 hours of Astronomy took place on 10 January in the Magoanine B neighborhood in Maputo City[17].



• ***The IAU NOCs Network***

Bulgaria

Lyuba Slavcheva-Mihova: Around 1700 people took part in six 100 Hours of Astronomy events in five venues across Bulgaria with an overall duration of 30 hours.

Czech Republic

Sona Ehlerová: Czech Republic hosted an astronomical exhibition at the Senate to start IAU 100.

Germany

Markus Possel: Germany is gearing up for a nationwide Astronomy Day on 30 March on the subject of light pollution, as part of the IAU100 celebrations, with an estimated 200 local events.

Ireland

Clair McSweeney: Ireland is celebrating IAU100[3] with events focusing on Dark Skies[4] and informal outreach[5].

Italy

Stefano Sandrelli: Sky, poetry and fashion will all form part of 100 hours of astronomy in Italy[6].

Netherlands

Marieke Baan: The Netherlands is celebrating #iau100 with many (public) events[18,19].

Australia

Pete Wheeler: Australia's biggest astronomy festival will take place on 16 March in Perth, celebrating the IAU's centenary.

Serbia

Tijana Prodanovic: Serbia kicked off IAU100 with public observing events, lectures and citizen science astronomy projects[7].

Slovakia

Rudolf Galis: Slovakia commenced the IAU100 celebrations with two dozen public events during 100 hours of Astronomy[8].

Slovenia

Andreja Gomboc: Slovenia started IAU100 with public observations, lectures and exhibitions. More will follow[9]...

Azerbaijan

Famil Mustafa: Azerbaijan started the celebration of IAU100 with inclusive astronomy events, public observations, workshops and international conferences[2].

Malaysia

Fairos Asillam: An audience of 11 067 benefitted from activities at twenty venues across Malaysia via online and onsite activity.

Spain

Amelia Ortiz Gil: Spain started the IAU100 celebrations with 42 public events, including astronomical observations, workshops and concerts[10].

Turkey

Sinan Aliş: A total of 3300 people participated to the 30 different 100 Hours of Astronomy events organized in Turkey[11].

Poland

Krzysztof Czart: Many events marked IAU 100 in Poland, with a full list at IAU100 Poland website[12].

Portugal

Gustavo Rojas: IAU100 celebrations in Portugal have so far included events in thirteen cities[13].

United Kingdom

Robert Walsh: IAU100 kicked off with the Society of Popular Astronomy helping anyone to participate in their own observations as part of 100 Hours of Astronomy[14].

Japan

Hitoshi Yamaoka: Astronomy Comics (Manga) and a travelling library are planned for 2019.

Myanmar

Boothee Thaik Htun: MASES has organised an inspirational talk show by Dr.Padaythar Tin, Myanmar senior scientist at NASA.

Pakistan

Ghulam Murtaza: IAU100 is being celebrated in Pakistan with the commencement of 100 Hours of Astronomy event.

Notes

1 www.iau.org/public/noc/
2 www.shao.az/iau100
3 www.sciencespace.ie/international-astronomical-unions-100-year-anniversary/
4 www.darksky.ie
5 www.sciencespace.ie/celebrating-100-years-of-the-international-astronomical-union-ireland
6 www.media.inaf.it/2019/01/09/100-ore-di-astronomia-iau/
7 www.facebook.com/100iausrbija
8 iau100.sk
9 www.portalvvesolje.si
10 iaunoc.blogs.uv.es/iau100
11 iau100.tad.org.tr
12 www.iau100.pl
13 iau100-portugal.org/category/noticias
14 www.popastro.com/100hours
15 etssti.org/iau-100-ethiopia/
16 www.facebook.com/IAU-NOC-Mauritius-2276524215919158
17 claudiompgalanhane.weebly.com/galeria-de-fotos-photo-gallery.html
18 astronomie.nl/iau100
19 twitter.com/IAU100NL

Colophon

Editor-in-Chief
Sze-leung Cheung

Consulting Editor
Georgia Bladon

Executive Editor
Hidehiko Agata

Proofreaders
Rucha Kurtkoti
Veena Venkateshwaran

Layout and Production
Lina Canas
Haruka Suzuki

Contributors
Hidehiko Agata
Natalie Batalha
Benjamín Calvo-Mozo
Lina Canas
Alejandro Cárdenas-Avendaño
Sze-leung Cheung
Santiago Vargas Domínguez
Richard Fienberg
Ana Paula Germano
David Gruber
Sandra Benítez Herrera
Shigeyuki Karino
Freddy Moreno-Cárdenas
Martin Rees
Oana Saudu
Patrícia Figueiró Spinelli
László Szabados
Hitoshi Yamaoka
IAU National Outreach Contacts network
Bruno Merín Martín

Web Design and Development
Raquel Shida
Mathias Andre

IAU DIVISION C Commission C2
CAP Working Group
Farid Char
Sze-leung Cheung
Lars Lindberg Christensen
Georgia Bladon
Pedro Russo
Detlef Koschny

Address
CAPjournal,
IAU Office for Astronomy Outreach,
C/O National Astronomical Observatory of Japan
2-21-1 Osawa, Mitaka, Tokyo, 181-8588
Japan

E-mail
editor@capjournal.org

Website
www.capjournal.org

ISSNs
1996-5621 (Print) | 1996-563X (Web)

CAPjournal submission guidelines

We are keen to encourage readers to submit their own articles, reviews, and other content. Some key points are addressed below.

Technical and esoteric language should be either avoided or used with a footnoted explanation if absolutely required. All contributions will be made to conform to British spelling and punctuation practice. Figures and tables should be referred to as “Figure n” and “Table n” respectively. Acronyms should be spelt in full once and then parenthesised; thereafter they can then be used as lettered acronyms. Numerals should be used for numbers greater than two words and always for numbers greater than ten.

Manuscripts should be delivered in MS Word or text (.txt) format, with no formatting apart from bold, italics, super and subscripts. Hard carriage returns after each line should be avoided, as should double spacing between sentences. If the contribution contains figures, these may — just for the sake of overview — be pasted inline in the Word manuscript along with the caption (Word files below 4 MB are encouraged). However, images must also be delivered individually as Tiff, PDFs, vector-files (e.g.,.ai,.eps) in as high a resolution as possible (minimum 1000 pixels along the longest edge).

Copyright
Authors are solely responsible for ensuring copyright clearance to reproduce illustrations, text, etc., for which they themselves do not own the copyright. *CAPjournal* accepts only original submissions and will only reproduce previously published work by special arrangement.

Contact
Submissions should be sent to the Editor:
editor@capjournal.org

Submit articles for one of the following journal sections:

- News
- Announcement
- Interview
- Opinion
- Resources
- Best practice
- Review
- Research & Applications
- Correspondence
- Column

www.capjournal.org
Online issues
Free subscriptions
Article submission

Publishers

Sponsors

Collaboration