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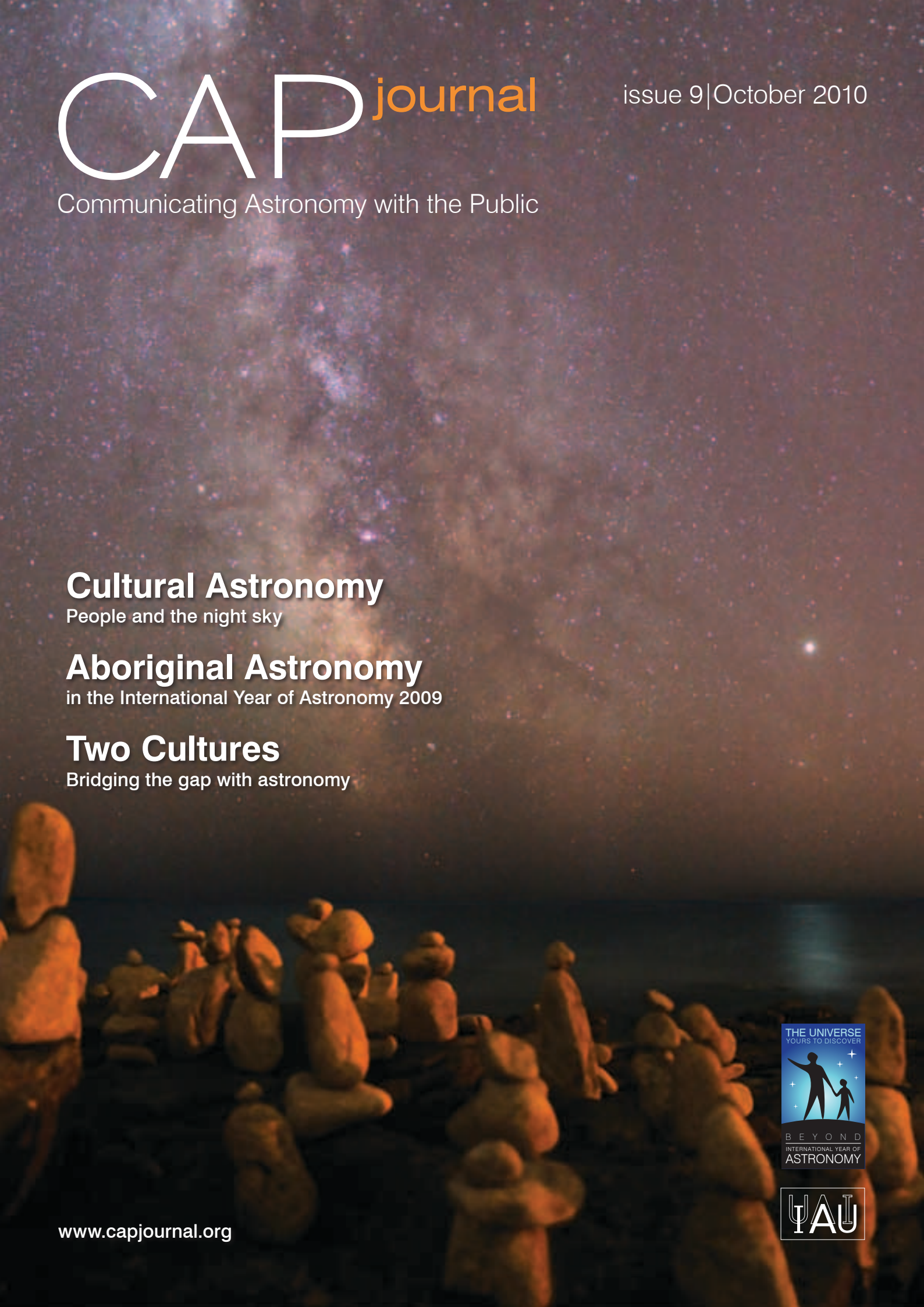

Cultural Astronomy
People and the night sky

Aboriginal Astronomy
in the International Year of Astronomy 2009

Two Cultures
Bridging the gap with astronomy

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Colophon

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ESO ePOD
Karl-Schwarzschild-Strasse 2
85748 Garching bei München
Germany

E-mail:
editor@capjournal.org

Website:
www.capjournal.org

Phone: +49 89 320 06 195
Fax: +49 89 320 2362

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Cover: Summer Milky Way shines over seaside stones of Lesconil in Brittany, France. Credit: TWAN/L. Laveder/Pixheaven.net.

Editorial

The International Year of Astronomy 2009 (IYA2009) was a success by any measure, as demonstrated in the recently published final report[1]. In this special issue of CAPjournal, we take a look at IYA2009 events that focused on cultural astronomy and discuss how including a historical or cultural aspect to an astronomy event can help to engage with a wider audience. By introducing a human element to the grand cosmos, we can make astronomy more enjoyable and easier to understand for the general public.

During IYA2009, many countries ran projects and events that can be classed as "Cultural Astronomy". The activities focused on indigenous astronomy, the history of astronomy and the inclusive nature of astronomy — a hobby that can be enjoyed by anyone, anywhere. Their activities included public events that combined telescope observing with storytelling, new learning modules for school children, theatre productions and cultural astronomy exhibitions.

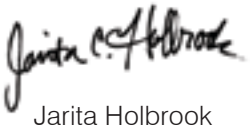
We hope that this small selection of events that we present in this issue of CAPjournal will encourage others to highlight the cultural aspect of astronomy in their own education and public outreach activities.

Between issues you can stay in touch through our website, www.capjournal.org, where you will find the current issues in PDF format, an astronomy communication and education job bank, submission guidelines and back issues.

We also welcome details about forthcoming astronomy and science communication events (conferences, meetings, etc.), training opportunities, job postings or courses offered. If you have astronomy and science communication-themed products, such as books, DVDs, television programmes, magazines or websites that you would like to see reviewed by the CAPjournal editorial team, simply send the necessary information to: editor@capjournal.org. Any questions, comments or opinions can also be sent to that address.

Happy reading,

Pedro Russo
Editor-in-Chief



Jarita Holbrook
Guest Editor

[1] The 1400-page IYA2009 Final Report is available here: http://www.astronomy2009.org/resources/documents/detail/iya2009_final_report/

Explained in 60 Seconds: Cultural Astronomy

Key Words

Written Communication
Case Study

Cultural astronomy has several formal definitions, but, in a nutshell, it is the study of the relationship that humans have with the night sky. This topic overlaps with the larger issue of how humans have responded to their natural environment over the ages. Archaeoastronomy is the most popular branch of cultural astronomy and encompasses how studying the heavens was embraced by the cultures of ancient civilisations. Stone tombs and monuments are the lasting legacies of this ancient cultural knowledge of the night sky. There are also studies of celestial knowledge being used as a form of social control, such as by the Sun King Shaka Zulu, and studies of how humans have used the sky to try to predict the future. The history of astronomy and the myths and legends associated with the night sky are nowadays an integral part of introductory astronomy classes, star parties and planetarium shows. In modern times, astronomy has also influenced our culture, through art, dance, music and poetry. Cultural astronomy engages the public by showing a human side of astronomy that people can relate to.

JC Holbrook
University of California

One of 177 Antas, a distinctive form of megalithic tomb, found in the central part of the Alentejo region, Portugal, and in the provinces of Badajoz and Cáceres, in the Extremadura region of Spain. These tombs are thought to have been constructed from c. 4000 BC onwards. The range of orientations of the 177 monuments corresponds almost exactly to the range of possible rising positions of the Sun. Credit: I. Gomes (www.flickr.com/photos/ivogomes). More information: www.astronomicalheritage.org

Australian Aboriginal Astronomy in the International Year of Astronomy 2009

Ray P. Norris
CSIRO Astronomy & Space Science, Australia
Warawara: Department of Indigenous Studies,
Macquarie University, Sydney, NSW, Australia
E-mail: Ray.Norris@csiro.au

Key Words

Aboriginal Astronomy
Outreach
Ethnoastronomy
Astronomy in Culture

Summary

Each of the 400 different Aboriginal cultures in Australia has a distinct mythology, and its own ceremonies and art forms, some of which have a strong astronomical component. Sadly, the Australian media tend to focus on negative aspects of contemporary Aboriginal culture, and very few non-Aboriginal people in the wider Australian community are aware of the intellectual depth of traditional Aboriginal cultures. The International Year of Astronomy 2009 seemed an excellent opportunity to tell the wider public about Aboriginal astronomy, so that they might understand something of the depth and complexity of traditional Aboriginal cultures. This article describes some of the challenges and successes of this programme, and the impact that this work has had on Australian perceptions of Aboriginal culture, helping to build a bridge across the cultures. It also describes the achievement of an unexpected and unplanned goal: the inclusion of Aboriginal astronomy opened up astronomy to a section of the population who had never before intentionally attended a talk on science.

Introduction

Each of the 400 different indigenous cultures in Australia has a distinct mythology, and its own ceremonies and art forms, some of which have a strong astronomical component. Many share common traditions such as the Emu in the Sky constellation of dark clouds, and various common stories about the Sun, Moon, Orion and the Pleiades. Several use the rising and setting of particular stars to indicate the time to move to a new campsite, with food sources appropriate to that season. At least two independent accounts suggest that traditional indigenous people associated eclipses with a conjunction of the Sun and Moon. For example, the explanation from North-West Arnhem Land of a lunar eclipse as a conjunction of the Sun-woman and Moon- man, when the Sun and Moon are on opposite sides of the sky, is evidence of a great intellectual leap by some Indigenous thinker in the distant past. Yolngu stories explaining how the Moon causes the

Figure 1. One of the paintings from the Ilgarijiri *(which means "things belonging to the sky" in the Wajarri Yamatji language) art exhibition. This painting is entitled Seven Sisters and is reproduced here by courtesy of the artist, Christine Collard. Photo: Curtin University.*

tides can be compared with Galileo's denials that the Moon had anything to do with it! One stone circle appears to indicate the position of the setting Sun on the horizon at the solstices and equinox, and there are suggestions of several other sites with an astronomical connection. Short reviews of this subject can be found in Norris & Hamacher (2009) and Norris & Norris (2009).

Since the British occupation of Australia over 200 years ago, Aboriginal Australians have been treated badly by the European majority. While all sections of responsible society are now trying to repair the damage, there remains an element of latent prejudice against Aboriginal Australians. This continues to be fuelled by negative stereotypes in the media, typically featuring allegations of child abuse or substance abuse in dysfunctional and marginalised Aboriginal communities. Rarely appearing in the media are the well-functioning communities in which charismatic elders of great integrity strive to achieve a balance of traditional values with health and education. These elders are also a fount of knowledge on Aboriginal cultures, including astronomy, and so an outreach programme on Aboriginal astronomy could also raise awareness in the wider public that not all Aboriginal communities conform to the negative stereotype.

The International year of Astronomy 2009 seemed an excellent opportunity to tell the story of Aboriginal astronomy to a wider public. In late 2008, Steven Tingay and Ray Norris established the IYA2009 Working Group on Australian Indigenous Astronomy (WGAIA) with two main goals:

- to raise the profile of Australian Aboriginal astronomy, thereby contributing to greater cross-cultural understanding;
- to use Aboriginal astronomy as a means of bringing astronomy to young people.

The WGAIA served primarily as a forum in which its members could interact and coordinate their individual activities.

The planned outreach programme

As well as coordinating individual activities, the WGAIA planned a number of activities as follows.

1. Public talks

The WGAIA planned a series of public talks on Aboriginal astronomy, to raise the awareness of this little-recognised aspect of Aboriginal culture. An estimated 60 public talks on Aboriginal astronomy were given, initiated through a wide range of channels.

2. Introductory book on Aboriginal astronomy

A small book (*Emu Dreaming*; Norris & Norris, 2009) was published privately and has been very well received. It quickly sold its initial print run of 1000, and is now in its second printing.

3. Virtual art gallery

There was an initial plan to build an art gallery on the web containing Aboriginal art with astronomical themes, with appropriate permissions. This idea, initiated by Steven Tingay, developed into a more substantive art exhibition (*Ilgarijiri* — things belonging to the sky), using art works (one of which is shown in Figure 1) with an astronomical theme produced by the artists of Yamaji Art cooperative in Geraldton, Western Australia, whose artists are drawn from the region in which the Australian SKA Pathfinder (ASKAP) telescope and the Murchison Widefield Array will be built. The first stage in this project was a visit to the Murchison Radio-astronomy Observatory by the artists and scientists from the International Centre for Radio Astronomy Research (ICRAR). During the visit the group discussed the country and the astronomy developments, as well as indigenous and non-indigenous stories of the sky, under the clear and dark skies of the mid-west of Western Australia. As a result of this interaction, the artists produced well over 100 original pieces of art. These pieces were exhibited in Geraldton and it was the largest event ever held at the Geraldton Regional Art Gallery. The exhibition was subsequently shown in Perth at Curtin University of Technology and

in Canberra, at the Australian Institute for Aboriginal and Torres Strait Islander Studies (AIATSIS). Finally, the exhibition travelled to Cape Town in South Africa and was shown at an international conference, Communicating Astronomy with the Public 2010. The art was included in a virtual gallery[1] and a project blog was kept online[2] and will be updated beyond 2009.

4. Conference

It seemed appropriate to mark IYA2009 by holding the first-ever symposium on Aboriginal astronomy, to which all those engaged in this field would be invited. The conference (see Figure 2) was kindly hosted by AIATSIS, in conjunction with the *Ilgarijiri* exhibition. It was very successful, with a range of talks and presentations ranging from mainstream academic studies to presentations built around music and dance. A symposium proceedings is currently in preparation.

The significance of this conference should not be underestimated. While many writers have made valuable contributions over the years to our knowledge of Aboriginal astronomy, their work has largely gone unnoticed, or been dismissed as a fringe activity, by the professional research community. This is now changing, and a small number of systematic research studies in Aboriginal astronomy are now under way. This symposium was hosted by Australia's leading body in Aboriginal studies, and was attended by several well-respected archaeologists and anthropologists. The symposium seems to have marked a transition, as Aboriginal astronomy grows from a fringe science to become a legitimate academic field of research.

Figure 2. Participants at the Symposium on Indigenous Astronomy held at the Australian Institute for Aboriginal and Torres Strait Islander Studies on the 27 November 2009, in conjunction with the launch of the art exhibition, Ilgarijiri *— things belonging to the sky. Some of the exhibition paintings can be seen behind the participants. Credit: Australian Institute for Aboriginal and Torres Strait Islander Studies.*

The unplanned outreach programme

As well as the planned activities, a number of other activities occurred either serendipitously or as a result of the increased awareness engendered by the planned activities. They are unplanned in the sense that WGAIA didn't foresee them, although each was of course meticulously planned by those involved in its production.

1. Radio and TV

A number of events were covered by the media (print, radio, and TV), and this increased exposure led to even greater media coverage. The highlight was the ABC-TV Message Stick documentary on Aboriginal astronomy, entitled *Before Galileo*, produced and directed by Grant Saunders of the ABC. This widely acclaimed programme was first aired on prime-time television, and subsequently repeated several times, as well as being highlighted on the ABC website. It features interviews with several members of WGAIA, including captivating contributions by senior Wardaman elder Bill Yidumduma Harney.

2. Print media and the web

In addition to articles specifically about Aboriginal astronomy, images from Aboriginal astronomy are widespread on the web and in print media. *The Emu in the Sky* image by Barnaby Norris, shown in Figure 3, was distributed by the Department of Education to every school in Australia, and, together with other Aboriginal astronomy images, now seems to pop up in the most unlikely places, and has been used as an illustration in a number of text books in several languages.

To celebrate the IYA2009, the ABC established an activity (Big Aussie Star Hunt) to get kids looking at the sky from their backyards. Included in the Big Aussie Star Hunt website is an Aboriginal astronomy theme, which has received excellent feedback on the ABC website.

3. The First Astronomers *show*

After the producer of the Darwin Festival, Jo Duffy, attended a talk by Ray Norris on Aboriginal astronomy, she invited creative producer Bec Allen and director Alex Galeazzi to team up with Ray Norris and Bill Yidumduma Harney (Figure 4) to produce an outdoor

Figure 3. The Emu in the Sky *by Barnaby Norris. Composed of dark clouds of dust in the Milky Way, the Emu rises above an Aboriginal rock engraving in Ku-ring-gai Chase National Park, Sydney, Australia. She stands upright above her engraving only at the time each year when the emus lay their eggs — an important food for the Ku-ring-gai Aboriginal people. Quite unlike European constellations, which are traced out by stars, the Emu is traced by the mysterious dark spaces between the stars. See her head and beak at the top right, her long neck stretching down to her body in the centre, and her legs trailing to the lower left. This powerful image in the sky is suggested by Hugh Cairns to be reflected in the ancient Aboriginal engraving in the rock below. Photo: Barnaby Norris.*

theatre show about Aboriginal astronomy. In this show, Bill and Ray compare their two worlds, of astrophysics and traditional belief. They discuss how the black hole at the centre of our Galaxy shares similarities to the Wardaman hole in the sky to which spirits fly, and combine ancient dreaming stories with real science, including the Sun as a star, dark clouds as the birthplaces of young stars, light-travel time and black holes. The show received excellent reviews after playing to audiences of 500–600 in the Darwin and Adelaide festivals, and is expected to appear in other Australian cities in 2010.

Outcomes

There has been no attempt to measure impact in a formal sense, although anecdotal evidence implies an impact far greater than initially expected by the WGAIA. In particular, the following outcomes have been noted.

1. An increased level of awareness of Aboriginal astronomy, and Aboriginal culture, amongst the public as a whole

Although this was the primary planned outcome, the degree of impact has been much higher than expected. In particular, informal feedback suggests that while most Australians are aware of some aspects of Aboriginal culture such as painting, music and dance, many were previously unaware of the intellectual component, such as the discovery of the causes of eclipses and tides.

A further side effect has been to dispel the widespread myth that Aboriginal people cannot count beyond four or five. This was taught in Australian schools until very recently, despite sound anthropological evidence of complex number systems that was well-established nearly a century ago.

2. Aboriginal astronomy as a way of teaching science

To understand Aboriginal astronomy requires some understanding of modern astronomy. For example, a western student cannot appreciate the significance of an eclipse without understanding the causes of eclipses. And Aboriginal number systems cannot be understood without understanding how our own number system works, which is perhaps why some arts-trained anthropologists failed to recognise the Aboriginal number systems in the first place! Teaching science by way of a traditional indigenous knowledge system seems an effective way of bringing scientific understanding, particularly to those who are unreceptive to conventional science teaching methods.

Perhaps even more fundamental is the demonstration of a scientific approach. Often, science is portrayed as a stand-alone subject, at a distance from cultural concerns. The Aboriginal astronomy outreach programme shows how astronomy is intimately linked to life and culture, how our different cultures lead us to interpret the world in different ways, and yet we are all under the same sky, trying to make sense of it, whatever our culture. It also shows that hard science can say something useful and relevant about a delicate cultural issue.

3. Science by stealth

An unexpected and unplanned outcome, which has been dubbed "science by stealth" by Helen Sim, is that the Aboriginal astronomy activities attract sections of the arts community who have never knowingly attended a talk on science, and seem to be surprised that science can actually be entertaining. By showing how science is linked to culture in traditional Aboriginal societies, we can also see how science is linked closely to our own culture. Some of the reviews that have appeared in the arts media are particularly gratifying, suggesting that combining

science with culture may be an effective way of bridging the "two cultures".

4. Validating Aboriginal cultures

Another unexpected result has been the warm reception by young Aboriginal children, who are surprised to find white Australians valuing and celebrating traditional Aboriginal knowledge. While the value of traditional knowledge has always been obvious to older members of their community, young people do not often see this value reflected in the European-dominated media.

Conclusion

IYA2009 has been a wonderful — and exhausting — year. It was obvious at the start of IYA2009 that we should use it to raise awareness of Aboriginal astronomy, and yet few of us understood what a pivotal year this would be for Aboriginal astronomy, a year in which the subject was transformed from a fringe science to a mainstream research topic. And few of us understood that the subject would catch the public imagination, resulting not only in greater awareness of Aboriginal astronomy, but also a greater awareness of how science is inextricably linked to culture.

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Acknowledgements

I acknowledge and respect the traditional owners of this land and its traditions, and particularly thank those Aboriginal elders and communities who have allowed us to share a part of their rich culture. I also thank all those people, both indigenous and non-indigenous, who have helped open public eyes to this wonderful facet of Aboriginal culture. I especially thank Bill Harney, Bec Allen, Hugh Cairns, Jo Duffy, Cressida Fforde, Alex Galeazzi, John Goldsmith, Duane Hamacher, Helen Sim, Steven Tingay, Barnaby Norris, Cilla Norris and all the members of the WGAIA.

Notes

[1] http://astronomy.curtin.edu.au/ilgarijiri

[2] http://ilgarijiri.wordpress.com

Biography

Ray Norris is an astrophysicist with CSIRO Astronomy & Space Science, whose day-job is researching the origin and cosmic evolution of galaxies. A side interest for the last few years has been the study of the astronomy of Aboriginal Australians, as a result of which he is now an Adjunct Professor in the Department of Indigenous Studies at Macquarie University, where he heads the Aboriginal Astronomy Research Group and enjoys working with several indigenous groups, particularly the Yolngu communities of eastern Arnhem Land.

Figure 4. Bill Harney and Ray Norris in the First Astronomers *show in Darwin. Credit: Bec Allen and the Darwin Festival.*

The Making of the Fathers of Astronomy Exhibit

Opinion

Christopher M. Graney
Otter Creek–South Harrison Observatory
Jefferson Community & Technical College, USA
E-mail: christopher.graney@kctcs.edu

Key Words

IYA2009
Exhibitions
History of Astronomy

Summary

The International Year of Astronomy 2009 stretched a few days into 2010 here in Louisville, Kentucky — the Fathers of Astronomy exhibit at the Frazier International History Museum did not close until 3 January 2010. Fathers of Astronomy, which was open for five months, told the story of Galileo through authentic original editions of three books — the 1493 *Nuremberg Chronicle*, Nicolas Copernicus's 1543 *On the Revolutions of Heavenly Spheres*, and Galileo Galilei's 1632 *Dialogue Concerning the two Chief World Systems*. The success of "Fathers" resulted from three very different partners coming together and combining resources to produce a history-themed IYA2009 programme of the highest quality at minimal cost. Lessons learned from the exhibit may be of value to people interested in communicating astronomy to the public.

Introduction

The three partners behind the Fathers of Astronomy exhibit were the Frazier International History Museum, the University of Louisville Libraries, and Otter Creek–South Harrison Observatory. Each partner made a unique contribution without which "Fathers" could not have existed.

The Frazier International History Museum (Figure 1) in Louisville seeks to bring history to life through live interpretations by costumed interpreters, multimedia presentations, educational programming and hands-on learning. The museum's exhibits include the Frazier's permanent collection and a substantial collection from Britain's Royal Armouries. The Frazier contributed the space for the Fathers of Astronomy exhibit; the professional resources to properly handle, display and keep safe the extremely rare books that were the centrepiece of the exhibit; and the marketing expertise to get word of the exhibit to the public.

The University of Louisville (UofL) Libraries' Department of Rare Books and Special Collections supports the academic programmes of the University of Louisville. The collections are available for use by all faculty and students. In addition, the staff produce exhibitions, special lectures and other presentations to enhance the quality of classroom teaching and to present the collections to a wider public audience. Within Rare Books is the William Marshall Bullitt Collection of rare first editions of key publications in the history of science, including works by Gauss, Copernicus, Newton, Euclid and Kepler. UofL contributed to Fathers of Astronomy the artefacts of the exhibit — the books themselves.

Otter Creek–South Harrison Observatory is a small public observatory. This observatory is jointly operated by Jefferson Community & Technical College of Louisville, Kentucky,

and the Parks and Recreation department of Harrison County, Indiana. Its primary mission is education and outreach, but it is also the site of an active programme of research in the area of historical astronomy. Otter Creek–South Harrison Observatory contributed to Fathers of Astronomy the initial impetus for the exhibit, some key networking, and the explanatory materials (display panels) for the exhibit.

Fathers of Astronomy was conceived when I approached Delinda Buie, Curator of Rare Books at UofL, about doing a IYA2009 programme with a history of astronomy theme. Buie was excited about the idea; she wanted a programme in which the public could get significant direct exposure to the key scientific works of the Copernican Revolution in the Bullitt Collection — the original works of Copernicus and Galileo. The question was, where could these valuable works be publicly displayed? Few institutions in Louisville could handle such artefacts, but somewhat providentially, Buie suggested a place where it would be suitable — the Frazier. Before long Buie, Madeleine Burnside (the Frazier's Executive Director) and I were sitting down for a meeting, and Fathers of Astronomy began to come together in earnest.

Creating "Fathers" required all parties to learn. No one had a steeper learning curve than the astronomer on the team — me. The pages of this journal have included various references to astronomers' skill (or lack thereof) in communicating with the public. I received a crash course from the Frazier's staff in how to write for the visiting public. Informative panels were to contain no more than 150 words, plus up to three images that could feature captions of 50 words maximum.

Astronomer (outraged): "One hundred and fifty words? You must be joking."

Frazier staff (patiently): "If you go longer than that, people will be overwhelmed and will not read it."

Astronomer (still outraged): "What point is there in making an exhibit with no content?"

Frazier staff (still patiently): "You do not have to eliminate content — you just have to figure out precisely what you want people to know, and then say just that, and succinctly. You can do it."

Indeed, I learned that I could! I cut the word count of my original drafts for the informative panels by over 60%. In the end I became convinced that following the Frazier's guidelines resulted in a final product that did not sacrifice content, and that was vastly improved.

There were other compromises. Buie and I envisioned a short exhibit, but Burnside urged that it run for half a year. I pushed for the exhibit to focus on Galileo's story from a scientific perspective — what he did and saw and why his work was influential — and to stay away from broader "science and society" or "science and religion" themes. Then there was the question of which books would be in the exhibit — *On the Revolutions* and the *Dialogue*, yes, but should they be accompanied by the Bullitt collection's original edition of Newton's *Principia*? That would help to illustrate the direction of science after Galileo. Or perhaps they should be accompanied by the *Nuremberg Chronicle*, a large and beautiful book that would help to illustrate a pre-Copernican worldview. Finally, the space available did not allow for all four books to be displayed. Ultimately we settled on a five-month long exhibit, with the *Chronicle* accompanying *On the Revolutions* and the *Dialogue*; the display panels presented a strongly scientific focus, but there was some mention of broader themes in the book labels.

The exhibit could never have happened were it not for 21st century technology — or at least it could never have happened without a much larger budget. The Frazier had materials on hand for creating exhibits, but no resources specific to the history of astronomy. To provide historical background, explanatory information, and just nice pictures for people to look at, we used high resolution images of books from the Bullitt Collection. What's more, the University of Oklahoma Libraries' History of Science Collection granted us permission to use high resolution images from their online archive. Therefore our display material included images from books such as Galileo's 1610 *Starry Messenger* and the works of Tycho Brahe. To develop museum-quality panels we simply created what we wanted in very high resolution PDF format and dropped the PDFs off at a local print shop with a large-format printer. They did a fine job creating the panels and a large backdrop for one of the exhibit cases (see Figures 2 and 3) for a very reasonable cost. The visiting public never knew that this exhibit of books was put together for so little cost, using local resources.

The three partners for Fathers of Astronomy would have liked the public to know more about the local nature of the exhibit. The Frazier was quite successful in getting the media's attention. Two regional TV stations had coverage of "Fathers" on their news programmes, complete with camera footage of the exhibit and commentary from the Frazier staff. One of Kentucky's major newspapers ran a story, as did the local public radio station. "Fathers" even garnered some brief national exposure, being the Event of the Day on NBC's Early Today show (Figure 4). But the local nature of the exhibit was not featured in the media coverage. All three exhibit

Figure 1. The Frazier International History Museum in Louisville, Kentucky.

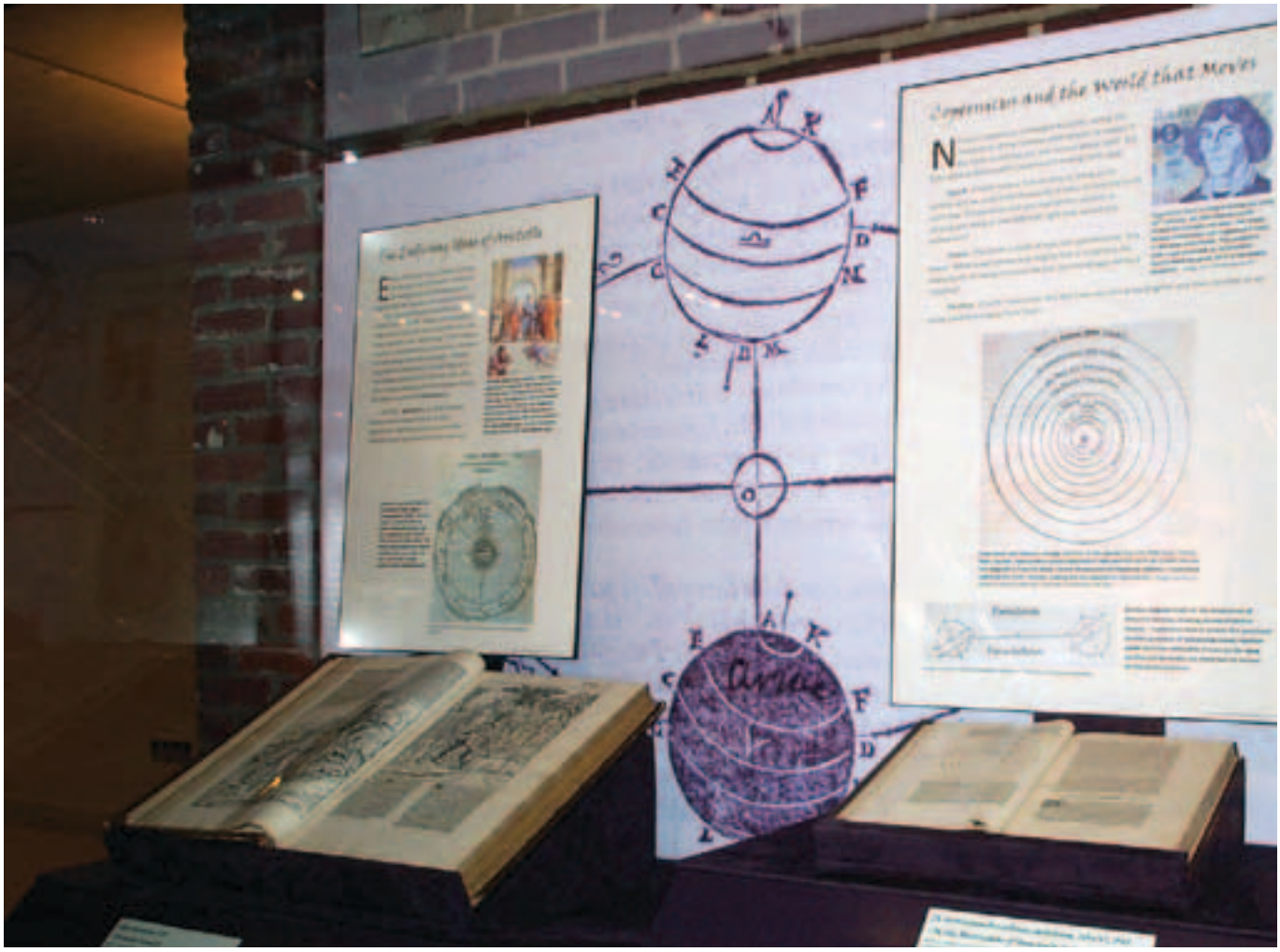

Figure 2. Display of original editions of the Nuremberg Chronicle *and* On the Revolutions of Heavenly Spheres*, in the Fathers of Astronomy exhibit at the Frazier international History Museum.*

partners have an ongoing interest in communicating to the public of Kentucky that local resources exist — be it a museum, a collection of rare books, or a public observatory with outreach and research. The challenging nature of communicating the local aspect of Fathers of Astronomy probably means that the media coverage will not translate into a wider awareness of, for example, the existence of the Bullitt Collection's astronomical treasures.

Another challenge revealed itself over time. The Frazier reports that interest in Fathers of Astronomy was strong. People who saw the exhibit liked it. People came to the museum specifically for "Fathers". However, as an astronomer, I was disappointed in many people's reactions to it — or to be more specific, their lack of reactions. My family has a membership at the Frazier and my wife is a long-

Figure 3. Informative panels in the Fathers of Astronomy exhibit.

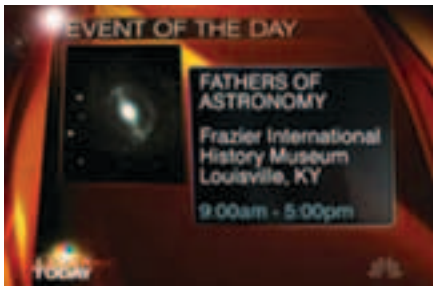

Figure 4. History of Astronomy was the Event of the Day for 23 September 2009. NBC's commented, "Open your minds to books from centuries past written by groundbreaking scientists and dealing with the skies above, at 'Fathers of Astronomy' at the Frazier International History Museum."

time volunteer, so I had plenty of opportunity to surreptitiously watch people going by the exhibit, which was prominently located near the doors of the museum. In doing so, I had the humbling experience of seeing people, who had paid admission to visit a museum and therefore already demonstrated some interest in learning, walk right past something I think is absolutely fascinating. We astronomers tend to think that people will love — LOVE! — the things we think are interesting, if only we expose them properly. Fathers of Astronomy disabused me of that notion! Yes, plenty of people took a real interest in "Fathers". But plenty more did not even glance at it as they walked by. Were we to do the exhibit again I might suggest a large interactive device — a telescope set up to look at a little picture of the Moon on the far wall, or a coin well to demonstrate orbital motion — but would that simply get some of those who just walked by the exhibit to merely glance at the telescope or play with the coin well? Despite the International Year of Astronomy 2009; despite Galileo's work being unbelievably influential in making our modern world what it is today; despite having his original work in the exhibit; despite the exhibit being in a beautiful, fantastic museum with a supremely competent staff; in short, despite having ideal conditions to communicate this aspect of astronomy to the public, to many people Galileo and the story of astronomy is "not even uninteresting". This does not take away from the exhibit's success. But it does offer a sobering lesson in the realities of trying to communicate astronomy to even the museum-going public.

But the lesson was not too sobering. All three partners are very happy with Fathers of Astronomy, as evidenced by the plans afoot for further collaboration in an exhibit on Isaac Newton! We are all very happy to have been able to bring the story of Galileo and an original *Dialogue Concerning the two Chief World Systems* to the public during the International Year of Astronomy 2009 (Figure 5).

Biography

Christopher M. Graney is an astronomer at the Otter Creek–South Harrison Observatory and professor of Physics at the Jefferson Community & Technical College, Louisville, KY. Personal website: http://legacy.jefferson.kctcs.edu/faculty/graney/

Figure 5. An original edition of Galileo's Dialogue *on display at Fathers of Astronomy.*

Mi'kmaq Night Sky Stories; Patterns of Interconnectiveness, Vitality and Nourishment

Prune Harris
Cape Breton University, Canada
E-mail: prune_harris@cbu.ca

Cheryl Bartlett
Cape Breton University, Canada
E-Mail: cheryl_bartlett@cbu.ca

Murdena Marshall
Cape Breton University, Canada
E-Mail: murdena_marshall@cbu.ca

Albert Marshall
Cape Breton University, Canada
E-Mail: albert_marshall@cbu.ca

Key Words

Integrative Science
Indigenous Science
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Cultural Astronomy

Summary

This article shares some of the experiences of an integrative science team based at Cape Breton University, Canada. Integrative science is defined as "bringing together Indigenous and Western scientific knowledge and ways of knowing" and the team includes Mi'kmaq Elders and educators, Cheryl Bartlett and her Research Associates. Together we worked to rekindle the Mi'kmaq Sky *Story, Muin and the Seven Hunters*, to produce a DVD of the story as well as a children's book, and then to share it with people throughout Canada and the world. We offer insights into the manner in which night sky stories engender interconnectiveness[1] and interdependability[2] through their cultural, scientific and ecological teachings and so help to revitalise the culture and the individual by feeding all aspects of the human experience (spiritual, emotional, physical and cognitional). We explore the concept of storywork[3], with emphasis on the relationship between storyteller and listener as a story is told, as well as considering the multi-layered aspect of Indigenous stories.

Introduction

From twilight to dawn, the night sky embraces us all, whether we are conscious of it or not. Throughout the world, each culture has its own night sky stories — stories that have woven the fabric of that culture, just as the culture has itself woven the fabric of the specific story. This article will look at some of the ways in which we, the integrative science team at Cape Breton University in Sydney, Nova Scotia, Canada, began working with the Mi'kmaq night sky story *Muin and the Seven Hunters* for the International Year of Astronomy 2009, and how such night sky stories can make the essential interconnectiveness clear as well as perpetually nourishing and revitalising the Mi'kmaq culture and people. The Mi'kmaq are the Indigenous (Aboriginal) Peoples of Atlantic Canada; their ancestral territory is known as Mi'kma'ki and includes the present day Canadian provinces of Nova Scotia, Prince Edward Island, most of New Brunswick, the Gaspe of Quebec, and southwest Newfoundland, as well as parts of the State of Maine in the United States of America.

Muin and the Seven Hunters

The integrative science research team includes Mi'kmaq Elders and educators, Canada Research Chair Cheryl Bartlett, students and research associates. Integrative science is defined as "bringing together Indigenous and Western scientific knowledge and ways of knowing". It uses pioneering, praxis-based research following integrative, action and participatory methodologies within a co-learning journey with, by, and for Aboriginal peoples and communities (Bartlett, 2005; Bartlett et al., 2010; Comeau et al., 2005; Hatcher et al., 2009; Iwama et al., in press). It was conceived in the mid-1990s in collaboration with key Mi'kmaq individuals to bring radical innovation into the educational system to begin to address the shocking underparticipation by Aboriginal young people in university science programmes and thus also in careers that require such an education. Mi'kmaq Elder Albert Marshall has introduced the guiding principle of "Two-eyed Seeing", which emphasises learning to see from one eye with strengths in Indigenous knowledge and ways, and learning to see from the other eye with strengths in Eurocentric (or Western, or mainstream)

knowledge and ways. Elder Albert stresses that we must learn to use these two eyes together, for the benefit of all.

The Canadian International Year of Astronomy 2009 (IYA2009) National Steering Committee, chaired by Jim Hesser (Director, Dominion Astrophysical Observatory, Herzberg Institute of Astrophysics, National Research Council of Canada, Canada), made a special request to the integrative science team: to form the Canadian Aboriginal Working Group for IYA2009 to help celebrate Aboriginal knowledge of astronomy alongside mainstream science. Mi'kmaq Elders gave their approval and endorsement for the integrative science team to proceed with the idea to highlight a Mi'kmaq night sky story as a contribution to IYA2009 celebrations in Canada. *Muin and the Seven Hunters* was the immediate choice as it is the story with which Elder Lillian Marshall from the Mi'kmaq community of Potlotek (Chapel Island) had been working for over 20 years. It is a rich, vibrant story that links the annual cycle of natural, seasonal events as observed by the Mi'kmaq with the movement of stars about the North Celestial Pole Star, known as *Tatapn* by the Mi'kmaq.

The story evolves in the sky and tells of *Muin* (the Mi'kmaq word for Black Bear), as she awakens from her winter sleep and, leaving her celestial den, descends to the ground in search of food. She is chased by the Seven Bird Hunters who pursue her through the spring and summer months, eventually killing her in the autumn and celebrating their success with a feast in winter. Muin's life-spirit (*wjijamijel*) returns to her den in the sky to enter the body of a new bear who, in turn, wakes from her winter sleep, to once again descend to Earth and be pursued by the Hunters, and so the story continues eternally.

The complete animated story of *Muin and the Seven Hunters* can be found online[4]. In a modern Eurocentric culture that is unfamiliar with stories as a primary way of

Figure 1. Muin and the Seven Hunters.

Mi'kmaq	Arabic	English
Muin		Black Bear
Ntuksuinu'k		The Hunters
Jipjawej	Alioth	Robin
Jiji'kes	Mizar	Chickadee
Wow	Alcor	Cooking Pot
Mikjaqoqwej	Alkaid	Grey Jay
Ples	Seginus	Passenger Pigeon
Tities	Izar	Blue Jay
Ku ku kwes	Arcturus	Barred Owl
Kupkwe'j	Mufrid	Saw-whet Owl

The Stars in the Story

Figure 2. The names of the stars in the story in Mi'kmaq, Arabic and English.

teaching, it may at first be difficult to grasp the immense richness within this story, wherein astronomical, cultural and ecological concepts are woven together to form the living knowledge that is transmitted in oral form from generation to generation. Many Indigenous/Aboriginal worldviews have, as a central pillar, the fundamental interconnectiveness and interdependability of everything (Archibald, 2008; Henderson, 2009; Little Bear, 2009). This is known to the Mi'kmaq by the concept transferred through the word *elitasualtulti'k* whereby humans, animals, plants, stones, trees, the sky, water (i.e., "all my relations") are intimately and continually connected. In Elder Albert Marshall's words, *"We humans are part and parcel of the whole. And, everything that we do to our natural world, we also do to ourselves. Humans are but a very small part of the whole. Our natural world provides for us, shelters us, nourishes us."* Indigenous scholar Jo-Ann Archibald in her book, *Indigenous Storywork: Educating the Heart, Mind, Body and Spirit*, has closely explored the effects of stories, storytelling and storywork in the transfer of knowledge of such interconnectiveness among Coast Salish and Stó:lō Elders in British Columbia, Canada. She states that the common goal is *"to attain a mutual balance and harmony among animals, people, elements of nature and the Spirit world"* (Archibald, 2008, p11). And to attain this goal, ways of acquiring knowledge and codes of behaviour are both essential and embedded in cultural practices. Thus, the sacred tenets of respect, relationship, reverence, reciprocity, ritual (ceremony), repetition and responsibility are essential to the vitality and nourishment of individuals and community. With the traditional oral transmission of legends, stories, and teachings, such tenets are established and continuously reinforced. Within Mi'kma'ki however, due to colonisation and associated atrocities such as residential schools and centralisation, such continuity of the teaching of oral traditions through stories has been at best disrupted, and at worst, lost to all other than Elders.

So it was most fortunate that the story of *Muin* had been written down and published by the anthropologist Stansbury Hagar (Hagar, 1900). Using this written source, the integrative science team and Elder Lillian Marshall were able to work together to determine which stars (using their Arabic names) were which Birds (using their Mi'kmaq names), and where these stars were positioned in the night sky (see Table 1). Elder Murdena Marshall from the Mi'kmaq community of Eskasoni tells us of the Mi'kmaq phrase *"Klo'qwejk ila'lukupjik"*, which best translates as: *"The stars are lined up in a certain way … they know their spots."* They know their place within the pattern in the night sky and, through the story of *Muin*, the Mi'kmaq know the positions and movement of the relevant stars throughout the year.

Interconnectiveness is illustrated in the story of *Muin* in many ways. As in all Mi'kmaq stories, it is told using the present tense. This means that it is not a story of long long ago, or even long ago, but rather it is a story of now, as relevant to those living under the sky today as it was to their ancestors. Elder Murdena Marshall explains: *"The sky will always be there. You are part of the sky when you are on Earth. It is a part of your everyday life. The sky is alive and demands respect from you."* The use of the present tense also reminds us that the story is always happening, that it is eternal, that it has no end. This reinforces the concept of a circular time (von Thater-Braan, 2001) rather than the linear time familiar to many holding a Eurocentric worldview and, as such, helps guide the principle that all actions taken now directly impact future generations.

As an ecological teaching tool, *Muin* provides information regarding the flora and fauna of the ecozone where the story has emerged. The Bird Hunters, namely, *Jijawej* (Robin), *Jiki'kes* (Chickadee), *Mikjaqoqwej* (Gray Jay), *Ples* (Passenger Pigeon), *Tities* (Blue Jay), *Ku Ku Kwes* (the Barred Owl), and *Kupkwe'j* (the Northern Saw-Whet Owl), are described in relation to each other and their environment, revealing an understanding of the behavioural patterns of the birds (e.g., *Mikjaqoqwej* has a habit of turning up only after a kill has been made, *Jiki'kes* is sharp eyed, and *Kupkwe'j* has a rasping cry and must often find enough food in winter by flying elsewhere rather than staying in Mi'kma'ki). We are told by Mi'kmaq Elders that night sky stories are of immense importance: *"They are a part of our learning, a component of life, such as the earth, water and the forest."*

Muin, as with most Mi'kmaq stories, is multi-layered, revealing stories within stories. In *Muin* we learn how *Jipjawej* got his red breast, why and when the leaves of the maple tree turn red, and that *Kupkwe'j* can be vengeful when mocked (to highlight just

a few sub-stories). Elder Murdena Marshall indicates that such stories are very intimate, in that beyond the ecological concepts they also provide history, entertainment, cultural revitalisation and language reinforcement. With the multi-layered aspect of each story, the participation of the listener is as paramount as the way in which the living spirit of the story is held by the storyteller. Stories such as *Muin* are heard many times so the participating listener can develop a relationship with the spirit of the story and thus deepen her or his experience and understanding as the story is told. Archibald (2008) cites such synergistic interactions between storyteller, listener and story as a critical principle of storywork. Elder Albert Marshall tells us, *"Traditionally, nothing was taught as black and white. Everything was story ... where you have the responsibility to listen and reflect. This is a much more profound way of learning because you have the opportunity for a relationship with the knowledge."*

Muin also provides the oral calendar from which the timing of Mi'kmaq celebrations and activities could be calculated. *Muin's* position in the sky determines when hunting is forbidden: in spring, as she emerges from her den, hunting is not allowed as it is the time of breeding and young being born. As *Muin* moves along the horizon during summer it is understood that the time has come to pick berries or to swim in the local lakes with no risk to the new life (e.g., baby fish) within the waters. As *Muin* rises on her hind legs in the fall, it is time to hunt and gather provisions for the winter. Furthermore, and key to the ideas in the story, once the first new Moon has passed after *Muin* is lying on her back in the winter sky, it is the time for *Aqtapukewey Wi'kupaltimk* (the Mi'kmaq Mid-Winter Feast). It is a traditional Mi'kmaq ceremony of deep significance with giving thanks to all spirits, especially to the Great Spirit, for the blessings of life, health and community, and marks the closing of the old year and beginning of the new. Over 20 years ago, through her work with *Muin*, Elder Lillian Marshall was able to renew and revive this traditional ceremony in her home community of Potlotek. Celebrations today may not be as elaborate as those of their ancestors, but people in Potlotek (and elsewhere, as slowly the ceremony is being revived in a few other Mi'kmaq communities) celebrate this most important traditional ceremony of the year with passion and thanksgiving.

Elder Albert Marshall believes that in the efforts to revive the Indigenous culture, the sky stories are the last piece in the re-assembling jigsaw puzzle, and that this understanding has lagged behind in cultural revitalisation work. It is hoped that our work with *Muin and the Seven Hunters* starts to address this last missing jigsaw piece. A children's book of the story, written in Mi'kmaq and English, is currently being published and the DVD of the animated story is being widely taken up by schools within Unama'ki (Cape Breton). It has also been screened nationally in a number of settings, including the Canada Science and Technology Museum in Ottawa during the celebrations to herald the start of International Year of Astronomy 2009, and it was distributed to all delegates at CAP 2010 in Cape Town, South Africa. Yet *Muin* is about just one part of the night sky, and the Mi'kmaq people have many more rich stories for other parts of the night sky. The Mi'kmaq Elders who helped with the *Muin* project and IYA2009 encourage other Aboriginal peoples across Canada to reconnect with their night sky stories in the firm belief that it is essential for all Aboriginal children to feel connected to the night sky. Together, we also hope *Muin* can help awaken all people to the richness of Indigenous science stories around the world.

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Notes

[1] Interconnectiveness: The dynamic of mindfully living within an expanding sense of holistic relationships with everything and everyone, i.e. "all my relations" or "all of Creation".

[2] Interdependability: The ability to mindfully live one's responsibilities within a network of relationships.

[3] Storywork: the lifelong journey of educating one's heart, mind, body and spirit towards interconnectiveness and interdependence.

[4] www.integrativescience.ca and www.astronomy2009.ca.

Biographies

The authors of this article are part of the integrative science team based at Cape Breton University in Sydney, Nova Scotia, Canada, including Prune Harris and Cheryl Bartlett who work at the university and Mi'kmaq Elders Murdena and Albert who live in the community of Eskasoni, in Cape Breton, Nova Scotia. They form a trans-disciplinary team that talks and walks together in a co-learning journey. All four are dedicated to sharing an ever-evolving understanding of Two-eyed Seeing for the benefit of humanity, all our relations and Mother Earth.

Making Astronomy Culturally Relevant

Nancy Alima Ali
UC Berkeley, Space Sciences Lab, California, USA
E-mail: nali@ssl.berkeley.edu

Key Words

Cultural Astronomy
Archaeoastronomy
Public Outreach
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Summary

This article investigates how astronomy can be made relevant to ethnically diverse audiences by integrating astronomical concepts within cultural contexts. A series of Cultural Astronomy workshops is used to illustrate how highlighting the human connection to astronomy makes it easier to relate to.

Introduction

Do a Google image search using the term "astronomer" and the first image that comes up is Vermeer's painting *The Astronomer* (Figure 1). Illuminated by soft light falling through a window, the astronomer is gazing at a celestial globe. The next image in the search results is a cartoon of a young boy gazing through a telescope. This is followed by a glow-in-the-dark jigsaw puzzle of a wizard in a fanciful observatory. Keep going and you'll find a variety of photos of contemporary astronomers sitting in front of computers. What is striking about all these images is that, by and large, all the astronomers depicted appear to be Caucasian. In fact, the only notable ethnic diversity in the first three pages of the Google search results is a green alien.

This lack of diversity is an indication of the face of astronomy that is presented to the general public. Unfortunately, it sends a message that astronomy is an enterprise specific to one ethnic group, when the truth is that sky-gazing is a universal human endeavour. The overwhelming majority of cultures around the world have gazed at the sky and used their observations in daily life (Kelley & Milone, 2004). Considering that more than one third of the United States population identifies itself as an ethnic minority (Minckler, 2008), we, as astronomy communicators, would do well to acknowledge the diversity of the sky-gazing heritage.

Figure 1. The Astronomer *by Vermeer.*

In an attempt to highlight cultural connections to astronomical knowledge, I created and taught a series of Cultural Astronomy workshops for the general public that presented specific astronomical concepts within cultural contexts. The underlying premise was that exploring the cultural connections to astronomy would appeal to segments of the population that might not otherwise engage in astronomy education. As it turned out, this approach was not only effective with ethnic minorities, but also with the Caucasian majority. Feedback provided by workshop participants indicated that highlighting the human connection to astronomy brings astronomy down to Earth by making it easier to relate to. Instead of being remote and incomprehensible, astronomy becomes something that can be experienced every day in a personal way.

Cultural Astronomy workshops

The series of three Cultural Astronomy workshops were offered to the general public through the non-credit outreach division of Windward Community College in Kaneohe, Hawaii, USA. The workshop series took place on three Sunday afternoons in January and February, 2008. Registration was open to anyone aged ten and up, although the vast majority of the participants were adults. In total, 100 people attended the workshop series. Two of the workshops were roughly equally attended by males and females, while the third (which was inadvertently scheduled during the Super Bowl football game) was attended predominantly by females.

The workshops were organised thematically around the Sun, the Moon and the stars. Each workshop focused on an astronomi-

cal concept related to one of the themes, exploring the concept from both scientific and cultural perspectives. Each 90-minute workshop included a planetarium demonstration of the astronomical concept, a lecture component using PowerPoint slides and a hands-on activity. Opportunities for discussion were sprinkled throughout the workshops.

The Sun workshop explored the astronomical concepts of solstices and equinoxes within the context of the Native Hawaiian site Kukaniloko. Kukaniloko is a place that was used by the Hawaiian royalty as a birthing site, but it also is reported to have astronomical connections. Looking towards the Waianae Mountains from Kukaniloko, the Sun sets over the highest point of the mountain range at the equinoxes, into the lowest valley of the range at the winter solstice and at the point where the mountain range meets the ocean at the summer solstice. Investigating the astronomical connections of Kukaniloko gave a purpose for understanding the observable movement of the Sun along the horizon as related to seasonal change.

The Moon workshop focused on how the phases of the Moon were used as the basis of the Hawaiian calendar. The Hawaiian calendar was composed of twelve months that began with the first sighting of the waxing crescent Moon and ended with the new Moon (Beckwith, 1932). Since a synodic month is approximately 29.5 days long, a year in the Hawaiian lunar calendar would be approximately 354 days long. However, the Hawaiian calendar also included a sidereal year, based on the rising of the Pleiades at sunset (Malo, 1951). Since a sidereal year is approximately 365.25 days long, the Hawaiians must have had some way of intercalating the discrepancy of approximately 11 days. This example provided an excellent context for exploring the nature of the Moon's orbit around the Earth and the Earth's orbit around the Sun.

The Stars workshop investigated how Polaris, also known as the Pole Star, may have been used in Polynesian celestial navigation. It is well known that the first people who came to Hawaii voyaged on canoes from Polynesia using only natural cues, including the stars, to guide them (Finney, 1994). The star Polaris is currently used in Hawaiian navigation as a latitude marker (Polynesian Voyaging Society, 2008). Because the Polynesian migrations to Hawaii occurred over a period of several hundred years (TenBruggencate, 2006), the effect of precession must be taken into account when considering how Polaris was used in navigation. Presenting precession within a cultural context provided a reason for learning about such an abstract concept.

Participant feedback

In order to assess the effectiveness of integrating astronomy and culture as a way of engaging minority audiences, workshop participants were asked to complete a survey and were invited to provide feedback through informal focus groups.

At the end of each workshop, participants completed a paper survey that included a space for them to list their ethnicity. The purpose of this was to obtain data regarding the attendance of ethnic minorities in the workshop. The survey did not include preset ethnicity categories, but rather allowed people to write in their response. Eighty-three percent of workshop participants completed the survey. Of the participants who completed the survey, 47% identified themselves as Caucasian, 38% identified as belonging to two or more ethnicities, 9% as Asian, 4% provided no response and 2% identified as "other" (Figure 2).

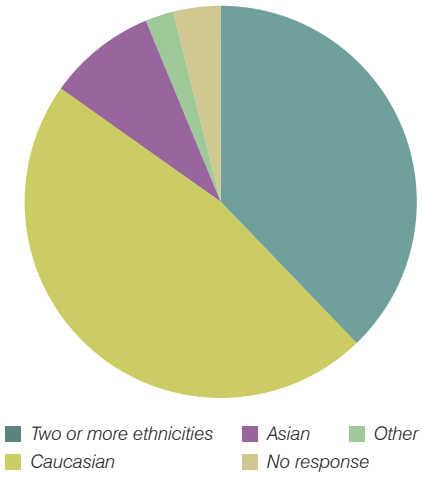

Figure 2. Workshop participant ethnicities.

In addition to the survey, participants were invited to linger after the workshops to provide feedback during informal focus groups. During the focus groups, participants responded to question prompts to share their thoughts regarding the value of integrating astronomy and culture. In total, 28 people participated in the focus groups. The responses that emerged from the focus group participants confirmed the value of recognising cultural minority perspectives of astronomy as a way of engaging the public.

When asked why they were interested in cultural astronomy, numerous participants responded that it made astronomy more understandable by making it easier to relate to. In the words of one participant, *"Astronomy is so out there, not here where I live."* Another participant elaborated on this by saying, *"It has more meaning for people because you can see how [astronomy] has some kind of help to your life … you can apply it to your life."* A third participant explained how integrating cultural aspects makes astronomy *"come alive more, rather than boring you silly with a bunch of math. Because angles are cute, but who cares? So when you see a reason why somebody would be watching the stars for culture or for navigation or doing planting or for other purposes, that just means more."*

A second theme that emerged was that of valuing non-European cultures. One participant explained how, in her opinion, *"Just to teach [astronomy] in terms of European [culture] is almost offensive. You want to know how you have value too and how your heritage is equally valid. Everyone wants to know their importance. It wasn't just Europeans looking at the sky."* In the case of Hawaii, where much of the traditional knowledge was lost due to the active suppression of the native language and cultural practices in the early 20th century, there is a desire now for people to reconnect with their culture. One participant described how teaching about traditional knowledge related to the stars is important in a larger sense because it is *"part of salvaging the identity of culture for the kids"*. Another participant put it this way: *"This is just another brick in the sense of building the wall of understanding."*

Guidelines for integrating astronomy and culture

Based on the experiences gained from the Cultural Astronomy workshop series, I have developed three guidelines for integrating astronomy and culture.

1. Make it relevant

Relevance to your target audience should be a primary consideration in choosing which cultural contexts and scientific concepts to integrate. In the case of the Cultural Astronomy workshops, the participants represented a variety of cultural backgrounds, but an interest in Native Hawaiian culture was shared among all. There is currently a great deal of interest in Hawaiian culture in Hawaii, creating a market for workshops and programmes that focus on Hawaiian culture. This workshop series built on this common interest and used it as a springboard for teaching astronomical concepts.

Likewise, the science concepts explored should be relevant to the target audience. In this case, the movement of the Sun along the horizon, the phases of the Moon and the use of Polaris as a marker of the north celestial pole are all concepts that have relevance to Hawaiian culture and can be easily viewed in Hawaii. In contrast, Pamela Eastlick (1995) describes trying to

teach children in Micronesia how to build sundials, only to discover that the gnomon would need to be about a millimetre high in order to be accurate for Micronesia's low latitude. Clearly, sundials are not culturally relevant in Micronesia.

2. Make it authentic

In the early 1990s, the Bishop Museum in Hawaii held a contest to choose a name for the phenomena of the zenith passage of the Sun. The phrase Lahaina Noon was chosen because it means "cruel Sun" in Hawaiian (Pukui, 1974; Williams, 2005)[1]. Although the contest may have been intended to engage the public in astronomy, it ignored the fact that the Hawaiian language already had a term describing the zenith passage of the Sun.

The Hawaiian term for this phenomena is *kau ka la i ka lolo* (Pukui, 1974)[2]. It may not be as catchy as Lahaina Noon, but it is certainly a more authentic and meaningful term. The phrase roughly translates to "the Sun rests on the brain". Hawaiians believe that the moment in which a person's shadow disappears as the Sun passes over the zenith is a time of great personal power. At this moment the person's *mana* or energy would collect inside and the person becomes aligned with the forces of the Universe (Pukui, Haertig & Lee, 1972).

Because of the Bishop Museum's role as an authority on Hawaiian culture and astronomy, the phrase Lahaina Noon survives within Hawaii. Each time Lahaina Noon is repeated it represents a lost opportunity for educating the public about the original Hawaiian knowledge regarding the zenith passage of the Sun.

This example illustrates the need for cultural content to be based on authentic cultural information rather than inventiveness, conjecture, misunderstanding or exaggeration. Otherwise, there is the risk that repeated inaccuracies become known as truth. In choosing the cultural content, seek out knowledge from cultural experts such as anthropologists, archaeologists, linguists, community leaders and elders. Cultural astronomy is interdisciplinary by nature, so sources of information must be gathered from a variety of field studies.

3. Make it holistic

The nature of scientific study often involves breaking down a concept or phenomenon into its constituent parts. In astronomy, a particular star may be understood as a mass of hydrogen and helium atoms which can be reduced to an equation. Yet cultural perspectives of the cosmos tend to present a holistic understanding of the natural world. Cultural understanding of a star may integrate observations of the star's colour and seasonal movements with mythological connections that contain historical elements and practical guidance for everyday life. When integrating astronomy with culture, it is important to honour this holistic way of knowing by drawing connections.

For example, a holistic exploration of the Mayan understanding of the stars Alnitek, Rigel and Saiph could highlight the role of these stars as symbolising the three stones of a traditional Mayan cooking hearth, out of which comes the mythological smoke of creation, which can be seen in the sky as the Orion Nebula (Freidel, Schele & Parker, 1993). Scientific understanding of the stars is integrated with mythology, cosmology and daily life of the Mayan people.

Conclusion

Few things evoke a sense of wonder more than the mysteries of the cosmos. Yet while black holes and spiral galaxies capture people's imaginations, they can also seem very remote from human experience. The challenge for astronomy communicators is to bring the cosmos down to Earth so that the astronomical concepts become meaningful to people. Integrating astronomical concepts within cultural contexts provides a strategy for making astronomy relevant by highlighting the celestial heritage of ethnic minorities.

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Notes

[1] The correct Hawaiian spelling for Lahaina Noon includes a macron over the first two "a's" in Lahaina.

[2] The correct Hawaiian spelling for *kau ka la i ka lolo* includes macrons over the "a" in la.

Biography

Nancy Alima Ali is the Coordinator of Public Programs at the Center for Science Education at University of California Berkeley's Space Sciences Laboratory. Throughout her career, she has taught STEM topics to people of all ages in both formal and informal settings. Before moving to California, Nancy managed Windward Community College's planetarium and served as the Science Education Manager at Bishop Museum in Hawaii. Nancy Ali became interested in cultural astronomy while working at Bishop Museum, where she learned how Hawaiian people used celestial navigation. Following this passion, she earned a Master of Education degree from Lesley University, specialising in integrating astronomy and culture. Nancy developed and taught an "Intro to Archaeoastronomy" course for Windward Community College, as well as wrote a monthly astronomy column for the *Honolulu Star–Bulletin* newspaper.

International Year of Astronomy 2009

Final Report

The 1400-page final report for the International Year of Astronomy 2009 (IYA2009) is a compilation of the achievements of the 216 IYA2009 stakeholders — 148 countries, 40 international organisations and 28 global projects. The report shows the excitement, engagement and community involvement engendered by IYA2009. The report is intended to stand as a record of the legacy of this astonishing international celebration of astronomy. Download the International Year of Astronomy 2009 Final Report here: www.astronomy2009.org

Challenging C. P. Snow: Active Interaction between Arts, Cultural Heritage and the Universe in Finland

Tapio Markkanen
Ursa Astronomical Association, Helsinki, Finland
E-mail: tapio.markkanen@helsinki.fi

Key Words

Arts and Sciences
Dialogue Between Astronomy and Arts
Two Cultures

Summary

Many events in Finland during the International Year of Astronomy 2009 (IYA2009) clearly demonstrated that there can be real interactions between the arts, humanities and science. We have found the 50-year-old concept, introduced by C. P. Snow, of two cultures unable to engage in a dialogue to be irrelevant. In Finland, astronomy has always been popular. The IYA2009 was celebrated in Finland with many local, national and international events. Altogether there were more than 400 events of all sizes. Arts and cultural activities were essential parts of many of these events.

Introduction

The Finns find the Universe, and thus astronomy, very interesting. Astronomy is the most popular scientific topic in the media — newspapers, journals, TV and radio alike. The community of amateur astronomers in Finland is big for the population size. At the end of 2009, the Ursa Astronomical Association, the national astronomy organisation, had over 15 000 members out of a population of around 5.2 million. More than 40 local astronomy societies are active all over the country. Most of them have an observatory for public star parties and schools and for their own observations. In most cases the observatories have been built with the financial support of the local community.

Ursa publishes the journal *Tähdet ja avaruus* (Stars and Space), which is issued eight times a year. The journal is one of the most esteemed publications that popularises science in Finnish. Ursa is also an important science publishing house with more than 100 popular books on astronomy and related sciences to its name. Ursa has a leadership role in astronomy in Finland, as mathematics and science teachers actively develop their work in co-operation with Ursa, creating new methods of teaching and learning, often as part of an international collaboration.

The 150th anniversary of astrophysics

The IYA2009 was officially inaugurated in Finland on 7 January 2009 as one of major events of the Science Forum, a nationwide biannual science communication event held from 7 to 10 January 2009 at the University of Helsinki. The main theme of 2009 was evolution. Cosmic evolution played a major role at the lectures and at other events. The 150th anniversary of spectroscopy, invented in 1859 by Robert Bunsen and Robert Kirchhoff, was also commemorated. This new technique revolutionised chemical analysis and marked the beginning of two new sciences — physical chemistry and astrophysics. It became possible to find the composition of the stars and other celestial bodies.

The importance of spectral analysis is indicated in the monument to Emperor Alexander II and to the political reforms and advanced legislation of 1863 in Finland. The importance of this scientific discovery is made clear in the monument's design, as in just a few decades, a tool essential for a breakthrough in research was used as a symbol in the statue, and its significance was generally recognised (see Figure 1).

Figure 1. Lux and the spectroscope. Since 1894, the monument, created by Johannes Takanen and Walter Runeberg, has stood in the Senate Square in the very centre of Helsinki. One of its figures, the goddess of knowledge, is holding a spectroscope as a symbol of intellectual inquiry and research, rather than the more conventional papyrus scroll or compass.

Voyage to the Moon

In the IYA2009, the arts received public attention at many events in Finland. At Kiasma, the National Museum of Modern Art in Helsinki, an international team of artists, Jussi Kivi, Oliver Kochta, Iina Kohonen and Mika Taanila created a multi-faceted art exhibition and an interlinked series of events named *Expedition To The Solar Eclipse*, running from 6 March to 7 June with themes relating to solar eclipse expeditions and space travel, with Ulla Taipale as curator. This group of artists had travelled to Novosibirsk for the 2008 total solar eclipse. Agnes Meyer-Brandis enlivened a voyage to the Moon by using a special species of geese — Moon geese (see Figure 2) — as told by Francis Goodwin in his book, *The Man in the Moone, or a Discourse of a Voyage thither*, by Domingo Gonsales, published posthumously in 1638. The artists and scientists also discussed explorations in time and space. The exhibition ended with a walk and series of events through the centre of Helsinki from Kiasma, the Museum of Modern Art to the Ursa's Observatory, with a stop and visit to the Helsinki University Observatory.

The heavens and the human mind interaction

The 7th International Conference on Environmental Aesthetics was the culmination of a series of scholarly conferences arranged between 26 and 28 March at Valamo Monastery in Heinävesi by Yrjö Sepänmaa, Professor of Environmental Aesthetics at the University of Joensuu. The theme was the aesthetics of the sky, space and heaven. The artistic contribution included several art performances, posters and exhibitions. People attach multiple, parallel and overlapping meanings to the concept "celestial". The conference approached this multi-layered idea from three perspectives: through its cultural and scientific significance, through different individual perceptions and how the various experiences could be depicted. Looking at the subject from the perspective of cultural history, aesthetics, spirituality and the sciences, separately and together, opened up interesting views. Three themes were discussed from the different points of view, the mythological and religious sky, the sky as atmosphere and space, and the imaged and imagined sky. The conference papers will be published as a book edited by Yrjö Sepänmaa. The weather favoured the conference because on the second night a star party was organised with the assistance of the astronomical society Warkauden Kassiopeia. The telescopes were provided and excellent guidance given by the chairperson of the society, Veli-Pekka Hentunen.

Global folklore and space exploration

In Joensuu, in central northeast Finland, the Museum of Northern Carelia and the local astronomy society Seulaset (the Pleiades) produced an exhibition that spanned a vast range of topics, from the age-old traditions of calendars and myths of creation of the world, to cosmic evolution as part of modern science, and GPS navigation and space astronomy (see Figure 3). The interactive exhibition was produced by Pertti Pääkkönen, Chair of the Seulaset

Figure 2. The artist Agnes Meyer-Brandis meets the Moon geese for a voyage to the Moon during the total solar eclipse in 2008. The experiment is part of Capsula´s guided expeditions. Photo: The Moon goose experiment/Agnes Meyer-Brandis 2008/VG-Bildkunst.

Figure 3. Space night for children in Joensuu. A space-themed masquerade brought about a hundred children to the Museum of North Carelia. On the right, a giant World Egg, part of many creation myths from round the world.

Society and a researcher at the University of Joensuu, and Iiris Heino and Outi Suoranta of the Museum and many enthusiastic colleagues. It was visited by many groups, including school classes with their teachers and the general public and was extensively covered by media. The name of the exhibition (8 October 2009 – 21 March 2010) was *Väinämöisen polvelta tähiksi taivaalle*, From the Knee of Väinämöinen to the Heavenly Stars. Väinämöinen is a central character — an omnipotent sage — in the Finnish national epos *Kalevala*.

C. P. Snow was wrong — The Galileo Symposium on the History of Philosophy and Science

Galileo Galilei was remembered in many contexts over the year. The general public was also reminded of the fundamental importance of the discoveries of Johannes Kepler in his *Astronomia Nova* published 1609. One commemorative multi-day event for teachers, young people and the general public was a symposium on the development of philosophy and science and their impact on people and society, arranged at the Maunula Science Gymnasium in Helsinki by nine educational, scholarly and cultural organisations, including Ursa. One of the guest lecturers was Jon Jenkins of the SETI Institute, who gave a presentation entitled *Hunting for Other Worlds — Kepler Probe and Exoplanets*. A special afternoon session was dedicated to the interaction between art and science. Four eminent artists, the sculptor Lauri Anttila, the novelist Olli Jalonen, the composer Kari Rydman and the visual artist Jyrki Siukonen discussed the role and meaning of the Universe in their creative work. With impressive pieces of art as examples, the audience was really carried through time and space to the heart of artistic creation. The artists demonstrated how deeply and seriously the concepts and structures of science can influence the arts. The presentations were followed by a lively discussion with the audience. The year 2009 also was the 50th anniversary of C. P. Snow's famous lecture *Two Cultures* in which he claimed that the arts and sciences are unable to communicate. The symposium convincingly showed that Snow was wrong. In the evening of the first day of the symposium, the drama group from the Martinlaakso Gymnasium of Vantaa presented a play on Galileo and his science. The text and setting on the stage were created by the pupils and their teachers by using different literary and scientific sources.

Figure 4. The history of astronomy was also part of Helsinki City Museum's exhibition The Night at Sederholm House. Photo: Helsinki City Museum.

Lights and shadows of the night

The Helsinki City Museum has an exhibition called *The Night at the Sederholm House*, which is located at the corner of the Senate Square in the very centre of Helsinki. The house was built in 1757 and is the oldest surviving house in Helsinki after the fire of 1808. The exhibition was planned by Tiina Väisänen and produced by Jaana Mellanen and Minna Sarantola-Weiss. The working group consisted of Marcus Haga, Eva Packalén, Päivi Roivainen and Hilkka Vallisaari with many colleagues. By displaying complete, genuine interiors, views of the historic town of Helsinki, pieces of art and everyday utensils, the exhibition describes different aspects of life in a city during a night in times past. One room is dedicated to time-keeping and astronomical research at the now 175-year-old University Observatory (see Figure 4). Old photographs and other material describe the glorious past of that institution, centrally placed in the city. One of the main attractions is the Observatory's heliometer made by Joseph von Fraunhofer. The exhibition is open until 29 August 2010.

Figure 5. The history of the visual representation of the skies was displayed at the National Library's exhibition, The View from Paradise*, in Helsinki.*

Figure 6. Lauri Anttila's piece of sculpture showing the solar spectrum at noon at Ursa Observatory. Visualisation courtesy of Lauri Anttila.

The View from Paradise

The National Library of Finland is celebrating the International Year of Astronomy with an exhibition on the history of the maps of the heavens entitled *The View from Paradise*. The globes of antiquity have given way to today's digital databases which hold detailed information that can be used for analyses of the structure and evolution of the Universe. Besides the technical prerequisites for producing the charts, an examination of star maps reveals wide-ranging cultural linkages because each era's economic, cultural and political needs have always influenced the mapping of the heavens. In order to have a complete view of the Universe, the heavens were traditionally looked at from outside, as if from paradise. When it was understood that the stars were not fixed on a solid material sphere, but dispersed at different distances across a vast space, there was no longer any point in looking at the sky from outside. The point of view of the star maps was now from Earth. The great Finnish tradition in sky mapping is presented through the works of astronomers like Friedrich Argelander, Adalbert Krueger and Anders Donner (see Figure 5). Sky maps and guidebooks for amateur astronomers were also displayed at the exhibition. The exhibition was planned by Tapio Markkanen, designed by Marjaana Kinnermä and produced by Inkeri Pitkäranta. The exhibition closed on 30 April 2010 and will be available in virtual form[1]. A book with the same title in Finnish was published by Ursa.

Commemorating the International Year of Astronomy 2009

Lauri Anttila is an internationally known sculptor. Throughout his career Anttila has created pieces of art that connect the everyday environment, both urban and natural, with the cosmos. A long-time active observer himself, Anttila has created pieces that include the sundial on the floor of the Rovaniemi airport terminal, giving the position of the Sun at noon and the corrected official time (1992); and a second sundial that is possibly the biggest in the world, which gives the noon at each of the four time zones of Europe (Vuosaari, Helsinki 2000); and the memorial to the Finnish solar eclipse expeditions of 1945 and 1947. On the monument in Kangaslampi, Varkaus (2005), the Sun connects observation sites in Bana (Ghana), Bocaiuva (Brazil), Poroluoto and Kangaslampi (Finland). In May 1947 two Finnish expeditions to Ghana and Brazil were the first to determine the distance (about 5459 km) between the Old and New Worlds by direct triangulation. Ursa Astronomical Association asked Lauri Anttila to create a sundial at the site of the Ursa public observatory in Kaivopuisto, Helsinki. Anttila has created a horizontal sundial which is illuminated by the Sun at noon (see Figure 6). The surface of the sundial is covered with a huge solar spectrum with the continuum and absorption lines of different elements of the solar atmosphere cast by a mirror at the wall of the Observatory. The monument will be delivered to the City of Helsinki in June 2010, and received by the Mayor of Helsinki, Jussi Pajunen, a long-time member of Ursa.

Conclusions

Finland hosted several events which connected astronomy to art and culture during IYA2009. The public response to these projects was strong, but perhaps more importantly, new works emerged from the collaboration of scientists and artists.

Notes

[1] http://www.nationallibrary.fi

Biography

Tapio Markkanen obtained his doctorate in 1977 at the University of Helsinki. He has taught astronomy there and done research on Galactic structure, interstellar magnetic fields and star formation. He has also published scholarly works on the history of science. Tapio Markkanen has also been active in developing science education and communication. He is chairperson of the Ursa Astronomical Association for 2008–2011. As chair of the Finnish National Commission for UNESCO he also participates in the activities of that organisation.

The Universe in Your City — Nineteen Capitals

Daniel Scarpa
Kappa Crucis Observatory
E-mail: astrotienda@kappacrucis.com.uy

Antonio Más
Kappa Crucis Observatory
E-mail: astrotienda@kappacrucis.com.uy

Key Words

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Summary

The programme, The Universe in Your City — Nineteen Capitals, took us to each of Uruguay´s nineteen provincial capitals. In each capital we erected our Kappa Crucis Digital Mobile Planetarium and were able to reach a wide range of children of school age, and especially children in "critical contexts" (i.e. socially and economically deprived children). We transported our equipment, together with the exhibition materials for the IYA2009 Cornerstone project, From Earth To The Universe — and set it up in open public spaces, staying in each location for one week and offering an average of nine daily 40-minute presentations. Each session featured information on Galileo Galilei´s discoveries, the Uruguayan night sky and the cultural heritage provided by the sky.

A record number of 46 428 people participated in the 884 sessions held between April and September; while many more simply visited the exhibition. This reflects the remarkable success of the project.

Introduction

The Kappa Crucis Mobile Planetarium is a cultural enterprise dedicated to the promotion of astronomy. We have been travelling around the country since 2005, visiting a variety of educational and cultural institutions and offering sessions addressed to audiences of all ages.

Uruguay has a total population of over three million inhabitants, divided as follows: one and a half million people in Montevideo, the country´s capital city, and the rest among nineteen departments. Each of the provincial capital cities that our project visited had between twenty and ninety thousand people.

The offer of scientific programmes, especially in the field of astronomy, used to be limited to the Municipal Planetarium, located in Montevideo. Since 2005 the Kappa Crucis Mobile Planetarium has enabled other, less central communities to have access to this kind of information.

The birth of The Universe in Your City — Nineteen Capitals

To celebrate the International Year of Astronomy, we decided to undertake an ambitious enterprise. We started planning in February 2008 and once our research was complete, we began the process of designing and constructing a dome to be used in the project. The construction was a demanding six-month endeavour. The dome is made up of 41 self-supporting

Figure 1. The Kappa Crucis Mobile Planetarium set up in a square in Colonia del Sacramento, a historic tourist place and capital city of the department of Colonia.

glass fibre and expanded polyurethane panels. It is 5.5 metres in height and 8 metres in diameter.

To enhance our presentations we used a digital projection system for planetariums, the Digitarium projection system, which offered a wide range of possibilities, ranging from ordinary sky projection to Full Dome capability.

As the dome was under construction, we prepared scripts to accompany the sessions. In order to do so, we counted on a multidisciplinary team composed of elementary and high school teachers, as well as professional and amateur astronomers. Teamwork enabled us to create one session which included Galileo Galilei and the importance of his discoveries, and adapt it to different levels, both in terms of age groups and cognitive competence. We also generated materials that would complement the sessions. The remaining phase was to make contacts and elaborate our step-by-step plan.

Objectives of the programme

Our general objectives were the following: firstly, to contribute to the process of popularising science and the development of the population´s scientific culture; secondly, to motivate people, and most especially children, to approach astronomy and awaken their interest in topics related to the Universe; thirdly, to support teachers' daily work by providing them with an advanced pedagogic tool. In addition, our main specific objectives were to promote scientific and technological knowledge in the framework of the International Year of Astronomy 2009, and to reach the nineteen provincial capital cities of Uruguay with the Digital Mobile Planetarium between April and October 2009, decentralising and democratising a cultural space for the promotion of science and technology.

At this point, it is interesting to remark on the cultural objective of the topics presented in our talks. Historically observations of the sky were carried out by native people in the south of our continent. Although there is no written record of whether the Charrúas — the main group of native inhabitants of Uruguay — observed the sky, there are a number of stories that have been transmitted orally down the generations about the observation of the sky and the interpretations that these ancient peoples made of what they saw.

That is why — beyond the technical explanations that we can give about the official constellations — we incorporate ancient stories into the content of our presentations to keep these stories alive for the generations to come. At the planetarium, we, for example, explain to the children about the method of orientation based on the constellation of the Southern Cross. To us, the Southern Cross is clearly cross-shaped. However, we show the children how, by joining the stars that form the constellation in a different way, we can see the footstep of a *ñandú* (pronounced "nyan do", and known in English as the rhea), as seen by the ancients. The native people had represented in the sky one of the most useful creatures around them. This large, ostrich-like bird was a source of food and was present in their daily life. These native birds can still be found in the fields of the southern part of South America. Thus, since our children are familiar with these birds, they will remember and most likely share this story every time they look at the constellation.

The development of the programme

Our project consisted of installing the digital mobile planetarium for a week-long stay in each of the 19 capital cities of our country's departments, providing educational sessions for students at both the primary and secondary levels of schooling. In addition, there were similar sessions addressed to the general public. These presentations were accompanied by the exhibition, From Earth To The Universe, in the following way: a series of large images with backlit illumination were displayed alongside a 12-metre-long gallery providing access to the dome; the rest of the images were shown in digital form.

This working procedure meant transporting the equipment in three vehicles, i.e. a truck, a van and a private car, and hiring

Figure 2. Daniel Scarpa conducting a planetarium session.

eight people to put up the dome — which took ten hours — and later take it down — which took another five hours, following the same cycle in every location! Even so, on average, nine daily sessions were offered.

Each presentation lasted 40 minutes. During this time, participants not only learned about Galileo Galilei and the importance of his discoveries, but also had the chance to observe a projection of the night sky of Uruguay while being exposed to its significance in terms of our cultural heritage. Thus, at the end of each presentation, participants were assigned different tasks related to the observation of the sky at night to be performed on their own, regardless of their location. To help the participants carry out these observation tasks, we drew a map of the sky as visible from our latitude and gave it to teachers for further distribution to students.

Results

In order to accomplish our initial objectives, we also relied on thorough secretarial work from our headquarters in Montevideo. As each group of students arrived, the teacher was handed an evaluation form, where each teacher was required to enter his or her opinion or level of satisfaction by means of a specially designed scale, as well as given the opportunity to make further comments. In this way, we gathered and later processed information regarding the number of teachers attending and feedback on the project. We received 1222 completed forms. A grid was also used to keep a record of the schools and groups attending. The following figures summarise this section: total number of attendees: 46 428, distributed as follows: primary school students: 31 186; secondary school students: 6135. General public: 7627; teachers: 1480. Among the many institutions that participated in this project, we included the following: rural schools (some of which had just three students; others a maximum of ten), kindergartens, and special schools, e.g., for the deaf, mentally challenged, adult schools and orphanages.

Figure 3. The dome at the international square right on the Uruguayan–Brazilian border — with the two halves of the dome in different countries!

Conclusions

Employing such systematic procedures for data collection enabled us to arrive at the conclusions that follow: the project was highly successful and had a significant impact in each of the places visited. If we consider that, for 94% of the attendees, this was their first experience of going to a planetarium, we know that one of our main objectives — decentralising and democratising — was accomplished. The feedback gathered from both teachers and students on both the contents and the proposal was extremely favourable.

However, not only did the participants express their satisfaction with the event; the media provided support, due to the fact that, every time the planetarium reached a location, it attracted attention from the local people and it was given widespread media coverage. Uruguayan TV provided coverage of the project free of charge, in the belief that the programme deserved such treatment in view of its cultural interest and national scope.

Finally, the most positive result comes from the teachers' evaluation of the impact of the project in their classrooms: 89% said the project had an important impact; the remaining 11% not only agreed, but also provided additional feedback comments. These data allow us to project into the future and plan new and equally innovative activities to continue taking scientific and particularly astronomy-related knowledge to the different areas of our country.

Biographies

Daniel Scarpa and **Antonio Mas** are Uruguayan amateur astronomers. They participate actively within the community of astronomers through their various activities. Since the opening of the Kappa Crucis Observatory (MPC 913) in 1999, they have made presentations in both national and international conventions. In 2001 they opened the first astroshop in Mercosur. In 2005, they introduced the first mobile planetarium in Uruguay and in 2009, the first digital planetarium.

Value of Vintage Observatories and Historic Telescopes in Communicating Astronomy with the Public

Trudy E. Bell
Antique Telescope Society
E-mail: t.e.bell@ieee.org

Key Words

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Summary

The Antique Telescope Society convened a thematic workshop, The Vintage Observatory: Thriving in the 21st Century, on 2–4 May 2008. The workshop's purpose was to bring together those charged with the care of observatories and telescopes built before World War II, to examine common issues and share practical solutions, specifically in preparation for the International Year of Astronomy in 2009. Although much of the workshop concerned issues of preservation and restoration, several sessions focused on the uses of historical artefacts as a means for public education and outreach on astronomy and the history of astronomy, including discussion of the unique opportunities *vintage* observatories and telescopes offer in intriguing the public about astronomy.

Introduction

Today worldwide, historically significant telescopes and observatories are an endangered species. Every year, more observatories, large and small, fall victim to college and university boardroom logic that "old = outmoded junk" and "new = best"; thus, vintage telescopes and facilities are being discarded and replaced with modern computer-controlled "go-to" telescopes, or the observatory land is even being turned over to a different use. Disappearing with the artefacts are not only exquisite optics, but also unique and valuable opportunities for communicating to the public both the history of astronomy and the fundamentals of astronomy itself.

History and context

Between about 1800 and 1940, more than 250 private and institutional observatories housing telescopes and other astronomical instruments of various sizes were founded across the United States, plus a similar number in other nations combined. Many were still functioning well into the 1960s and 1970s. In the latter third of the 20th century, however, a great number — including some prominent institutions with large, exquisite instruments — fell into disuse and were decommissioned or wholly demolished. Today, scores lie in disrepair and are in danger of being razed[1].

Historians have become so alarmed about the increasing pace of destruction of historically significant astronomical sites and artefacts that several high level initiatives have been launched worldwide to preserve and protect them.

In 2004, the United Nations' Educational, Scientific, and Cultural Organization (UNESCO) approved a "thematic initiative" on astronomy and world heritage, seeking nominations of astronomical sites for recognition. This initiative inspired the Historical Astronomy Division (HAD) of the American Astronomical Society (AAS) to consider how the AAS should respond. As input to the deliberations, special sessions on preserving astronomical assets were held at the Biennial Workshop on the History of Astronomy VII in July 2005 at Notre Dame University, the October 2005 annual convention of the Antique Telescope Society at the Cincinnati Observatory, and at the January 2006 session of HAD at the annual AAS meeting in Seattle, Washington. In September 2006, historians David H. DeVorkin of the Smithsonian Institution and Stephen C. McCluskey of West Virginia University — serving as an *ad hoc* committee on preservation — drafted a five-page white-paper memorandum on how the American Astronomical Society might support UNESCO's initiative. In January 2007, the American Astronomical Society established a Working Group on the Preservation of Astronomical Heritage (WGPAH), charged with *"developing and disseminating procedures, criteria*

and priorities for identifying, designating, and preserving astronomical structures, instruments and records so that they will continue to be available for astronomical and historical research, for the teaching of astronomy, and for outreach to the general public"[2].

Motivated by all these initiatives, in April 2007, a team of five individuals led by the former managing editor of the *Journal of the Antique Telescope Society*, Trudy E. Bell, and the executive director of the Cincinnati Observatory Center, Craig Niemi, sought and received approval from the board of directors of the Antique Telescope Society (ATS) to convene a first-ever thematic workshop devoted to discussing imaginative and non-traditional opportunities and means for historically significant astronomical observatories to thrive in the 21st century.

Within the ATS, it was long known from dozens of successful examples that *historical* equipment has a unique power to convey the wonders and science of *modern* astronomy to the public. Sharing what has worked with others at institutions wondering whether to restore or discard a vintage observatory seemed particularly timely, because of upcoming celebrations in 2008 and 2009 of the 400th anniversary of the invention of the telescope and Galileo's turning it toward the heavens, as well as of the International Year of Astronomy in 2009[3].

The workshop was intended to encourage discussion about a wide range of operational issues, including novel approaches to publicity, fundraising, preservation, restoration, research (both historical and astronomical), and both formal and informal astronomy education. Because one goal also was to introduce people to the human resources within the ATS, the workshop was publicised well beyond the society's membership to attract a wide variety of individuals with similar interests, including:

- astronomy teachers, professors and informal educators;
- directors/overseers of pre-WWII astronomical observatories;
- museum curators or other custodians of astronomical instruments and books;
- members of amateur astronomy societies or local historical associations;
- preservationists concerned with maintaining local cultural heritage;
- board members, trustees, public outreach officers, fundraisers, and donors for the restoration and continued operation of older telescopes or observatories;
- professional restorers of historic astronomical instruments and buildings;
- astronomers;
- historians;
- planetarium directors; and
- historical re-enactors and professional story-tellers.

Figure 1. Attendees of the Antique Telescope Society's May 2008 thematic workshop, The Vintage Observatory: Thriving in the 21st Century, were photographed on the steps of the main building of the Cincinnati Observatory Center. The photograph was taken by Perry W. Remaklus (front row, all in white). The five co-organisers of the thematic workshop, standing front row centre just to the right of Remaklus, are, in order: Trudy E. Bell (black vest), John E. Ventre (red shirt), Craig B. Waff (plaid shirt), Valerie Niemi (gray jacket) and Craig Niemi (blue shirt).

The workshop itself

After 13 months of intense planning, the thematic workshop, The Vintage Observatory: Thriving in the 21st Century, was hosted by the Cincinnati Observatory Center in Cincinnati, Ohio, USA, on 2–4 May 2008[4].

The beautifully restored Cincinnati Observatory Center affords a gold-standard example of how a historically significant 19th century observatory can thrive in the 21st century, through creative programmes in informal education and public outreach, as well as innovative financial support (including renting the facilities and grounds for corporate retreats, on-location filming, weddings and other special events). Thus, the workshop included a behind-the-scenes tour of the buildings

Figure 2. The historical setting of a vintage observatory allows opportunities for non-traditional informal education about astronomy through techniques more commonly used at Civil War sites and other historical venues, such as historical re-enactors in period dress. At the Friday night ice-cream social at the ATS thematic workshop, Sir Isaac Newton made an unexpected appearance to discuss optics and telescopes. Credit: Perry W. Remaklus.

and instruments, plus observing through the 11¼-inch Merz & Mahler refractor (the largest in the United States when completed in 1845) and the 16-inch Alvan Clark & Sons refractor (still the largest refractor in Ohio since its completion in 1904).

Recognising that small to medium-sized institutions, plus observatories in distress, were likely to have lean budgets, every effort was made to minimise the costs of the workshop to participants. The $99 registration fee included an ice-cream social on Friday evening plus four full meals (Saturday breakfast, lunch, and dinner, plus Sunday breakfast) and a 2-inch binder and CD of useful references. The registration fee was kept so low because costs were partially offset by a modest grant from the Cincinnati Observatory Center itself, *pro bono* use of the facilities for three days, and energetic volunteer effort by the Friends of The Observatory. One of the co-organisers (Valerie Niemi) was a travel agent, who also researched modestly priced accommodation and offered to set up economical room-sharing arrangements for attendees.

The programme was absolutely packed (the image of drinking from a fire hose occurred to several attendees). To encourage idea-sharing among registrants, ample time was allotted for discussion both after each individual talk and at the end of each session. One unique event was a hands-on Saturday evening brainstorming session called Observatory Makeover. For it, those affiliated with instruments or observatories in distress were encouraged to lay all challenges, concerns and obstacles before the compassionate assembled wisdom so that many heads and hearts could offer concrete assessment, recommendations and relevant contacts to extend help for specific situations.

Highlights of public outreach findings

Throughout the workshop, a recurring message was that the highest form of physical preservation of historic artefacts is regular use. Taken as a whole, the presentations and discussions touched on various advantages *uniquely offered by historical observatories* — some with telescopes fairly small by the standards of astronomy today — in communicating astronomy to the public in today's high-tech age. Several highlights distilled from the discussions include:

- The physical beauty of manual vintage instruments has the effect of humanising astronomy and astronomers. Several participants spoke of hearing *"Wow!"* echoing through the dome when visitors enter and unexpectedly find themselves beholding polished mahogany and gleaming brass rather than antiseptic white lab equipment with computer screens. Many members of the general public already cherish antiques both for their physical beauty and their connection to human history. On an antique telescope, the various knobs and handles of the manual movements silently attest *"touch me — I am also designed for human hands"*. There is tactile pleasure in their use: century-old brass and glass offer a magnificent experience in cultural appreciation. *"History allows us to appeal to people not usually interested in science, by giving them a higher comfort level,"* observed the director of the Dudley Observatory in Schenectady, New York. Describing the work done and discoveries made with the telescope and the personalities of the astronomers who used it also humanises scientists, helping the public to understand their driving curiosity. In essence, she noted, *"We use history to 'trick' people into enjoying astronomy — and, by extension, science."*

- Vintage telescopes offer the public a first-hand *personal* connection to the Universe because the optics of most telescopes fashioned before

World War II were optimised for visual observing with the human eye. Moreover, vintage telescopes by the masters are optically superb. For optical excellence, Alvan Clark and John Brashear are to telescopes what Stradivarius and Guarnerius are to violins: in side-by-side optical tests for colour, resolution and clarity, many modern commercial telescopes of the same aperture pale by comparison. Repeatedly, participants recounted how at star parties or public observing nights that feature both modern and vintage telescopes, without fail people would walk right by the modern equipment — even if it was fitted with a CCD-imaging system and a video screen showing an eye-catching image of a planet or galaxy — and head straight for the antique instrument, saying, *"I want to look through a telescope."* Even if the image shown on the computer screen showed more colour or detail than a human eye could perceive through an eyepiece, members of the general public still wanted to see a celestial object *with their own eyes*. Workshop participants remarked how they often heard gasps when visitors took their first-ever look through a telescope — and that years later, some members of the public still recollect how inspired and awe-struck they felt at *personally* viewing the rings of Saturn or the moons of Jupiter or the pale Ring Nebula in Lyra.

- The clearly visible gears and setting circles of vintage telescopes can concretely demonstrate the fundamentals of the celestial sphere. Because older instruments are wholly manual, the motions of the telescope mount can be used to illustrate concepts such as celestial latitude and longitude, compensation for the rotation of the Earth, the position of the observer's meridian, etc. One presenter recounted: *"As I was talking about slewing west [to find an object], the father of a student exclaimed, 'I don't get all this east–west stuff — what is it?' So I stopped and explained it to him, using this giant equatorial mount as an example. I argue that such teachable moments happen only because I was not standing at a point-and-click console pressing a button that said 'GO TO [object]', but instead was reading the circles and searching for the target manually with an antique instrument."* With a manual telescope, abstract concepts are made physically concrete.

Figure 3. A group of middle school students are shown the 23-inch Alvan Clark refractor at the Charles E. Daniel Observatory at the Roper Mountain Science Center in Greenville, North Carolina by staff astronomer Doug Gegen. Originally built for Princeton University in 1882, this telescope is now one of the largest vintage refractors in the nation regularly devoted to education and public outreach. Credit: Roper Mountain Science Center.

- The size of a vintage telescope, whether large or small, is an asset in communicating astronomy to the public. The director of the Charles E. Daniel Observatory at the Roper Mountain Science Center in Greenville, South Carolina, at which is mounted the 23-inch Alvan Clark refractor originally installed in 1882 at the Halsted Observatory at Princeton University, recounted how he often hears impressed members of the public exclaim, *"That is the biggest telescope I've ever seen!"* The telescope tube is well over 30 feet long, three times longer than modern compact Schmidt–Cassegrain reflectors of equivalent aperture and thus three times as impressive. On the other hand, a small antique refractor with a lens just a few inches across conveys the silent message *"you, too, can appreciate the stars from home with a modest instrument — you don't need to be a professional"*.

- Vintage telescopes can awaken the public's historical awareness of how astronomical observatories are part of our *cultural* heritage. In the late 19th century, the race to build the world's largest telescope was the Victorian space programme. Most non-historians readily accept the value of preserving our cultural heritage in rare and precious documents (such as the Declaration of Independence), artefacts (such as the *Mona Lisa*), structures (such as the Golden Gate Bridge or the Brooklyn Bridge) and institutions (such as the birthplaces of US Presidents) in addition to books and photographs. The public even readily accepts the value of preserving the first telescopes of Galileo and Newton. It is but a short step to explain that in the nineteenth century, telescopes were romantic icons, revered as crowning achievements of the industrial revolution, to the point that every small town that built an observatory basked in an exalted status. Such history can then lead to descriptions of some of the 19th century's prin-

cipal discoveries, and thus directly to the development of astronomical concepts.

- A superbly working vintage telescope clearly demonstrates that a telescope's mechanical usefulness is a function of care and maintenance, not of age — and that the optics are ageless. A century ago, telescopes were consciously designed and crafted for all time; they also were built to be accessible for routine cleaning and lubrication. Instruments decay not when a telescope or observatory attains a certain age, but when they lie neglected for surprisingly few years. Even a modern computerised "go-to" telescope installed as recently as 2000 may be effectively junk today if its dome has been left open to rain, birds and vandals; moreover, even if it has been physically maintained, it may still be effectively useless if its software has not been kept up to date — a worthwhile caution for today's consumerist disposable culture.

- A vintage telescope that participates in an ongoing programme of regular observations communicates the fact that century-old instruments are highly useful even for 21st century astronomical *research*. For members of the public interested not only in stargazing, but also pursuing a personal astronomical research project of genuine scientific value, much has been written about research opportunities well within the reach of telescopes of small aperture (as small as three inches!), including vintage instruments[5]. Like Audubon bird counts or migrating salamander counts, which need manpower more than specialised instruments, certain types of astronomical research (for example, on comets, variable stars, double stars, and lunar and asteroid occultations) require careful systematic observations by many geographically dispersed sets of eyes, not large apertures or modern equipment.

Conclusions

Success stories abound about the unique advantages of vintage telescopes and observatories for communicating astronomy to the public. But altogether too many historic observatories, large and small, are now teetering on the brink, some of them with sizeable and historically important instruments. Once telescopes and observatories are demolished, often in secret and too fast for public comment, our astronomical and cultural heritage — plus its value for communicating astronomy to a 21st century public — is gone *forever*.

The Antique Telescope Society

The Antique Telescope Society, founded in 1991, is an international organisation. Recognised as a tax-exempt organisation under Section 501(c)(3) of the Internal Revenue Code, its purpose is to unite colleagues interested in antique astronomical telescopes, binoculars, books and related items; and to promote the memberships' interests in astronomical history and discovery, the history of optics, and the preservation and use of astronomical instruments through stewardship and education. The principal activities of the Antique Telescope Society are publishing a journal, organising meetings, providing assistance with the restoration of instruments, hosting shows and displays, preserving historical data and guiding collectors. More information can be found at http://oldscope.org/.

The Cincinnati Observatory Center (COC), also a 501(c)(3) organisation, promotes the study, practice and enjoyment of astronomy among a broad audience. It also assists professional and amateur astronomers, schools and universities in furthering their educational efforts on behalf of astronomy and related STEM (science, technology, engineering and mathematics) disciplines. While fulfilling this mission, the COC maintains the integrity and heritage of an historic 19th century observatory, including relevant artefacts illustrating the history of astronomy and its relationship to broader fields of science throughout the years. The fully functional 1845 Merz & Mahler and 1904 Alvan Clark & Sons telescopes are the backbone of this unique educational centre and are used by students of all ages almost every clear night. More information can be found at www.cincinnatiobservatory.org.

Notes

[1] Just since 2000, casualties have included the Flower and Cook Observatory in Philadelphia, Pennsylvania, and transit circle telescope buildings at the US Naval Observatory, the latter against advice from both their own architectural historian and the US Commission of Fine Arts. Observatories now boarded up with dim futures include the Ricard Observatory of Santa Clara University (16-inch Clark refractor). Also facing an uncertain future is the 40-inch of Yerkes Observatory in Williams Bay, Wisconsin (still the world's largest refractor) and the 61-inch Fecker reflector of Oak Ridge Observatory in Harvard, Massachusetts (largest telescope east of the Mississippi). Observatories that have been successfully restored for public outreach and education include the Cincinnati Observatory (now called the Cincinnati Observatory Center, with its 11¼-inch Merz and 16-inch Clark), the Chamberlin Observatory in Denver (20-inch Clark), and the Mount Wilson Observatory (with the 100-inch Hooker reflector, once the largest telescope in the world) in California.

[2] The focus of the AAS's Working Group on the Preservation of Astronomical Heritage is more on 19th and 20th century instruments, observatories and papers; information about it (including this quoted text) appears at http://members.aas.org/comms/wgpah.cfm. Background about the UNESCO initiative on astronomy and world heritage appears at http://whc.unesco.org/en/astronomy. and here http://www.astronomicalheritage.org/.

[3] For more about IYA2009 and beyond, see http://www.astronomy2009.org/. For one site about a public television special on the 400th anniversary of Galileo's turning the telescope onto the heavens, see http://www.400years.org/.

[4] Details about the thematic workshop, The Vintage Observatory: Thriving in the 21st Century, still appear on the Antique Telescope Society website at http://www.oldscope.org/in2008ws.htm. The eight-page final programme is available at http://www.webari.com/oldscope/document/tws080502-final-program.pdf and abstracts of all the talks (17 pages) at http://www.webari.com/oldscope/document/tws080502-abstracts.pdf.

[5] Many resources about astronomical research by small telescopes are relevant for instruments of all vintages, and are focused on research that can be done to supplement school curricula rather than for public outreach. Nonetheless, some of the information is relevant to pre-war instruments for communicating astronomy to the public. One key reference book is Russell M. Genet, Jolyon M. Johnson and Vera Wallen, editors, *Small Telescopes and Astronomical Research*, Collins Foundation Press, 2010 and the National Academies of Science 2010 position paper, *The Small Research Telescope Challenge*, at http://www.eclipse-t.com/nas%20paper.pdf. See also Terry D. Oswalt, *Preserving Access to Small Observatories Throughout the World: The Role of University Consortia and Collaboration*, International Amateur–Professional Photoelectric Photometry Communications, 69 (Fall 1997), p 1–5, http://adsabs.harvard.edu/full/1997IAPPP.69....1O.

Biography

Trudy E. Bell (M.A. 1978, New York University) is a former editor for *Scientific American* and *IEEE Spectrum* magazines and the author, co-author, or editor of a dozen books. Nineteen of her 450+ articles have won top journalism prizes, including the 2006 David N. Schramm Award of the American Astronomical Society. For the Spring 2010 semester, she was a Presidential Fellow in the SAGES Program at Case Western Reserve University.

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FRONT: This spectacular panoramic view shows the Carina Nebula and was taken with the Wide Field Imager on the MPG/ESO 2.2-metre telescope at ESO's La Silla Observatory in Chile.

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