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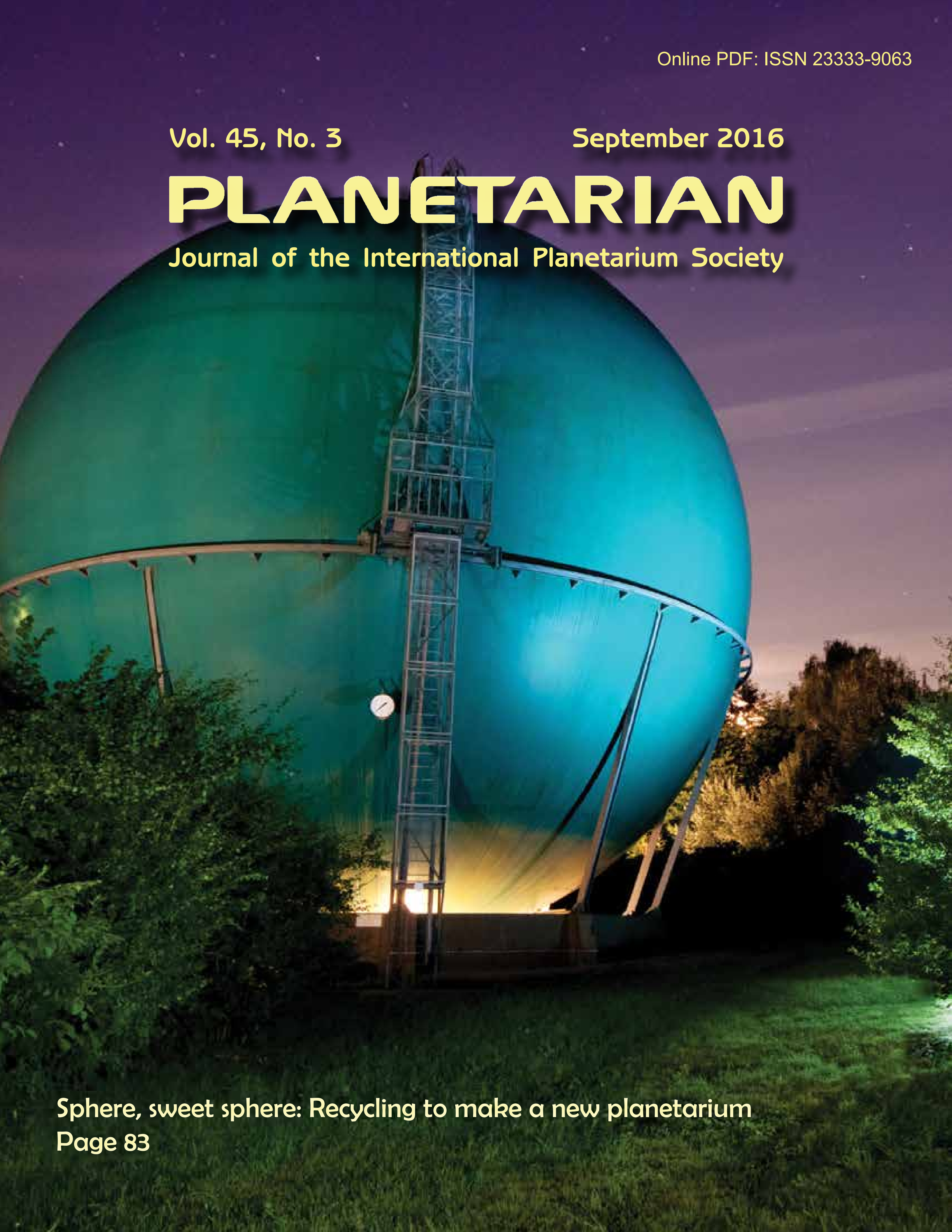

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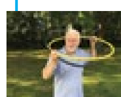

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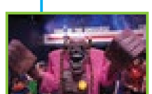

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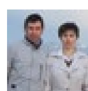

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Solingen, a city located close to Cologne in western Germany, will soon receive a new and unique planetarium installed inside a former gas storage tank. See more in International News on page 83. Photo courtesey of Norman Schwarz.

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- Research articles dealing with educational aspects of the planetarium and other topics are highly desirable and will be refereed if applicable and requested.
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In Front of the Console

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Another pudgy issue; watching learning in progress

You have another record-breaking issue in your hands (or on your screen, if you are reading online): 104 pages. There was a lot of action to share as a result of IPS 2016 in Warsaw and the Council meeting that preceded it.

Throughout this issue you'll see the Revolve logo from the conference. That will tell you that the column or story contains news or details from the conference.

I will echo what others throughout this issue have said: the conference was amazing. It was wonderful to finally meet people who I know through the pages of *Planetarian* and email addresses, but have never met face to face.

Unlike past years, I could not devote pages to pictures for this conference. But don't be disappointed; the still-active conference website at ips2016.org has many pictures in the gallery section. Conference photographer Frank-Michael Arndt really captured the "feel" of IPS.

There are two research papers in this issue. The first (starting on page 20) is a study of what influences planetarium educators and how it affects their teaching methods.

The second is quite a bit different. It is the sharing of a tremendous amount of research into fulldome projection systems done by Lars Lindberg Christensen and others from the European Southern Observatory to prepare for the ESO Supernova Planetarium and Visitor Centre now under construction. This is an example of one of the best traits of planetarians: we like to share with our peers. He didn't have to do it, but Lars took the time and devoted the effort to write a lengthy report with the intent of saving time and effort for others. It starts on page 30.

There are plenty of "fun" articles, too. To help prepare for the 2017 eclipse are marketing tips from Ken Miller (page 38), a spiffy (and free) cartoon explanation of eclipses from Jay Ryan (page 42), and a look at eclipses past and future by Fred Espenak (page 44).

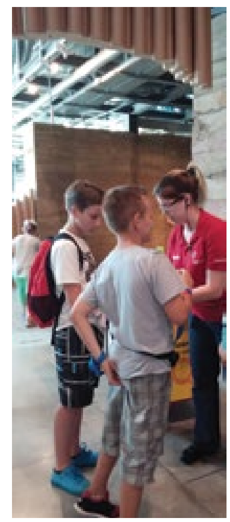
In Dayton (Ohio), GeekFest has proven to be a popular event at the Boonshoft Museum. There were so many wonderful pictures of creative activities and costumes that I made a gallery that reminds me of character trading cards (page 47) to share them. In Siberia, about as far away from Dayton as you can get, Pavel and Evgeniia at Irkutsk Planetarium share how they arranged observing sessions and the positive feedback they've received.

There also is a wonderful note about the global nature of IPS at the end of Irkutsk's article that you shouldn't miss (page 55).

A future planetarian at work

I want to share just one personal experience from Warsaw. The Copernicus Science Centre was open during the conference, so we were able to watch students and families enjoy their time there.

This is a shout out to Katarzyna Zdrojewska, who was captivating middle schoolers with physics-based demonstrations. (Think about the meaning of that sentence!) She certainly has what it takes to be a planetarian: she was professional and passionate and really connected with her audiences. She also enjoyed sharing the secrets behind her demonstrations with me.



This also created a dilemma. My best picture of her is rather — er, um — let's say it's typical of a middle school boy and leave it at that. I will apologize to his mother the next time I'm in Warsaw. ☆

IPS Officer elections start on 1 October

Martin George
Chair, IPS Elections Committee

In October and November this year, IPS members will vote for the officers who will hold the positions of President-Elect, Secretary, and Treasurer for 2017-18.

In addition, in the next few weeks, members will receive notice of proposed amendments of the IPS By-Laws. Voting for these proposed amendments must be by signed ballot, in according with Article XIII. These signed ballots may be returned by either mail or scanned/photographed image by email. All members are asked to watch for this in their incoming postal mail, along with more details about the proposed changes.

The voting for officers is done electronically through the IPS website.

The President-Elect will be IPS President in 2019-20, and Past President in 2021-22. The other two positions are held for two years only. In 2018, the next elections will be held, and once again IPS members will vote for candidates standing for all three positions.

Here, in this issue of *Planetarian*, the candidates for the 2016 elections present their statements, starting on page 8. I urge you to read them all carefully so that you have an informed choice when you cast your votes. All candidates were asked to provide statements totalling at most 500 words.

The statements you read here also will shortly be available on the IPS website at ips-planetarium.org.

Voting for officers will take place from October 1 to November 30, 2016, inclusive, and will take place on the IPS website, where there will be a clear link to the voting process and instructions.

All members will receive a reminder from me by email in September, following which hard copy ballot papers will be sent out by mail to any members whose email addresses bounce as a result of the email. If you have changed your email address recently, please ensure that you have your correct address on file with Treasurer Ann Bragg (ann.bragg@marietta.edu) as soon as possible. You also can update your files by logging in to the IPS website.

I look forward to a big turnout in the upcoming elections! If you have any queries, please email me at martingeorge3@hotmail.com. ☆

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Dear Fellow Planetarians

"The future belongs to those who are creative, not to those who merely follow instructions and act on command."

This statement reflects a paradigm shift now emerging in our educational systems, businesses, and IPS. It was said by Robert Firmhofer, CEO of Copernicus Science Centre, one of the most successful science centers in the world and host of our incredible IPS 2016 Conference. I was fortunate to have many occasions to speak with him and discovered valuable insight into his success, which will touch upon within this article.

Since many of our readers attended the IPS2016 Conference, I want to use the conference as an example of what happens when we allow creative freedom to resolve certain long-standing issues with our conferences, which it did, and it added a few surprises!

Monika Malinowska and I enjoy a chat during one of the luncheons. She and Maciej Ligowski, along with the entire staff of the Copernicus Science Centre, worked miracles for the conference. Photo by Frank-Michael Arndt.

Robert had given his young, talented professional team the task of organizing the conference. Monika Malinowska and Maciej Ligowski were assigned lead positions, and both were fully committed to organizing the best conference ever. One of the ways of achieving this goal was to address and resolve recurring conference complaints. The biggest, for more than a decade, had to do with sponsor presentations extending into the late evening hours.

The Copernicus Science Centre team clearly had to be creative in their approach because IPS had never solved the problem. We couldn't give them instructions as to what to do. Robert could not give his team instructions as to how to solve the issue. The team shouldered the task.

Their idea was to add two temporary domes outdoors, fully exposed to the elements. These domes had to withstand sun, rain and windstorms, and be fully equipped with sound and projectors, seats, air conditioning, lights, and generators. Climate control trailers attached to each one acted as server rooms for all computers. For this to happen to satisfy certain sponsor requirements, one of the domes was custom designed, as it turned out, by the same Polish company that built the domes featured in the movie *The Martian*.

A new type of schedule had to be created to move hundreds of people from one dome to another and through the dome village and exhibit areas while allowing each delegate the opportunity to see everything they desired. This all had to happen during the day so that the evenings were free for social events and networking. In order for this to work, sponsors had to repeat their presentations 5 times.

The paradigm shift worked

This was not business as usual. It required a fundamental change, a paradigm shift, in conference planning. And it was a wild success! Delegates and sponsors were satisfied—no, ecstatic! The old complaints evaporated into thin air. What did we learn? Get out of the way and let our teams loose to collaborate, problem solve, and create.

I think of Robert Firmhofer in the same category with Elon Musk and Carter Emmart. These courageous and gifted people have provided the safe environment for creative young professionals (as they once were themselves) to work together to achieve that which has never been done before—something that benefits us all. They allow their teams the freedom to challenge themselves and drive their own passion and creative thought processes. It's a risk—one shared by all members of the team and ultimately by the leader who entrusted the team. What ensues is an adventure with the full realization of consequences. A call to boldly cooperate towards success.

One of the highlights of the conference was the creative sponsor presentations which blew my mind. Please remember that I have been watching sponsor presentations for 35 years so I am a good judge. Many of the presentations were nothing short of sensational.

Dancing the night away

Earlier, I mentioned the host had planned some surprises. My best memory of all was our final evening together at the banquet held in the artsy Soho section of Warsaw. We were served wine with a delicious dinner while enjoying a band. Lovely, but not unusual, until I noticed movement to my right and turned to see planetarians from all nations dancing in the center aisle between tables. I had never seen this before at an IPS Conference! Planetarians of all ages and cultures dancing together!

But the best was yet to come. After dinner, Robert encouraged me to look behind the stage. I found 3 DJ's, including a celebrity DJ who was 76 years old. Just then, she started spinning "The Twist." Those of us who grew up with Chubby Checker and the Twist found ourselves right in the swing of things as the younger generation asked "How do you do that," making their best attempts.

The disc spinning continued as we danced passed midnight. (And, if I were giving a special award for the coolest dance moves, it would go to Ryan Wyatt. Ask him about it the next time you see him.)

What great fun! What a great surprise! What a perfect way to celebrate the end of the best IPS Conference of all time!

Thanks to all who volunteer and contribute to IPS. The shift has already begun to foster the safe environment for you to creatively and boldly go where we have never gone before! ☆

THANK YOU SPONSORS OF IPS 2016

On behalf of the IPS Officers, Council, members, and the entire staff of the Copernicus Science Centre and the Heavens of Copernicus Planetarium, we extend our heart-felt gratitude to you, the Sponsors of IPS 2016, for what we believe was the most successful conference ever!

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Meet your candidates for office

Candidates for President-Elect

Jack Dunn

I'm very honored to be nominated as IPS President-Elect. Part of that honor is simply being named as a nominee to an office held by many outstanding planetarians I've known as leaders in our profession.

Historically, I was there at the Conference of American Planetarium Educators in 1970 and saw the beginnings of our society. I was one of the founders of the Great Plains Planetarium Association and glad it was accepted into IPS, which helped planetarians in the central plains of the United States.

IPS president Jim Hooks brought me into being involved more in IPS and I met new friends from all over the world. I enjoyed working with this amazing group while on and off IPS council for many years. I was involved in committees, from copyright to technology. The main point of my region and IPS was to help planetariums because we always seemed to operate on limited budgets and with limited staff compared to some other media. Yet planetariums had a far greater reach in their impact and IPS was there to encourage this.

Just as the planetarium world has evolved with the introduction of digital projection, IPS also faces the need for evolution. We have many new artists, producers, and visualization specialists entering the medium, while at the same time there is still the need for teaching science and reaching audiences with an appreciation of the cosmos.

My thought about IPS is that it must serve all sizes of domes and continue to encourage the effective use of those domes in all parts of the world. I said at the Warsaw conference that I love the historical perspective and experience I have gained by being a planetarian since the late 1960s. But, at the same time, I look forward to all the amazing possibilities that are now being realized in those domes.

IPS has a role to support the future in sharing experience and knowledge among planetarians who, even with the advent of the internet, can still be isolated. It is from attending regional and IPS conferences and through the contacts I made that I learned most of my knowledge of how to try and run an effective planetarium. We need to continue to reach all the domes we can, and welcome all those new persons coming into our profession.

So, I appreciate my years of history, but I also want to look forward and grow our IPS universe. ☆

Lee Ann Henning

At Thomas Jefferson High School for Science & Technology in Fairfax County, Virginia, USA, I teach a year-long astronomy course to juniors/seniors, a senior-level course in astronomy and astrophysics research lab, and offer planetarium presentations to K-12 schools in my region of the school district.

Besides my experience in IPS, I am a long-time member of IPS Affiliate Middle Atlantic Planetarium Society, for which I have held the offices of Secretary, President, Board Member, and Education Committee Chair.

Goal/Vision as president-elect: As a teacher and a planetarium director I have tried to live by Christa McAuliffe's words, "I touch the future...I teach." I hope that I bring that same spirit to IPS in my work with colleagues and the promise of Vision 2020. In our profession we learn from each other. Our interactions provide us with opportunities to learn new techniques, exchange ideas, and gain fresh insight from newer members. It is also our responsibility to pass on those lessons we have learned and to share our experiences - to be mentors. Everyone has a contribution to make to our profession.

Whether our universe is in a portable, small, midsize, or large facility– each of us has a role to play. Our differences should not be a barrier, but, rather, our diversity makes us stronger. The respect and support for each other in this special community is vital to our growth and effectiveness.

Along with the other officers and Council, I will work diligently to move our organization forward in a cooperative and concerted effort. We will focus on the Vision 2020 Initiative to make our organization stronger and more relevant to all of our members, regardless of the size of the facility, the type of projector, or how long you have been in the profession. Members need to know and experience tangible benefits from being part of IPS other than just the core expectations (conference, journal, website, etc.). I will work to ensure the continuity of basic functions of our organization and will also incorporate additional services identified by the membership and by Vision 2020 recommendations.

Working with colleagues from all over the world has brought a perspective that enriches and humbles a person. I will strive to continue the positive efforts of the past Officer/Council teams. I will respect and follow our rules of governance and will deal with all issues in a constructive manner. In order for IPS to reach our potential and serve our membership, we must work as a team. We must focus on the goals of strengthening our organization and nurturing our diversity. There is room for all of us in this endeavor. Embracing the wonderful tools that technology offers us will enhance our abilities, but we must also maintain and support our traditional philosophies. Serving our membership in this journey is the most important part of our vision. That will be our top priority as we move together into the future. ☆

Levent Gurdemir

First off, I am truly honored to receive this nomination. This is such a prestigious and challenging position. Thank you to those who nominated me and supported my nomination.

I am the director of the Planetarium at the University of Texas at Arlington, located at the center of the Dallas/Fort Worth Metroplex. I am also the current president of SWAP (Southwestern Association of Planetariums). I previously served as SWAP president between 2010-2012 before I was re-elected this year. I have been proud member of IPS for ten years.

IPS is the only global planetarium organization that connects us around the world and therefore it is instrumental for our community. Beyond organizing very successful conferences, IPS has been providing valuable resources through its website and the journal *Planetarian*. Here is what I would like to contribute if I am the successful candidate:

Recruit new and young members, especially those from developing countries. There are countries in which IPS has no membership. A large number of small US planetariums also have not joined IPS. Young members will be instrumental to shape future of IPS as stated in the 2020 vision of the organization.

Improve and foster use of social media between the members of our community. Better connected members will make IPS even stronger.

Improve communication with regional organizations, especially those outside US. We need to encourage, engage, and help them to organize local events. We should also reach out and recruit new members from local organizations, such as astronomy clubs and observatories.

Partner up with agencies such as NASA, NSF, ESO, etc. to disseminate mini-grants to our community. I am also a member of NASA's Texas Space Grant Consortium, which disseminates such grants.

Foster and support STEM-related activities and develop outreach programs. Such activities in developing countries should be our top priority. The future is in STEM.

Develop an online IPS Library. All the resources and materials IPS has been disseminating will be organized and archived under a new online IPS library. The library will be the major resource for the professionals in our community. It will host training aids, how-to guides, current standards, educational content, royalty-free content, and more.

Improve the online IPS Database. Data are a critical part of decision making, and help us to see what is working and what is not. Implementation of a new online database will host lots of useful information, such as attendance/usage statistics, survey results, etc. Based on these data, it will be easier to forecast success.

Adopt a multi-lingual IPS. IPS is a global organization. However, the IPS website and its resources are only available in English. I would like to see the IPS website and all its resources be available in native language of every IPS member.

Let's make IPS even better! ☆

Mark SubbaRao

I am running for IPS President to help shape the future of the planetarium, this wonderful medium which can inspire the public like nothing else. The global community of planetarians is warm, collaborative, and innovative, and I am running for IPS President to help grow and nurture it. We are facing critical times for both our organization and our field as a whole. Immersive technology will soon be commonplace, the science we present is evolving faster than ever, and the technology we use is changing constantly. I believe that with forward-thinking vision and action we can not only thrive but prosper in this future. We have an opportunity to dramatically increase both our impact and the number of people we reach around the world—we only need to seize it.

In recent years I have taken an active role in the IPS. Which includes:

- Serving on the Vision2020 planning team, which is tasked with developing a strategy for how to best grow, strengthen and modernize the IPS;
- Chairing the IPS's Science and Data Visualization Task Force, which is tasked with preparing the planetarium community for the upcoming big data era;
- Serving on the IPS 2016 Conference Program Organizing Committee; and
- Writing a regular column, "Data to Dome," in *Planetarian*.

On the Vision2020 team I am responsible for Goal #2, "Strengthen ties with the professional scientific community in the field of astronomy and other space sciences to bring current research and discoveries to our audiences." During the Warsaw conference I reported on recent successes in this regard, which include:

- Developing a framework for a joint working group between IPS and the International Astronomical Union's Commission C2 (Communicating Astronomy with the Public).
- Representing the planetarium community during the American Astronomical Society's decision process regarding the stewardship of the Worldwide Telescope project.
- Working with the European Southern Observatory on the D2D "data to dome" platform that will enable content discovery, distribution, and sharing across different planetarium platforms.

If elected, I will focus on building a more active organization and expanding professional development opportunities. We will support research that demonstrates how effective the planetarium is. We will institute organizational changes to make IPS more nimble and responsive. We will increase revenues by growing memberships and seeking new sources of funding, such as government and foundational grants.

Another key focus would be building our global community by supporting planetarium development in emerging communities. In particular, I see incredible potential in Africa to leapfrog technologies and build a network of low-cost, but cutting-edge, planetariums.

My institution, the Adler Planetarium in Chicago, Illinois USA, is fully supportive of these efforts. The Adler is committed to providing me the time and resources that I will need to serve as IPS President. This support is part of new strategy for our institution, which seeks lend our expertise and resources to assist smaller institutions, and share content through global domecasts.

I am committed to serving IPS to the best of my ability and humbly request your support. ☆

Candidates for Executive Secretary

Patty Seaton

Hi! I'm Patty Seaton, the planetarium specialist at the Howard B. Owens Science Center for Prince George's County Public Schools in Maryland, USA. We have a large dome (almost 17m) that seats 170, but our primary mission is to serve students, often limiting class size to 60 so we can do live, interactive programming with them.

I've been at Owens for 16 years full time, but a total of 25 years part-time and as a volunteer. My mentor, Fred Stutz, encouraged me to become actively involved in the planetarium community. So I did. I hosted my first regional conference in 2003 for the Middle Atlantic Planetarium Society. As a host, I interacted with the entire Executive Board for many months prior to the actual conference. They encouraged me to run for office, and so I ran for, and was elected, President-Elect, and began my first 6-year term on the Board.

I helped orchestrate the 2007 "Triple Conjunction" conference sponsored by three US regions, but attended by delegates from all seven US regions. I wanted to continue the work that had begun under my leadership, so I ran for President-Elect again, and was elected to a second consecutive term. By now I had gained much experience as to how an organization ran. I enjoyed helping make decisions on policy with the goal of benefitting every member of the organization.

One of the most important roles I had, which I didn't fully appreciate until I did it, was to serve as the Affiliate Representative to IPS Council. I attended my first Council meeting at my first IPS conference in 2012. Upon meeting delegates from other Affiliates from literally all around the world, I was immediately humbled and felt privileged. Privileged to serve such an organization, and to help make decisions that would impact and benefit planetarians all over the world. It was a demanding, rewarding, experience.

My world started out so small. One planetarium. Then one region. One nation. And finally – the whole world was literally opened to me. What a joy to meet up with delegates from other organizations, other countries, who do the same thing I do. To realize that what we do is valued, is appreciated, is something that gets lost as we fade back into the reality of our day-to-day jobs, often small cogs in the larger wheel of our respective organizations. I value this experience so much that I desire to serve this organization in whatever capacity I can. It is a privilege and honor to do so.

And so, I respectfully offer myself as a candidate for Secretary. If elected, I will continue to work to serve for the benefit of the members of IPS, and through you all, your respective organizations. The world is bigger than just one institution! IPS brings the world so much closer. It's a joy to be a member. And a joy to serve. ☆

Rachel Thompson

Thank you for considering me as a candidate to the office of the International Planetarium Society Secretary. With joy I accept the honor and am pleased to have this opportunity to share my planetarium experiences with you.

Planetarium programs inspire and open students of all ages to a dream world. What stands out most about the IPS is an addictive passion the organization fosters. At each of three IPS conferences I have attended, every individual's perspective enriches the group, empowering growth as educators, entertainers, poets, programmers, scientists, and storytellers.

My planetarian journey began in 2004 at the University of North Texas (in Denton, Texas). As an education student, I was an assistant in the astronomy observatory and planetarium laboratory programs where art, science, and education were blended into one. I loved teaching those programs! One day the program director stopped in for my show and asked if I had considered a career in the planetarium. With this encouragement and a little time, I was soon working fulltime at that very same program for an incredible team. Their great care and investment in university students leads many to careers in astronomy, education, and physics.

After graduating, I taught high school to earn a teaching certificate. The brief hiatus from planetariums was memorable; ask me at the next conference! This work led me to the newly-renovated Noble Planetarium in Ft. Worth, Texas. The staff there is just as incredible, encouraging participation with the regional "local group" of planetarians and the Southwestern Association of Planetariums (SWAP). After working at the Noble, I moved to the Perot Museum of Nature and Science in Dallas, where educators impart love of learning through scientific inquiry.

I am an active participant in the international planetarium community. In 2011 SWAP elected me to serve as Affiliate Representative to IPS, where I have participated with Council for five years and the Education Committee for two. This summer SWAP redrafted its bylaws. Along with several other planetarians and the help of the Great Plains Planetarium Association, I helped facilitate this process, after which I was elected as secretary/treasurer of SWAP. In the upcoming months I am assisting with the electronic archival of SWAP's transcripts of annual meetings.

As a candidate for IPS Secretary, I offer: experience at IPS Council and as an elected officer in SWAP, perspective from employment at several types of planetarium institutions, joy found in being both a science educator and a student, and passion that this unique environment is worth preserving, promoting, and expanding to be more than an addition to the educational experience, but instead vital to the effort of bringing the awe and wonder of space to every person. ☆

Candidate for Treasurer

Ann Bragg

I am honored to be nominated to continue in the office of IPS Treasurer. Despite the additional work that holding an International Planetarium Society office entails, I have enjoyed participating in IPS in a deeper way. Although I am a member of many professional societies, including the American Astronomical Society and the American Association of Physics Teachers, I have found IPS to be the most helpful to me, not just in terms of operating my planetarium, but also in shaping my view of education, informing my teaching, and expanding my professional contacts. I am therefore pleased to have the opportunity to continue contributing to an organization that has been extremely important to my professional life.

My path into the planetarium field was not direct. I began my post-secondary education intending to become an astronomy researcher, earning a bachelor's in physics and both a master's and a PhD in astronomy. Towards the end of my doctoral program, I concluded that I was primarily interested in education and teaching, which eventually lead to my becoming both the planetarium director and an assistant professor of physics at Marietta College in Marietta, Ohio. Three years ago, I was promoted to associate professor. I have taught physics and astronomy courses at all levels, interacting with both general education students and physics majors.

I believe that my experience in the dome has improved the quality of my teaching; presenting astronomy to the general public keeps one honest about what an audience will and will not understand! Perhaps as a result, I have twice received the college's Outstanding Faculty Award, which is given by the Student Senate to one faculty member each year at graduation. I have also been active with service to the college. I recently served a two-year term on our Faculty Council and I also co-chaired a committee involved in writing Marietta College's most recent institutional accreditation report.

The most exciting aspect of my time as treasurer has been Vision 2020. As an officer, I have participated in some lively days with IPS Council dedicated to Vision 2020 during our 2015 and 2016 Council meetings. I believe that the future of IPS promises increased resources and opportunities for its members to enhance their skills as planetarians in collaboration with others. I look forward to continued participation in this process to improve the society for the good of all of its present and future members.

That said, some of the most essential duties of a treasurer are far less exciting. I have worked to maintain the financial integrity of the International Planetarium Society through timely and accurate record-keeping, bill payment, and tax filing, through ensuring that IPS funds are spent appropriately and in accordance with our by-laws, and through working with accountants on a review of our 2015 finances. In a second term, I would continue to be a good steward of IPS resources while helping to grow IPS membership through Vision 2020. ☆

Honoring and recognizing the good works of our members

Manos Kitsonas
Awards Committee
Eugenides Planetarium
Athens, Greece

One of the highlights of IPS Conferences is the presentation of awards. The Awards Committee solicits nominations throughout the year following the conference, and proposes recipients to Council. The 2016 award winners were approved at the 2016 Council meeting in Montreal Canada.

Members of the committee, in addition to myself, are Kris McCall and Tatsuyuki Arai.

Technology and Innovation Award

This year, the IPS Technology and Innovation Award was given to Carter Emmart, director of science visualisation at the American Museum of Natural History's Rose Center for Earth and Space/Hayden Planetarium, New York City (USA), by IPS President Joanne Young.

Since 1998, Carter has pioneered, developed further, and mastered methods of presenting our universe and the "art of flying" through the universe in planetariums. His work was adopted by countless digital planetarium professionals and was employed in dozens of planetariums around the globe.

His passion and commitment to data visualization and to the accurate and realistic 3D mapping of the sky and the motions of the different celestial objects, updated to display a three-dimensional perception of the universe, has inspired countless planetarians and educators worldwide and continues to have a profound impact on the international planetarium community.

Joining the technical production team for the Rose Center for Earth and Space during construction of the new Hayden Planetarium in 1998, Carter was one of the masterminds behind the development of the Digital Universe 3D Atlas.

Based on the NASA-funded Digital Galaxy Project, he developed early interactive realtime control & methods of presentation of stellar 3D datasets for domes.

He pioneered show production techniques in astronomical data visualization and pursued academic collaborations of planetariums with the data visualization community around the globe (among them the National Center for Supercomputing Applications, the San Diego Supercomputing Center, Linkoping University in Sweden and the National Astrophysical Observatory of Japan).

As director and visual choreographer, he used these collaborations and techniques to shape the format of space show production based in scientific data visualization, namely AMNH programs *Passport to the Universe* in 2000, *Search for Life: Are We Alone?* in 2003, *Cosmic Collisions in 2006*, *Field Trip to the Moon* in 2008, *Journey to the Stars* in 2009, and *Dark Universe* in 2013. These innovative productions became benchmarks and sources of inspiration for planetarium show production in many theaters worldwide.

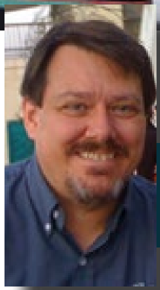
Carter presents and teaches the new capabilities of the digital planetarium to planetarium professionals and educators at many international conferences and educational venues, including remote interactive collaborations in locations around the globe—even in high schools in Cambodia.

By bringing interactive simulations into the dome during astrophysics conferences, Carter also made the science community aware of the new power of the planetarium as a research tool in analyzing 3D data sets and large scale phenomena, hence helping change the way scientists see the planetarium.

Since 2012 Carter started to direct yet another entirely new and revolutionary software development, called "OpenSpace"—an open source academic collaboration with Linkoping University, NASA's Goddard Spaceflight Center, and Johns Hopkins University in Baltimore, Maryland, to bring current space missions to planetarium domes and science centers in real-time.

In an experiment unique in the world, a prerelease version of OpenSpace allowed several planetariums around the world to witness the historic moment when NASA's New Horizons probe flew by Pluto on 14 July 2015, simulating in real-time the different instruments taking pictures and gathering data. This very successful event included an audio stream with live questions from planetarium audi-

Facing page: Carter Emmert at the awards luncheon podium; receiving the award from President Joanne Young. All photos by Frank-Michael Arndt.



Newly-named IPS Fellows are (from left) Patty Seaton, Christian Theis, Kai Santavuori, and (inset) Mark Trotter.

ences and answers from the project scientists.

Future releases of this free software will allow many more planetariums to participate in upcoming networked global science events, proving that the work of Carter Emmart continues to have a profound impact on countless planetarians and educators around the world.

IPS Fellows

The following four deserving IPS Members were named IPS Fellows:

Kai Santavuori from Finland

A key member of the Heureka Planetarium in Helsinki for many years and an invaluable asset of its exhibition and contents teams, Kai became the director/manager of the Heureka planetarium in 2011. As such, Kai led the massive renovation during which Heureka installed its new digital planetarium. Kai was in charge, not only of the selection and evaluation of the best equipment, the contract negotiations and the general overseeing of the installation, but was also responsible for all other aspects of the restoration that needed to be done, from the selection of the new chairs to the installation of the air conditioning system.

When the Nordic Planetarium Association Meeting was held in Helsinki in September, 2015, Kai, with great expertise and using his network and contacts, succeeded in organizing it in the best possible way, attracting the largest ever number of participants, namely 50 people from 15 nations. Kai is a long-standing member of the Board of NPA and has recently taken over the task of collecting news from NPA members to the international news section of *Planetarian*.

Patty Seaton from the USA

An astronomy and science educator, Patty Seaton worked at the National Air and Space Museum Planetarium for 5 years and, for the last 16 years, as director of the H.B. Owens Science Center Planetarium at the Prince George's County Public Schools in Lanham, Maryland. There, she has developed and introduced interactive science enrichment programs for all school ages (from Pre-K through college), using the planetarium theater as a classroom. She has also developed programs for the general public on a wide variety of astronomy topics, using popular fiction to teach astronomy.

In addition to her very active planetarium work, Patty has served as president for the Middle Atlantic Planetarium Society, actively participating in the organization of MAPS meetings, and also as the MAPS representative to the IPS Council.

She has presented her work at previous IPS conferences and collaborated with other groups in order to bring attention to the importance of the planetariums in education, as, for example, with the Italian Association of Planetaria. Patty is also a member of the IPS Education Committee.

Christian Theis from Germany

Educated as an astrophysicist, Christian has authored more than one hundred scientific publications since 1990, and has always had a focus on astronomy education, giving numerous public talks. He worked as a lecturer at the universities of Kiel and Vienna and has also worked in the USA, the UK, France, and Japan.

Since 2010 he has been the managing director (CEO) of the Planetarium Mannheim gGmbH, the company running the planetarium in Mannheim. In this position he is responsible for many show productions and astronomy education projects, including a leading role in several cooperative show productions that were created by a group of planetariums in Germany. Approximately 100,000 visitors flock to the Mannheim planetarium each year, a testament to his successful and hard work.

In addition to his very active planetarium work, Christian has been instrumental to the formation of the Society of the German-Speaking Planetariums (GDP) which was instituted as a formal society in 2011. A founding member of GDP, Christian has served on its founding board for four years as vice president. In this role, he was one of the initiators of the Walther Bauersfeld prize, an award donated by Carl Zeiss AG and given annually by GDP to scriptwriters of youth-oriented astronomy show scripts.

Christian also has a strong international focus, and thus was responsible for relations of GDP to IPS by serving as GDP's first representative on the IPS Council for four years.

Mark Trotter from the USA

Mark has served the planetarium and space science community his entire adult life, a total of 35 years of planetarium work. He began as

(Continues on next page)

Two new ways to get involved

Susan Reynolds Button
sbuttonq2c@gmail.com

It was an extremely busy two days of meetings and decisions for the IPS Council prior to the 2016 Conference.

Along with other business, Council approved two new initiatives for members, the first one is designed to support professional development and the second to provide materials that can enhance scriptwriting with perspectives from a variety of nations.

A Week in the United States

In addition to providing professional development, a new initiative called A Week in the United States brings competition into the mix.

We are seeking two planetariums in the United States that will host and learn from a planetarium colleague from another country, and we are seeking applicants from other countries who would like to travel to the United States to present lessons and learn from their host colleagues.

First, on the US end, we are seeking expressions of interest from two planetarium facilities that would like to host an international colleague. You must be willing to provide $500 for their airline transportation (IPS will match that with another $500) and provide lodging and meals for the week. You may be able to get funding from your affiliate organization and/or other local planetariums or schools who would like to join you in hosting a guest planetarian.

On the other end, applications are requested from educators or astronomers who work with a planetarium and who are comfortable making presentations in the English language. Two winners will be selected to spend at least one week in the United States, giving talks and teaching lessons.

Deadline for applications is December 31, after which a committee of judges

(Continues on page 18)

Brno Planetarium Director Jiri Dusek joins in the applause after presenting the IPS-Eugenides Foundation Best Educational Production Award to Dimitrios Kontopoulos (center) and Mieko Hakkaku (right) for *The Man from the 9 Dimensions*. Photo by Frank-Michael Arndt.

student manager of the planetarium at Louisiana Tech University in Russton, Louisiana.

He followed this by his appointment as planetarium director at Sciport, Shreveport, Louisiana. During this tenure he presented astronomy news on weekly radio and television programs and performed hundreds of live presentations for students and the public.

His next position was at the Audubon Nature Center in New Orleans, continuing with activities as at Sciport.

He joined Bowen Technovation in 2011 and since then has continued to work on dozens of planetarium projects worldwide, including the USA, China, and Egypt. Throughout his dedicated career, Mark has exhibited a great understanding of space science, space exploration programs, educational methods, and planetarium business plans.

All new IPS Fellows received a Fellowship Diploma presented by Awards Committee member Tatsuyuki Arai.

Fulldome Festival Brno 2016 Award

The Festival was held with great success in Brno, in the Czech Republic, prior to the Warsaw Conference. In all, 66 shows were presented and lots of people participated at the wonderful Planetarium of Brno.

There were many excellent shows and the three awards went to:

The Audience Award: *Solar Superstorms*. The show is co-production of Spitz Creative Media, NCSA's Advanced Visualization Lab and Thomas Lucas Productions, in association with Fiske Planetarium at the University of Colorado (Boulder).

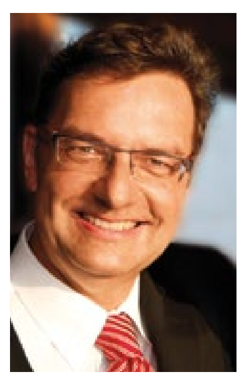
The Brno Observatory and Planetarium Director's Award: *Incoming!*, produced by the California Academy of Sciences.

The IPS-Eugenides Foundation Best Educational Production Award: *The Man from the 9 Dimensions*, a show produced by the National Museum of Emerging Science and Innovation, Miraikan, Japan.

The Audience and Director's Awards were presented in Brno and the IPS-Eugenides Foundation Best Educational Production Award was given in Warsaw by Brno Planetarium Director Jiri Dusek.

President Award

The IPS President Award was given to Past President Thomas Kraupe by President Joanne Young. Thomas Kraupe served in IPS's highest office in 2013-2014 and so far he is the only IPS president to have served a second term, after his first presidency in 1997-1998. His two terms as IPS President are a testament to his immense contribution and commitment to the IPS world, as he has creatively dedicated 12 years in total serving in the different Presidents' positions: two years for each term as President Elect, President, and Past President. ☆



Thomas Kraupe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Vision2020 update and recommended action

Vision2020 Initiative Team
Jon Elvert, Chair
Karrie Burglund, Digitalis Education Solutions, Inc.
Ruth Coalson, NSC Creative
Marc Moutin, Cite de l'espace
Mark SubbaRao, Adler Planetarium
Dan Tell, California Academy of Sciences
Mark Watson, Winchester Science Centre and Planetarium

Vision2020 Team Member Karrie Berglund updates attendees of the 2016 Conference about professional development activities. Photo by Frank-Michael Arndt.

This fall, in addition to electing a slate of IPS officers, you will be asked to vote on two measures that have the potential of dramatically increasing IPS membership and benefits, as well as redefining the length of time served by both the Secretary and Treasurer.

Our IPS bylaws mandate a general membership vote for such measures, and the Vision2020 team encourages you to vote in favor of them.

The rationale for these measures originated in the 2015 Council meeting in Montreal when the Vision2020 Initiative team shared its strategic plan, outlining the objectives and strategies for achieving Vision2020's six primary goals. The team engaged Council in generating numerous ideas that resulted in recommendations for considering meaningful and alternative futures of IPS.

These recommendations were presented to Council prior to the IPS conference in Warsaw in June for action. The Vision2020 team was delighted to hear that these recommendations gained the full support of Council, a clear and gratifying mandate to move IPS forward.

This article summarizes these recommendations that provide a framework for implementing future growth.

The recommendations

1. Adopt mission and vision statements.
2. Propose new membership categories with associated dues and benefits.
3. Intensify collaborations efforts with relevant organizations such as NASA, ESO, IAU, WWT, STScI, Kavli, IMERSA, LIPS and others.
4. Create strategies on evaluating and redeveloping the IPS web site.
5. Propose term limits for officers.
6. Develop professional development opportunities.

1. Mission and vision statements

Mission: Provide the planetarium community professional development, science literacy and arts/humanities awareness, innovative ideas, and partnerships in order to enhance the world's appreciation and understanding of our universe.

Vision: The International Planetarium Society will be the creative and supportive resource for innovation, advancement, and cooperation among planetariums worldwide.

2. Membership categories and benefits

The most frequently mentioned item in membership surveys was for creating a sliding scale of membership categories and related benefits. The rationale for these membership levels are:

- To dramatically increase IPS membership, which currently is historically low;
- To get new planetarians to join IPS
- To encourage IPS membership in emerging communities
- To be more equitable (staggered membership fees); and
- To increase IPS revenue

To further assist Council in thinking through the process of new opportunities and directions for growth, five different, but relevant, organizational models were compared to IPS in terms of governance, membership dues and benefits, conferences, and funding resources. The five organizations were the American Children's Museum (ACM), Astronomical Society of the Pacific (ASP), Association of Science-Technology Centers (ASTC), Immersive Media, Entertainment, Research, Science and Arts (IMERSA), and European Collaborative for Science, Industry, and Technology Exhibitions (ECSITE).

Recommended action: adjust membership categories, fees, and benefits as follows:

Individual $65 for one-year, $100 for two years

Benefits:

- Quarterly journal in print and digital editions
- Other periodic publications (conference proceedings, membership directory, special publications)
- Voting rights
- Member-only online repository of free resources such as fulldome shows, dome masters, "live" show scripts, music, and

- access to archived workshops, conferences, events, talks
- Online professional development resources **(new benefit)**

Small Institutional* $200 annually (new category); defined as an institution with an annual attendance less than 20,000 visitors.

Employees join as individuals but at reduced individual membership rate of $40

Benefits for institution, same as individual, plus:

- Recognition plaque for institution
- Logo and web site link on IPS web site
- Use of IPS logo on institution's web site

Medium Institutional* $400 annually (new category); defined as an institution with an annual attendance less than 100,000, but greater than 20,000 visitors.

Employees join as individuals but at reduced individual membership rate of $40

Benefits: same as above

Large Institutional* $600 annually (new category); defined as an institution with an annual attendance greater than 100,000 visitors.

Employees join as individuals but at reduced individual membership rate of $40

Benefits: same as above

Corporate* $600 annually

Employees join as individuals but at reduced individual membership rate of $40

Benefits: same as above, plus

- One annual access to database of members
- 10% discount on ads in *Planetarian* and online (on the web site, if decision is made to advertise online)

Corporate Benefactor* $1,000 annually (new category)

Employees join as individuals but at reduced individual membership rate of $40

Benefits: same as above, plus

- Larger logo and web site link placement on IPS web site

** Institution and Corporate must join in order to provide their employees the discounted membership rate. Employee members receive their own logins and access to IPS resources. This allows IPS to have a better list of the employees who participate in some way in IPS. Currently, unless someone employed by an institutional/corporate member is either the contact person or purchases their own individual membership, they do not appear in the membership database at all.*

Student/Career Starters $25 (new category); career starter defined as someone with three years or less experience in the planetarium field.

Benefits:

- Digital edition of *Planetarian*
- Access to online professional development resources
- Up to 50% discount on biennial conference registration (balance paid at discretion of conference host's budget)

Senior/Emeritus $50 one year, $80 two years (new category); senior defined as 60 years and older; emeritus defined as no longer formally employed.

Benefits:

- Same as Individual
- Invitation to a reception hosted by IPS especially for this category at its biennial conference.

Business Associate $25 (new category); intended for the one- or two-employee businesses that perform planetarium outreach programs.

Benefits:

- Digital edition of *Planetarian*
- Access to online professional development resources
- May attend IPS biennial conference at individual members rate

Associate $0 (new category); intended for planetarium volunteers or part-time planetarium employees in emerging communities. However, all applications for this category will be considered on a case-by-case basis.

Benefits:

- Digital edition of *Planetarian*
- Access to online professional development resources (first year free, second year $25.

3. Collaborative efforts

At the organizational level, the Vision2020 team recommends creating individual formal relationships with the groups representing the astronomy and space science communities based around areas of common interest. Over the past year the Vision2020 team has initiated a few relationships in this regard, and they can serve as models for future agreements going forward. The relationships include:

IAU: The IPS and the International Astronomical Union are in the process of creating a joint working group to coordinate activities between IPS and the IAU's Commission C2, Communicating Astronomy with the Public. The IPS council approved the creation of this working group during their meeting prior to the Warsaw conference.

AAS: The IPS and the American Astronomical Society have been collaborating with regard to the future of the Worldwide Telescope project. The result has been that the AAS has taken over the stewardship of the WWT from Microsoft, its originator. The adoption by the professional astronomy and planetarium communities of the same tools has great potential to bring new science into our domes.

NAOJ: The IPS is partnering with the National Astronomical Observatory of Japan to host a joint "Data to Dome" workshop in the spring of 2017.

ESO: The European Southern Observatory has taken a lead role in hosting and distributing planetarium content. ESO and the IPS Science and Data Visualization Task Force, along with the planetarium vendor community, are collaborating on the Data2Dome platform, which will enable content discovery, distribution, and sharing across various planetarium solutions. (See more about Data2Dome on page 61.-ed.)

In summary, Vision2020 recommends a two-tiered strategy for achieving collaborative relationships. At the organizational level, IPS will work to create, grow, and strengthen the relationships with the major professional astronomy and space science organizations, while also enabling all planetarians to strengthen the relationships with researchers in their own community.

4. Website

A comprehensive document analyzing and evaluating the current IPS web site was prepared by a hired consultant and given to Council prior to its meeting in Warsaw. This document evaluated the current site's content, functionality, and visual style with respect to how well it meets its effectiveness in communicating and engaging with its identified target audiences.

Recommendations included improvements to site navigation and design as well as implementing social media. These recommendations and specifications should be used as a guide for the development of a new website. This document is currently under review by Council.

(Continues on next page)

(Vision2020, continued from page 17)

5. Term limits

Many members feel that the current six-year commitment cycle for President is too long and discourages participation. Frequent turnover of officers would avoid a sense of stagnation, rejuvenate officers with new ideas, decrease overall apathy, and make interest in leadership roles more attractive, particularly among younger members.

Additional discussion was held on term limits for the Executive Secretary and the Treasurer, and agreement was reached that there should be no more than three terms in succession, for no more than six years in total.

In keeping with this decision, it was also recommended that the president should not serve for two consecutive terms.Although the proposed recommendation is for officers, affiliates were also strongly encouraged to rotate their representatives when feasible.

Recommended action adjust the By-Laws in include that the President will not serve consecutive terms and that the Secretary and Treasurer will be able to serve no more than a six-year period (maximum of three consecutive terms).

6. Professional development

Professional development (PD) is a critical and vital membership benefit. One of Vision2020's goals is to increase and promote various PD opportunities. Karrie Berglund and her team are still reviewing results from their post IPS2016 PD survey, but so far the three most-mentioned goals from the survey are:

1. Networking;
2. Learning about new technologies, media, and/or software; and
3. Learning about presentation techniques, particularly with regard to live programs.

Other topics of interest are:

- Live programs/LIPS-style workshops
- Fulldome production techniques and tools
- Science visualizations—getting data on the dome, live navigation of data, making data accessible to all domes
- Marketing techniques and strategies

These PD options will continue to be developed and expanded.

The future of V2020

Vision2020 will continue to push forward on what it believes to be essential in providing and meeting the needs of IPS members. The document presented to Council in Warsaw also included future recommendations that reflect the objectives (goals) and strategies of our strategic plan. Our team's six core goals, along with their detailed descriptions, are listed on the Vision2020 link located on the home page of the IPS web site www.ips-planetarium.org.

Lastly, I wish to thank the Vison2020 team members, listed above, for their dedication to improving the quality of our Society and for their continuing work on this important process. ☆

(Two new ways, continued from page 14)

composed of representatives from the host planetariums and IPS regional affiliates will carefully review each submission and choose the winners. Applicants will be notified of the committee's decisions no later than February 1.

Complete details are available on the IPS website at ips-planetarium.org/?page=share.

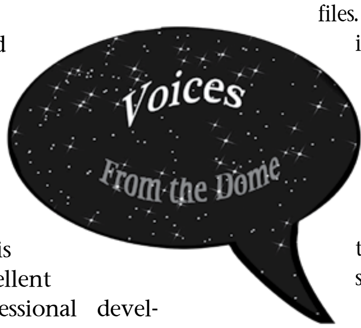
This project will lend itself to many opportunities for local publicity for the host(s) as well as the winners of the contest back home.

The IPS supports this initiative as an excellent opportunity for professional development and cultural exchange for both the winners and the host facility. We hope that you will think of ways that this initiative can be expanded to include cultural exchanges among all nations.

In addition, IPS hopes to expand the program beyond this first year and two candidates and support exchanges between all countries, especially for the cost of transportation. If you would like to contribute to this initiative, you can send a donation specified to support cultural exchange to:

IPS Treasurer Ann Bragg, Anderson Hancock Planetarium, Marietta College, 215 Fifth Street, Marietta, Ohio 45750 USA; email ann.bragg@marietta.edu.

Voices from the Dome



The goal of this second international project is a to build a collection of short audio clips (maximum 3 minutes each) that can easily be shared among planetariums as mp3 files. The project is open to all planetarium operators.

We are looking for spoken remembrances or "mini lessons" on classic planetarium topics, such as the North Star, the apparent movement of the sky, constellations, seasons, equinoxes and solstices, and more; the subjects that can be included are endless. Also helpful are planetarians' personal memories, or funny, curious, and interesting facts as you normally present them in your dome.

Or, if you prefer, you can contribute a simple "welcome to the planetarium" in your native tongue.

Imagine your computer full of audio files; you do not need to use many images that often obscure the stars; instead you can use many voices that help the audience to discover the real night sky. In this way perhaps you can challenge their misconceptions and enrich their perceptions.

When a wide audio database becomes available there will be enough choices in the subject and/or the geographic area of the "voices" to select a list of audio files (as in the past you selected a list of slides for a presentation) and introduce or translate each "voice" to the audience during a special planetarium show.

With these clips you can build live planetarium shows mainly using only one image, the same image projected in every planetarium in the world, the sky as viewed from Earth commented on and/or described by many voices.

Small or mobile planetariums also can easily use these files by connecting a mobile phone or laptop to your speakers.

Texts of high quality will be published in *Planetarian*, and their audio files made available through a searchable database freely available on the IPS web site.

To be sure that all the materials will be freely available and without cost or the necessity of any special permission, each audio file must be made without music and the work is released under the Creative Commons Attribution 4.0 International License (creativecommons.org/publicdomain).

Full details and more information about this project also are available on the IPS website at ips-planetarium.org/?page=share. ☆

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Factors influencing planetarium educator teaching methods at a science museum

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Abstract

A qualitative study was conducted exploring the ways three planetarium educators at an informal science center teach school programs and the factors that influence the teaching methods they use. Data collection techniques included an initial interview, observations of educators teaching planetarium programming, and a final interview. Results from this study found that teaching methods used by the participants included questioning, explanation, kinesthetics, modeling, observation, identification skills, reinforcement, prediction, and story-telling. The teaching methods of participants were informed by previous astronomy and professional experiences, education, purposes and goals for planetarium education, audience, and technology.

Introduction

A qualitative study was conducted to examine the ways planetarium educators teach program content, and the factors that influence the teaching methods they use. While planetariums can be found in many institutions such as schools, universities, government institutions, and science centers/museums (Small & Plummer, 2010), this study examines planetarium education that occurs within a science museum. The need to address planetarium education at science centers and museums is particularly relevant as many science centers are currently undergoing a paradigm shift from presenting information to promote an understanding of science to developing content that promotes engagement with science (Bevan & Xanthoudaki, 2008).

This paradigm shift in science centers and museums represents a great opportunity to educate the public about astronomy, but it also presents a challenge to planetarium educators to provide quality educational experiences within the planetarium setting. Small & Plummer (2010) found that while many commercially available fulldome movies are largely "push-button" (p. 1) programs that do not include a live-interactive component, "planetarium professionals want educationally oriented programs that offer the opportunity to interact with their audiences" (p. 8). If educators are to use interactive experiences as opposed to passive fulldome movies in planetariums to educate audiences about astronomy, it will be important to understand the current factors that influence planetarium educator teaching methods in order to develop effective professional development tools for educators.

Purpose of the study, research questions

The purpose of this case study is to identify the factors that influence planetarium educator teaching methods at a science museum located in the southwestern United States. The central question this study seeks to answer is:

- What factors inform planetarium educator teaching methods at a science museum?
- To more deeply explore this question, this study use the following sub-questions:
- In what ways do planetarium educators teach program content?
- What types of teaching and education background do planetarium educators have?
- What influences their current teaching methods?
- What do they view as the purpose of planetarium education?
- How does professional development influence planetarium educators?

Theoretical framework approach and researcher positionality

The positionality of this science education researcher is based upon a post-positivist ontology and epistemology, and a science education constructivist pedagogy. A post-positivist ontology and epistemology takes the stance of "critical realism" (Lincoln, Lynham, & Guba, 2011, p. 98), which assumes that while there may be a single reality, it can only be approximated and never fully understood (Creswell, 2013). While Lincoln et al. (2011) argue that post positivist and constructivist views are incommensurable, Gil-Pérez et al. (2002) argue that it is possible to have a constructivist pedagogy without constructivist epistemology, and that "constructivism in science education has little to do with philosophical constructivism" (p. 559).

In science education, constructivism is concerned with the active participation of groups and individuals in the construction of knowledge; however, it rejects notions and ideas that distort the nature of science (Gil-Pérez et al., 2002). Socially constructed ideas must, therefore, be consistent with the nature of science. This idea within science education constructivism is similar to the description of post positivists by Patton (2015) that states: "it is possible, using empirical evidence, to distinguish between more and less plausible claims" (p, 106). In this way, the pedagogy of constructivism in science education can be commensurable with an ontology and epistemology of post-positivism.

Based upon researcher positionality, the researcher used a post-positivist framework approach with a science education constructivist lens. A post-positivist approach is one that takes a "scientific approach to research" (Creswell, 2013, p.23), and accepts and evaluates multiple perspectives to develop an approximation of reality that is constructed by the researcher through data analysis (Creswell, 2013). Additionally, within a post-positivist framework, the researcher analyzes the data and interprets its meaning while attempting to control biases (Creswell, 2013). Using this approach, a case study methodology was used in which the researcher defined the parameters of the study, collected and analyzed the data, and interpreted the meaning. A science education constructivist lens was used to analyze the data and identify themes that emerged about how planetarium educators teach content and view themselves as educators.

Literature review: Educating in science centers and museums

When conducting research within a science center or museum, it is important to understand the educational role the museum plays

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in the community. The types of educational content provided by museums can include exhibits, performances, outreach activities, programs outside the museum, research, partnerships with other organizations, and web-related content (Hein, 2005).

While there are many methods and contexts to provide educational context to museum visitors, Hein (2005) contends that constructivism is "the most powerful and appropriate educational theory and practice for museums" because it "is an active process in which we as learners make meaning" (p. 359). Bell, Lewenstein, Shouse, & Feder (2009) identified six strands that represent the different goals science museums and educators may have when delivering science content: 1) developing an interest in science, 2) understanding science knowledge, 3) engaging in scientific reasoning, 4) reflecting on science, 5) engaging in scientific practice, and 6) identifying with the scientific enterprise.

Many science centers and museums are also beginning to go through a paradigm shift in how they present educational content. Traditionally, museums have presented information to promote an understanding of science content, but there is a growing trend for museums to develop content that promotes engagement with science (Bevan & Xanthoudaki, 2008). In line with this paradigm shift, Bevan & Xanthoudaki (2008) found that constructivist and socio-cultural pedagogical approaches were used by many educators in museums. However, they also found that without continued professional development, museum educators "often revert to conceptualizations of knowledge and pedagogy they themselves experienced in their own learning" (Bevan & Xanthoudaki, 2008, p. 108).

In light of these trends in science center and museum education, in this study the researcher used a scientific constructivist lens to identify the types of pedagogies employed by planetarium educators, examine the rational for utilizing those pedagogies, and determine if or how constructivist pedagogy is being used in planetarium education at a science center.

Literature review: Planetarium education

Even though planetariums are often connected with science centers and museums, they offer a unique educational setting that requires specialized research (Plummer, Schmoll, Yu, & Ghent, 2015). The learning environment created by planetarium education operates on a spectrum ranging from formal to informal education (Plummer et al., 2015). The type of learning environment that occurs in the planetarium is dependent upon the specific educational goal of the planetarium, and the delivery method used by planetarium educators (Plummer et al., 2015). Formal learning environments are characterized by teacher led lessons where "students have little control over what they study" (Plummer et al., 2015, p. 9), whereas informal learning environments focus on providing learners with a certain level of choice. Even though planetariums may be connected to an informal learning environment, such as a science center or museum, they may "offer more structured learning activities and time constraints than other parts of a museum or science center" (Plummer et al., 2015, p. 9). Portable planetariums that are brought out to schools may fall into the middle of the learning environment spectrum as they often combine informal learning strategies in connection with school curriculum (Plummer et al., 2015). When researching planetariums, Plummer et al. (2015) contend that research conducted in more formal environments should focus on analyzing how the structured elements of the program improve content knowledge, whereas research conducted in more informal environments should focus on understanding the use of social elements such as choice, interest, and motivation.

Sumners, Reiff, & Weber (2008) describe a study conducted using a portable planetarium that can be taken to schools. Their study examined the impact a 22-minute prerecorded fulldome show had on the earth science conceptual knowledge of students 3-12 years old. The study found that planetariums provide an "immersive environment" (Sumners, Reiff, & Weber, 2008, p. 1848), which can be a useful tool for engaging students in concept exploration. The authors concluded that the immersive experience is particularly useful in helping students understand "concepts that are intrinsically three-dimensional" (Sumners, Reiff, & Weber, 2008, p. 1848) such as earth and space science content. While this study examines the type of environment created by planetariums, the study focuses on use of fulldome movies rather than teaching methodology of the planetarium educator.

Chastenay (2015) conducted a study that examined how a live interactive portable planetarium program was used to teach the concept of the lunar cycle to students 12-14 years old. The study combined a planetarium program with student observations of lunar phases for 1 month prior to the planetarium show to allow them to have a real world context for the content taught in the planetarium. Within the study, the educator used the digital planetarium software to create a "highly realistic simulation" (Chastenay, 2015, p. 6) of a space-based perspective of the Moon. The space-based perspective shown in the planetarium created a discrepant event between what students observed prior to the planetarium and the simulation. The planetarium educator used a live interactive teaching style that included questioning methodology, and students were asked to develop potential explanations for the discrepancies between what they observed outside the planetarium and in the planetarium show. In addition, the educator asked students to make predictions about the position of the Moon, and then compare their predictions to the simulation of the motion of the Moon as seen in the planetarium. Chastenay (2015) concluded that this method of using a live interactive planetarium program in combination with student observations aided students in developing conceptual understanding of lunar models and applying that knowledge to make predictions regarding lunar position and phases.

Beliefs and practices of planetarium educators

While there are several studies regarding the educational benefits of planetariums, studies examining the teaching methodology beliefs and practices of planetarium educators are just emerging. Small & Plummer (2010) conducted a small survey of 36 planetarium professionals' beliefs about what the goals of planetariums should be, and how planetarium programs should be designed. The majority of planetarium professionals believe that the goal of planetariums should be to provide audiences with an "opportunity to learn more science content and to be inspired to continue learning more in the future" (Small & Plummer, 2010, p. 8). Small & Plummer (2010) also found that planetarium educators prefer interactive programming as opposed to fulldome movies, and they prefer to use live interaction methods that include: conversational dialog, questioning the audience, kinesthetic activities, props, and combining digital movies with live presentation.

In another case study, Plummer & Small (2013) explored the pedagogical choices and goals planetarium professionals have for audiences in the planetarium. The study found that the majority of participants had some level of formal education background, which impacted the pedagogical choices they made (Plummer & Small, 2013). However, the authors found that the two largest factors that impacted how participants interacted with their audiences were "experiences they have on the job, and working with audiences" (Plummer & Small, 2013, p. 8). Participant response also showed that many planetarium professionals draw on a learner-centered, constructivist philosophy to inform their teaching pedagogy (Plummer & Small, 2013).

(Continues on next page)

While their study provides insight into the ideas and beliefs of planetarium educators, it is limited due to relying solely on self-report and lacking observational data. This study seeks to expand on the current literature by combining interviews and observations to identify the ways planetarium educators teach.

Methods

Research approach

This qualitative study employed a collective case study approach. This approach is consistent with a post-positivist framework it provides an in-depth look at a specific case or cases within well-defined boundaries that are established by the researcher (Creswell, 2013). The rationale for a case study approach for the current study is based upon prior research. One limiting factor of Plummer & Small's (2013) of planetarium educator beliefs was that it was solely based on self-reporting, and the authors recommended additional research that combines interviews with observational data to further extend our understanding of the beliefs and practices of planetarium educators. This study used a case study approach in order to add to the body of knowledge previously established in the literature by obtaining in-depth data through interviews and observations to identify the factors that influence and inform planetarium educator teaching methods at a specific science museum.

Research site

The research was conducted with a portable planetarium educational program offered by a nature and science museum located in the southwestern United States. This site was selected in particular due to its many unique attributes, which make it suitable for a case study. First, the planetarium programming offered by the museum is mostly based on live, interactive programs using digital dome technology. Additionally, this research site's planetarium programming uses a portable planetarium that travels to different sites, including schools. Finally, the research site employs a large number of educators with a variety of educational backgrounds that range from no formal education training or experience at all to educators who have no prior education training or experience.

Participants and sample size

The participants for this study were selected from a purposeful sample (Creswell, 2013) of educators at the museum who taught planetarium programs. All planetarium educators at the museum were told about the study and given an opportunity to participate. After being provided with an informational packet, three planetarium educators provided their consent to participate in the study. The three participants in this study are *Anne*, ***Brittany***, and *Celina*. All of the participants are female, and have diverse personal and educational experiences. Their experiences as a planetarium educator at the museum ranged from 6 months to 35 years.

Data collection

Qualitative data was collected from observations and individual interviews with participants. Data collection methods included field notes and audio-recording during interviews and observations. The initial interview used an open-ended, semi-structured interview protocol. The initial interviews were 30-45 minutes in length. During the initial interview participants were asked to questions regarding their educational background, experience, teaching methods, views on professional development, and educational philosophies.

After the initial interview, the researcher conducted an observation of the planetarium educators teaching a 45-minute planetarium program. Due to the traveling nature of the portable planetarium, the observations were conducted in different elementary school locations. Observations were conducted in a 5-meter portable planetarium dome that used an omni-directional, fisheye lens projector located in the center. The dome used in this study was capable of accommodating up to 26 students, who would sit in a concentric configuration on the floor. The programs were taught by two planetarium educators at a time, who would walk around the perimeter of the dome while teaching. The programs were taught by two planetarium educators at a time. Observation protocol included the researcher recording descriptive and reflective notes during the program. The descriptive and reflective notes taken by the researcher were focused on the teaching methods used by the planetarium educators during the program. The methods of observation included the researcher sitting in the planetarium program being taught, recording field observations, and obtaining audio recording of the program.

Table 1
Observed Planetarium Teaching Methods

Participant	Teaching Method
Anne	Questioning Explanation Kinesthetic Modeling Observation Identification skills Reinforcement
Brittany	Questioning Explanation Observation Kinesthetic Identification skills Prediction Reinforcement Story-telling
Celina	Questioning Explanation Modeling Prediction Story-telling

A final interview was conducted with individual participants after the researcher observed the program. The final interview used an open ended, semi-structured interview protocol, and required approximately 15-20 minutes of the participants' time. The interviews were audio recorded, and the researcher also kept field notes from the interview. During the final interview, participants were asked questions related to the planetarium program observed by the researcher. Specifically, questions focused on the goals and teaching methods used by the instructor during the observed program.

Data analysis

An initial analysis of the data was conducted to identify relevant themes. After identifying themes, a second analysis was conducted by the researcher to further refine the themes. Themes were first analyzed in terms of each individual participant, and then in relation between participants. A word table was also used to help identify "similarities and differences among the cases" (Creswell, 2013, p. 200). The software program Wordle.net was used in combination with the word table to represent the data visually with a word cloud. Field notes from observations and interview transcripts were also analyzed to identify teaching methods used by the planetarium educators in this study. Teaching methods were coded using descriptive terminology. Additionally, the post-interview transcripts were analyzed to identify participant responses to the teaching methods used in the planetarium, and factors they believed influenced their decisions to use those methods. Participant responses were analyzed through a science education constructivist lens to compare the methods and beliefs of the participants in the study with principles of constructivist practice in science education. Additionally, the data were analyzed for content and trends that appear throughout the data. From the trends in data, this researcher developed naturalistic generalizations about the specific case from examining the data in this study. However, due to the limited scope of the study it will be difficult to form larger generalizations from the data.

Findings

After data analysis the findings of this study are presented by first examining the teaching methods used by the participants in the study, followed by the factors that influence their teaching methods.

Teaching methods

There were a number of teaching methods used by each educator. After analyzing field notes, and discussing the teaching methods used with each educator, the teaching methods used during planetarium programs were coded (Table 1). The teaching methods used by the participants included questioning, explanation, kinesthetic, modeling, observation, identification skills, reinforcement, prediction, and story-telling.

Anne and Brittany

Anne and Brittany taught a portable planetarium program together at a local elementary school. During the transportation and set up of the planetarium, both educators discussed and shared content ideas. Brittany made the comment "I've been doing this activity with identify directions, using hand motions to know what direction to look in the sky." During the planetarium set up Anne and Brittany continued to discuss what content they would focus on during the program. Content included focus on rotation versus revolution, and whether or not the term "orbit" is included in the state's science standards. Anne also talked with the teacher at the school to determine the content that should be covered in the program. The teacher asked that the educators review the solar system.

Once the students entered, both Anne and Brittany taught the program together and each used a variety of teaching methods. Anne used a combination of questioning, explanation, kinesthetic, modeling, observation, identification skills, and reinforcement techniques. Anne began the program by using a combination of questioning and observation methods by asking students to use their observation skills and identify what they saw as they entered the planetarium. Using the planetarium software, Anne sped up time to illustrate the motion of objects in the sky. While doing so, Anne employed kinesthetic methodology by asking students to place their hands on the ground to see if they could feel the Earth move. She then modeled the rotation of the Earth by using the projector in the middle of the planetarium as a representation of the sun and her face as a representation of the Earth. She then spun around to model the rotation of the Earth and day/night cycle. She continued the model by walking in a circle around the dome to model the revolution of the Earth.

As the program continued, the planetarium displayed the stars of the night sky. Anne helped students to identify the Big Dipper by creating an illustration of the constellation. She then continued by using kinesthetic methods to show students how to use the Big Dipper to identify Polaris, the North Star. Students used their hands to create a straight line from two stars in the Big Dipper to the next brightest star, which is Polaris. As the program continued, Anne displayed images of planets in the solar system, and provided explanation and details about each planet.

The program concluded by Anne reinforcing what the students had learned and asking students to explain the differences between rotation and revolution. In a follow up interview, Anne stated that her main goal was to review the concepts of rotation, revolution, and planets of the solar system. She felt that the methods she used in the program were effective in achieving her goal.

During the same program, Brittany also used a variety of teaching methods. Brit-

(Continues on next page)

Figure 1

tany used a combination of questioning, explanation, observation, prediction, kinesthetic, identification skills, reinforcement, and story-telling teaching methods. Before Anne sped up time in the planetarium, Brittany asked students to make a prediction of where the sun will be later in the afternoon, and to demonstrate their answer by pointing to a spot in the planetarium. As time was sped up, she asked students to evaluate their prediction, and explained that as the Earth rotates the sun appears to move from the east to the west in the sky.

When the planetarium program switched to the night sky, Brittany combined kinesthetic methodology to teach identification skill methodology. She asked a student to stand up, and pointed the student in a certain direction. Brittany then taught the students the phrase "If I put my left to the west, and my right to the east, then my nose knows where the north is." Brittany later explained that this method was something she learned as a young girl, and was useful in helping her identify the direction she was facing at night. Later in the program, Brittany helped students identify the constellation Cassiopeia. She then told a story related to queen Cassiopeia, and incorporated other constellations such as the Big Bear and Little Bear.

In a follow up interview, Brittany said that her goal was to help student review rotation and revolution and show them some interesting objects such as planets and galaxies. However, she said that she felt most of her time was spent explaining rather than using more interactive elements because the students in the program were talkative and not receptive to the program. She said that when students are not receptive, that limits the types of teaching methods she can use in the program.

Celina

Celina taught a portable planetarium program with another educator who was not a participant in the study. The program was taught at a spring break camp for elementary aged students. After the planetarium was set up, Celina talked with the teacher on site to ask about student ages and content to be covered. The students had been studying planets and nebulae, and the teacher requested that material to be addressed in the program. Prior to the program Celina also practiced using the technology to familiarize herself with the order of content she planned on covering with students.

When teaching the program, Celina used a variety of teaching methods: a combination of questioning, explanation, observation, prediction, modeling, and story-telling techniques. As students entered the planetarium, Celina asked them to make observations about what they noticed in the daytime sky being displayed on the dome. As she sped up the time of day within the planetarium, Celina provided explanation to the students that the sun appeared to be moving because the Earth was rotating. She then modeled this phenomena, using the projector to represent the sun and her nose was "Mount Nose." She began to slowly spin, and explained that her motion represented the day/night cycle we have on Earth.

As the program began to display the night sky, Celina pointed out the moon to the students and described the phases of the moon. She asked students to predict where the moon would be the next day by having them point to a location in the sky. Celina used the planetarium software to move the time to the next day so students could evaluate their predictions. Later in the program, Celina showed students the constellation Orion in the night sky, and told the students a story about Orion the Hunter.

Celina concluded the program by showing students images of Jupiter and explaining that the big red spot on the planet is a storm similar to a hurricane on Earth. However, at this point in the show, students were becoming talkative and Celina ended the show 5 minutes early.

In a follow up interview, Celina described her goal for the program was to get students interested in space. She described her experience as being largely successful, but noted that she had trouble towards the end of the program as the students were becoming increasingly talkative. She attributed the students' attitudes to their young age and their limited attention span.

Themes

After analyzing the interview transcripts, a number of themes emerged as factors that influence planetarium educator teaching methods. The themes include experience, education, purpose and goals, audience, and technology. Using these themes, a word cloud was created using words from participant transcripts that were associated with each theme (Figure 1). The word cloud illustrates words and phrases that appeared most frequently in conversation. It is evident from the word cloud that experience was the most frequently used word in discussion with teachers.

Experience

One factor discussed by participants that influenced their decisions as planetarium educators was personal experience. Each participant spoke extensively about their experiences, and the influences those experiences had on them. The experiences discussed

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(Factors, continued from page 24)

by participants were coded into two subthemes: astronomical and professional.

Astronomical experiences

Anne and Brittany both discussed their experiences with astronomy. In contrast, Celina did not discuss having extensive experience with astronomy apart from her education. Anne described her experiences with astronomy as having an influence on her as an educator. During the initial interview, she discussed her experience with astronomy as a young child. She recalled not being aware about many constellations except for the Big Dipper and Orion, but being impressed when a family member took her outside to observe the night sky through a telescope. To Anne, the sky looked different from the pictures of the stars she had seen in books and on screens. She additionally recalled an experience she had when her grandparents took her to Griffith Observatory (in Los Angeles). To Anne, these experiences made astronomy "a lot more interesting." This experience of using a telescope and visiting an observatory was more impactful for Anne than simply reading about that information from a book.

Anne continued to explain later in the interview that she tries to incorporate real life experiences into planetarium programs. She stated:

> I do ask them things like "Have you ever been out to your grandparent's house or had a house out on the lake or something, or up in the mountains? Have you been to somewhere where you can see dark skies?" A lot of them have and they go "Oh yeah, yeah, I've seen the Milky Way." If I ask them questions like that, they remember things that they've seen. But if you don't ask them the questions, then they forget.

Anne explained that creating connections to real world experiences is a part of her strategy as a planetarium educator. She uses questioning strategies to help students make those connections to the real world, which Anne believes helps students remember the content.

Brittany also discussed her experience with astronomy as being influential to her as a planetarium educator. For Brittany, it was her experiences with astronomy that drew her in to planetarium education. She recalled always wanting to study planets, saying "planetology is my real love." She also described a vivid experience with the night sky and with planetariums.

> Well, I've always been an amateur astronomer. When I was a teenager, we moved to El Paso, and that's dark sky out there, so I got to see lots of stars and I went to the planetarium in New York on the way to Texas and fell in love with the planetarium.

Brittany's discussion focused on how her experiences moved her into being a planetarium educator due to her passion for studying planets and being exposed to planetariums as a child. Brittany also further elaborated about her experiences with astronomy as an amateur astronomer. She has over twenty years of experience hosting star parties with a statewide astronomical society. Additionally, she talked in detail about hosting a star party in Cancun to observe Halley's Comet. The experiences described by Brittany highlight her enthusiasm and passion for astronomy, which has impacted her as a planetarium educator.

Professional experiences

Each participant described the importance of their professional experiences, which included specific workplace experiences in the planetarium, collaborations with other educators, and additional professional experiences that have been influential.

Anne has over 15 years of experience as a planetarium educator. She described her professional experience of moving from a fixed dome, which is a planetarium that resides within a permanent structure, to teaching in a portable planetarium. In the fixed dome, Anne was behind the control console, and able to plan out and organize shows with precision. However, she explained she found the transition to the portable dome to be really difficult, because instead of being behind the console with a script in front of her, she was on the floor with the students and was required to interact with them in a way she was not used to. However, after working with another educator and with additional practice, she became confident in teaching programs in the portable planetarium. She explained:

> So I worked with [another educator] quite a bit, learned some of his techniques for dealing with kids who don't want to listen to you and how to make them want to listen and just how to get around that whole "I'm sitting here behind them and they're all taller than me" mentality. I don't sit anymore, I walk, so that made a huge difference. He said "You just need to walk around, you just need to not sit, but you need to be up on the periphery all the time" and that made a huge difference. I feel like I had more presence, so I could get their attention a little bit better.

Brittany also discussed the influence on her teaching from professional experiences and collaborations. She has been a member of an international organization of planetarium educators and researchers for the past 35 years. During the interview, she stated "I know that I got a lot out of my interaction with other educators." Some teaching strategies that Brittany mentioned she used as a result of professional collaborations included "teaching with movement," using models, and incorporating light bars into the planetarium. She stated that she learned about teaching with movement after reading a paper published by the international organization she was a member of. She began incorporating models of the Earth and moon to represent celestial motion after seeing another educator use the models while teaching a program. Brittany stated that she had conversation with a vendor during a convention about using a light bar to help students see slightly better in the planetarium, and that she planned to purchase one to use in programs.

At the time of the interview, Celina had six months of professional experience as a planetarium educator. When she discussed her professional experience, the focus of her statements involved her transition into becoming a planetarium educator. She had been a software engineer. She stated that she did not like the corporate world, and left to become an educator. Her focus as an educator was in science education because of her engineering background and interest in physics and astronomy. Celina also discussed how what she has learned about the strategies used in planetarium education has come from her experiences with other educators. She has learned how to use the technology to run the planetarium program, and she also learned several teaching strategies such as questioning and story-telling from watching other educators teach.

Education

Education is one factor that has played an influential role for all planetarium educators. Each has diverse educational experiences. Anne has a master's degree in interdisciplinary studies, combining women's studies and art, and she does have experience with astronomy classes as well. Brittany has a bachelor's degree in geology. Celina has a master's degree in curriculum & instruction with an emphasis in science education. Each of the participants discussed how their educational experiences influenced them as planetarium educators.

While Anne's degree was in women's studies and art, she discussed how that led her into planetarium education. She recalled that as part of her art program she interned at a museum that had a special exhibit, and at the end of her internship someone approached her to volunteer in the planetarium. It was at the same time that she was volunteering

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(Factors, continued from page 26)

in the planetarium that she began taking an astronomy course. She was impressed by what she learned and enjoyed getting to go out at night and observe the night sky with a telescope. It was her volunteering experience combined with her astronomy course that led her into becoming a planetarium educator.

Brittany's discussion of her educational background focused on impacts of specific courses and instructors, rather than her degree in geology. She discussed how one instructor in particular, whom she refers to as a "role model," influenced the teaching methods she uses.

> I had an astronomy professor at community college when I was much younger, and I took one of those courses. He was a questioner. He would ask trick questions. He was really good. He's the one who opened up the job for me to teach ... and then he used the planetarium for reinforcement. And experience, that kind of thing. That's why I like the idea that a lot of different things instead of just one thing, one way.

According to Brittany, this professor used questioning techniques in combination with the planetarium to provide students with an experience to reinforce learning. These strategies are key strategies Brittany stated that she uses in her teaching, and she can attribute her methodology to an astronomy professor she had in college.

Celina has a master's degree in curriculum & instruction, and much of her discussion on education focused on how her degree helped inform her methodology. Her educational experience made her aware of curriculum-based approaches, and also made her aware of student-centered teaching methodology. During her program, Celina also took two astronomy courses that provided her with specific teaching lessons. She explained:

> [Hands on methods] was something that we learned and I took two astronomy courses. We had different techniques that we learned, different experiments that we learned to try to help students understand and help them get more interested in the topic.

Celina elaborated that one specific method she learned from her educational experience included using Play-Doh to create models of the Earth and moon, and use those to represent scale distances in the solar system. Celina was able to identify how her formal education training through her master's program has influenced her approaches as a planetarium educator.

Purpose and Goals

The interviews with educators also highlighted similar views among them regarding the purpose for planetarium education. The common theme was to inspire audiences. While their views on the purpose of planetarium education were similar, there were some differences between them on specific goals the educators had for planetarium programs.

For Anne, the purpose of planetarium is to "get [students] interested in what's up there." She continued:

> There's no one class, except an astronomy class, that really talks about space. We really need to know more about it and they don't really talk much about it in classes. They have a very, very small section of it in the third grade and then they don't really do it much in the other grade levels, except seasons and that kind of thing ... it's not like the Apollo days, when everyone's just so excited about space, but there's so many more interesting things going on.

Anne described that one purpose for planetarium education is to make up for a lack of space education in the formal classroom. Additionally, she believes there has been a change in interests of students, and there is a lack of interest in space. In order to address this deficiency in education and lack of interest from students, she explained that the goals for planetarium education should be to "help the teachers, push the ideas, in a real environment or way they can actually see what they're talking about in class." She believes the goal of planetarium education should be to provide students with additional experiences that supplement what they are learning in the classroom. This influences her decisions as a planetarium educator because she stated that she tries to find ways to introduce real-world experiences into her planetarium programs.

Brittany also views the purpose of planetarium education as inspiring students. However, she continued "but at the same time inspire people to enjoy the sky and related sciences." For Brittany, the planetarium is a tool that can be used to inspire students to pursue many fields of science, rather than just astronomy. The goal she has for planetarium education is that students recognize that "the universe is a beautiful place." She explained that to accomplish this goal she uses the planetarium to show students "the pretty pictures" to allow them to experience the beauty of the universe.

Celina views the purpose of planetarium education as making education appealing for students. She explained:

> Planetarium education is one of those things that I feel is really innovative and helpful because if you're just sitting in a classroom with lecturing based topics, students might not [be engaged} ... I think the planetarium is a little bit better of a way to help kids understand and it's just pretty interesting.

Celina views the planetarium as a way to make education interesting to students as opposed to lecture. She further elaborated that with students interested in learning, her goals for planetarium education are for students to leave with an "understanding of how vast the universe is." She views the planetarium as a useful tool in engaging students, and then using that interest and engagement to teach them specific content.

Audience

Another factor that influenced how participants taught planetarium programs was the specific audiences being taught. Each participant identified using different teaching methods with younger students than they would use with older students. However, some methods were used regardless of age of the participants.

For younger students, participants discussed finding methods to keep their attention focused on the program. Anne explained that she used the planetarium software to direct the attention of younger students to what she wants them to look at. Brittany also discusses using multiple methods with younger students. She said that one cue for her to change her teaching method was when she would "see them start wiggling around and talking to each other." When Brittany sees students losing attention, she explained that she would switch between questioning, kinesthetic, and modeling techniques. Celina also discussed keeping content age appropriate. She explained:

> With the younger kids, I think you just kind of overwhelm them with too much detail, then they kind of get lost. I think if you just show them a lot of different basic things, that might be a little bit better.

While Anne and Brittany discussed changing methodologies based on age, Celina focused on the type of content. However, each participant discussed the importance of changing how planetarium education programs are taught to accommodate the age of the audience.

Setting/technology

Another factor that was influential to how Anne and Brittany taught in the planetarium is technology. Both educators had experience in multiple planetarium settings, and discussed the differences between the types of planetariums they taught in. Celina only had six months of experience in portable planetariums, and did not discuss technology as a factor that influenced her teaching.

Anne discussed the trouble she faced moving from a fixed dome to a portable planetarium. In the fixed dome, Anne described how she was able to use the computer to "make a program that was pretty organized." The program was automated, and followed a tight schedule. However, with the portable planetarium, she discussed how she had to control the show throughout the program while also discussing the content. While she sees benefits in the flexibility of changing the program in a portable planetarium to meet audience needs, she Anne identified the different types of planetarium technology as a factor that influenced her teaching style.

Brittany also discussed the differences between teaching in different types of planetariums. One difference she mentioned had to deal with space. She explained:

> In the [fixed] ...we had a place that was sort of like a diagonal stage area where we could do things. But at the Museum, it was a small dome, and they could fit 30 people in seats and a big machine in the middle of the floor. So we didn't have room to do very much.

This limited space depending on the type of planetarium used is one factor that influences Brittany's teaching style.

Conclusion: Discussion

The purpose of this study was to identify the factors that influence teaching methods for planetarium educators at a science museum located in the southwestern United States. It is evident from the findings that there are many factors that inform planetarium educator teaching methodology. Results from this study found that teaching methods used by the participants included questioning, explanation, kinesthetic, modeling, observation, identification skills, reinforcement, prediction, and story-telling. The teaching methods of participants were informed by previous astronomical and professional experiences, education, purposes and goals for planetarium education, audience, and technology.

Findings showed a variety of factors that influenced the teaching methods used by planetarium educators; however, as highlighted by the word cloud, experience was the most discussed factor as being influential to educator teaching methodology. Experiences discussed by participants included both real life experiences with astronomy and professional experiences. Both Anne and Brittany shared stories about how connections with astronomy and real life experiences of looking at the night sky were influential to them. Anne described the influence her experiences with astronomy had on her, and she wanted to use the planetarium to give students similar experiences. Her teaching methodology included attempting to connect the content with real world experiences of students. Brittany shared stories of hosting star parties around the world, including viewing Halley's comet in Cancun. Her experiences highlighted her passion for astronomy, and were in line with her goal of showing people that the Universe is a beautiful place.

The desire of the educators in this study wanting to connect content with real life experiences is consistent with a Deweyan philosophy of education. Dewey (1916) believed that "an ounce of experience is better than a ton of theory" (p. 75) because only experience can verify theory. Additionally, according to Dewey (1907), "the only way to unite the parts of the system is to unite each to life" (p. 89). This concept of uniting content and experiences based on everyday life is a recurring theme throughout Dewey's writings on the need for experience in education, and it is consistent with the approach taken by Anne and Brittany in planetarium education.

Another interesting finding involved the teaching methods used by planetarium educators, and how they were used. There were a number of methods used to encourage student interest, such as kinesthetic, modeling, making predictions, and story-telling, which are in line with science education constructivist teaching methodologies. These methods allowed students to construct ideas that were consistent with scientific discovery and the nature of science, such as with using the technique of "Mount Nose" to teach the concept of rotation and revolution. Interestingly, while the educators did not describe familiarity with constructivist philosophy during their interviews, to varying degrees each participant used methodology consistent with that philosophy.

The differences in planetarium settings also had an impactful effect on planetarium educators. Anne discussed the difficulty of transitioning from a fixed-dome planetarium to portable planetarium. While confident in a fixed-dome setting, she was less comfortable with her abilities to teach to students in a portable setting. Brittany discussed how space limitations of different types of planetariums directly impacted the type of content she could teach. Different planetarium technologies have strengths and weaknesses that should be considered when planning planetarium content.

Implications

The results of this study have a number of implications for planetarium educators and science centers. First, educators should be aware of the factors that influence their teaching methods, and how they decide on what content to address in live-planetarium shows. In this study, one of the largest influential factors on planetarium educators was experience. Educators should be aware of their own experiences and find ways to incorporate that into their planetarium programs. It may also be beneficial for educators to seek out additional astronomical experiences that they can then bring back into their educational programs. Additionally, having a well-defined understanding of the purpose for planetarium education as well as the goals hoped to be achieved can lead to refinement of planetarium programs.

The findings of this study are also valuable for leaders at science centers and museums who are responsible for professional development of planetarium educators. Professional development should embrace the diversity of educator experiences and address content appropriate for the diversity of audiences served in the planetarium. It will also be important to incorporate reflective opportunities into professional development sessions so that planetarium educators can understand the importance of their own experiences in how they teach. Just as formal educator training has shifted "its focus from skills to knowledge and reflection," (Grossman, Hammerness, & McDonald., 2009, p. 274) so too must professional development for planetarium educators. Additionally, workplace experience and collaborations with other planetarium educators were influential factors for the participants in this study. It will be important for professional development opportunities to emphasize these experiences and provide opportunities for educators to collaborate with each to share ideas and help with professional growth.

Limitations

There are several limitations with this study. First, due to the limited size of this case study the presented findings may not be generalizable to the larger planetarium educator community. Another potential limitation of this study is that one aspect of data collection relied on participant self-report. One way this study sought to address this limitation is by collecting data using multiple methods, including interviews and observations. Finally, there may be possible limitations that come from researcher positionality and post-positivist approach to the proposed study. This approach may have introduced researcher bias to both data collection and interpretation. This study sought to minimize this impact by discussing researcher positionality, and using validated instruments and methodology for data collection and analysis.

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Characterizing fulldome planetarium projection systems

Interpretation and implications for digital non-hybrid planetarium display selections

Abstract

In the period from May 2013 to May 2016, 20 different planetarium facilities, mostly in Europe and centred on the Munich area, were visited by staff from the European Southern Observatory (ESO) to gather subjective and quantitative information about planetarium fulldome displays. This information served to inform the choice of planetarium system for the ESO Supernova Planetarium & Visitor Centre. This information is here summarised to inform the planetarium community about our findings.

This paper (Paper II) concludes 3 years of non-contiguous research into what the different planetarium systems can offer, and of learning about the state of the field of planetariums. Paper I (Rößner et al., 2016) summarises the results of a measurement campaign in seven of the planetariums, delivering quantitative information to support some of the conclusions in this paper. Despite considerable uncertainties for some of the parameters, we include a template spreadsheet that can help inform some of the decisions.

For non-hybrid digital fulldome systems, and with the current (2016) technical possibilities and equipment price points, our findings are as follows:

1. To ensure a proper representation of the colours of astronomical content, we recommend selecting a system bright enough to deliver a white dome luminance of at least 5 cd/m2.
2. To lower cross-reflection, a dome reflectivity of at most 50% is recommended.
3. We recommend calculating the planetarium resolution as: The average number of pixels along all half great-circles, after edge blending.
4. We recommend using an eye-resolution of 1 arc-minute as a canonical aim for a "good" planetarium display.
5. An 8k-10k display today can be considered a "good" display with regard to resolution. Arguably the resolution problem will only really disappear for all spectators in a dome when it becomes possible to achieve displays (and content) with much higher resolution, like 15k or even more, especially when vector content like stars, lines and text are displayed.
6. Based on our calculations, we recommend not focusing on projector native contrast, but on the resulting dome checkerboard contrast. We recommend selecting an on-dome checkerboard contrast of at least 6:1.

Lars Lindberg Christensen
European Southern Observatory
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Immersed in a fulldome environment, spectators are transported to places they have never been. Photo courtesy Evans & Sutherland

Preface

When we researched planetarium fulldome systems for the ESO Supernova, we recognised a need in the community to provide an unbiased view of the topic supported by measurements. With just a few thousand fulldome installations, this is clearly a niche field. Combined with planetariums' often being cash-strapped, ESO, as an intergovernmental organization, has with the advent of the ESO Supernova—"the world's first open source planetarium"—taken on the role to deliver various free services to the community. This also involves giving advice on issues such as fulldome systems.

All the visited installations were treated equally and neutrally. The conclusions are presented without bias, and solely represent the subjective opinion of the author and not of ESO.

Introduction

Needless to say, the choice of the planetarium display is one of the biggest decisions for a planetarium, as it can break or make the operational model. The system can either be a source of daily aggravation and loss of time, or a flexible, carefully tuned and maintained machine, the limitations of which are understood and taken into account in the operational model.

It is estimated that in 2015, up to 123 million people visited the 4105 planetariums around the world (Loch Ness Productions, 2015)[1]. The environment planetariums offer immersive experiences unmatched by any other type of museum environment.

1 Estimated numbers are only based on visitors' attendance at 10% of the world's domes (independent of dome size), so the extrapolation to a global attendance estimate should be made with caution.

In the use case we're particularly interested in, a fulldome (non-hybrid) system would deliver an intense, immersive fulldome experience to leave the visitor in awe of our universe. Choosing a planetarium display system that can deliver this special experience is a complex process involving many different considerations of an artistic, technical, and managerial nature. Further complexity in the choice arises from planetariums being very different (in size, inclination, dome construction, etc), and, unlike cinemas, which are

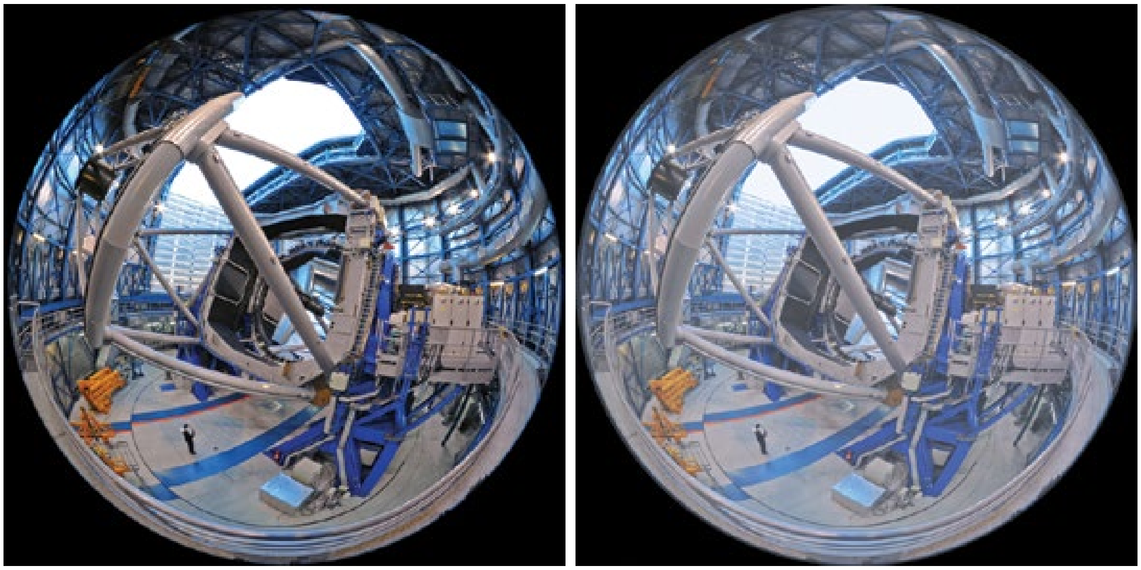

Fig. 2: A great-looking image (left) will tend to suffer significantly from cross-scattering in a dome—it "washes out" (right). To some degree one can compensate for this effect during the show production, but the main issues need to be addressed in the requirements for the dome reflectivity and projection system during construction. Note that only the electronic version of this figure represents the calculations well. Credit: ESO/S. Brunier.

required to be DCI compliant (SMPTE, 2011), standards for dome displays do not exist.

Despite the ~100 million annual visitors to planetariums, the planetarium as an optical system has not been thoroughly characterized and understood yet. The findings presented here were informed by in-situ measurements (see Rößner et al., 2016, hereafter Paper I, which in turn relies heavily on Ganter, 2012).

Paper I, available for preview at supernova.eso.org/for-planetariums, characterizes the way light propagates in the largest optical element of a planetarium: the dome itself. In an ideal world, one would aim for a projection system with high luminance and high contrast. However, in reality, effects such as cross-reflection occur, compromising the projection quality.

An important physical difference between the standard displays in our daily lives and the dome is that the dome does not emit light, but reflects light back to the spectators. Since the dome is hemispheric, a significant portion of the light from one part of the dome is cross-scattered and ends on another part of the dome (see the section on contrast below). It is important to take this into consideration and address it in the technical requirements for the system.

Paper I outlines the theory of light propagation in a dome and is complemented by in-situ luminance and contrast measurements in seven domes: Vienna, Freiburg, Munich, Laupheim, Münster, Heidelberg, and Augsburg.

Brightness

As a result of financial and technical limitations, very few planetarium displays so far have been what would subjectively be called bright and vivid. It is expensive to purchase bright projectors and, in addition, the cross-scattering washes out some of the colours. How can the optimal brightness of a display be determined? It is a known fact in the community, although rarely stated, that most planetarium displays, subjectively assessed, are faint. Very few displays are considered "too bright." Astronomical images and renderings have not been projected with the same richness, contrast and intensity as a DCI-compliant cinema movie, a movie displayed on an TV OLED display, or a laser show. This is illustrated in Fig. 3.

For colourful images of astronomical objects in particular this is an important aspect, since the native dynamic range and gamut of astronomical observations are very large.

Informed by the measurements in Paper I and the subjective impression of the displays, we have the following finding:

Finding 1: To ensure a proper representation of the colours of astronomical content, we recommend selecting a system bright enough to deliver a white dome luminance of at least 5 cd/m2.

Dome reflectivity

As described in detail in Paper I, the dome as an optical element presents certain limitations to the contrast that appears on it. Contrast specifications that projector manufacturers publish often, if not always, describe the luminance ratio between a "full white" and a subsequent "full black" projection (the interframe contrast). These numbers can be very high, typically more than 10,000:1. However, depending on the particular use, this definition of the term "contrast" can be misleading.

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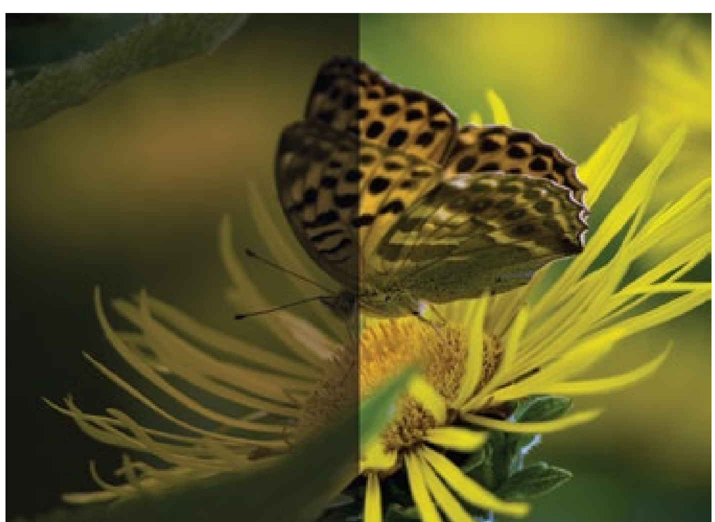


Fig.3: An illustration of the difference between vivid colours seen in print, on computer displays and in TV (right) versus a typical subdued, low-saturation fulldome display (left). Credit: ESO/M. Kornmesser

For fulldome videos, what is more relevant is the degree to which light from bright areas of the dome "spills" onto black areas as a result of dome cross-scattering. The intra-frame (or ANSI-) contrast is a more appropriate number to describe this. It describes the ratio of black and white areas projected alongside in the same frame. This "type" of contrast is, therefore, also referred to as the checkerboard contrast.

The lower the dome reflectivity, the better the checkerboard contrast. On the other hand, the lower the dome reflectivity, the lower the (maximum) luminance of the projection. With today's technical standards and price-points, we find a 50% dome reflectivity to be a good compromise, provided that the projectors are powerful enough to ensure a white dome luminance of 5 cd/m2 at that dome reflectivity.

Finding 2: To lower cross-reflection, a dome reflectivity of at most 50% is recommended.

Resolution

For a discussion of the optimal realistic resolution of the display on the dome (the dome diameter resolution) please also see the excellent article by Voss (2012).

There is a lack of consistency in the industry about how the terms "4k" and "8k" are defined, but many seem to agree this should refer to the mean pixel count on all half great circles across the dome—the diameter of an equivalent dome master frame. Different half great circles can give different resolutions due to the uneven pixel density on the dome.

Finding 3: We recommend calculating the planetarium resolution as: The average number of pixels along all half great-circles, after edge blending.

According to Ackerman (1962) the typical eye resolution limit is about 1.7 arcminutes ($5\cdot10^{-4}$ radians) for most people. In an extreme case, for those with most acute vision in optimal circumstances, it can be as low as 0.8 arc-minutes (Wikilectures, 2014). Taking 1 arc-minute as a canonical best estimate for the eye resolution limit during a mixed planetarium show (stars and pre-rendered content), a 10,800 pixels display is needed if a visitor in a seat in the centre of the dome (180 degrees x 60 arc-minutes) should not experience pixelated images.

Comparing with print resolutions, we note that designers apply a golden rule of 300 DPI (dots per inch) for print graphics (Spoon Graphics, 2016). An A4 page (21 cm wide, or 8.27 inches) would need 2480 pixels to print at this nominal print resolution of 300 DPI, giving a width of one pixel of 8.46 x 10-3 cm. With a typical reading distance of 40 cm, this corresponds to an angular resolution of 43"[2], just a bit better than the suggested 1 arc-minute/pixel eye resolution limit, confirming this as a "good" resolution to aim for.

Finding 4: We recommend using an eye-resolution of 1 arc-minute as a canonical aim for a "good" planetarium display.

A designer will argue that printing at significantly below the canonical 300 DPI for the print resolution causes visibly pixelated prints at normal reading distances. It is generally accepted that one should not print below 150 DPI for high-quality results. A planetarium display of, for instance, 4k corresponds to a print-out at 81 DPI at normal reading distance[3]. A planetarium display for a viewer in the centre with the same quality as a 300 DPI print product would need to have a resolution of 15k[4].

Furthermore, a print designer might also argue that the golden rule of 300 DPI is only really valid for bitmaps, i.e. pixel-based images. For vector graphics, like typefaces or line art, a significantly higher resolution than 300 DPI, like 800 or even 1200 DPI, is often recommended (see e.g. CreativePro, 2014). A line can be visibly jagged if rasterized and printed even at 300 DPI[5]. In live planetarium displays, stars, grids and texts displayed on the dome are inherently vector objects, rendered as bitmaps, and one could argue they would benefit from being rasterized at an even higher resolution than that which corresponds to 300 DPI (~15k in a dome) to display without artifacts.

These theoretical considerations are supported by our own subjective experience during the visits to the planetariums. A 4k system produces fairly large "fluffy" stars, which are not as representative of a natural night sky as an 8k system.

Two additional factors need to be considered. Firstly, as anyone who has grown up watching TV in PAL or NTSC resolution (which actually looked kind of OK), there is a considerable difference in the perceived resolution of moving images and that of stills/prints. This is an argument for reducing the need for very high res displays somewhat. Another indication pointing in the same direction is the very nice article from NSC Creative that provides the results of side-by-side screening of 4k and 8k CGI images side by side in an 8k planetarium. The conclusion is that it is hard to see the difference, also as the 4k material benefits from the 8k display (NSC Creative, 2014)[6].

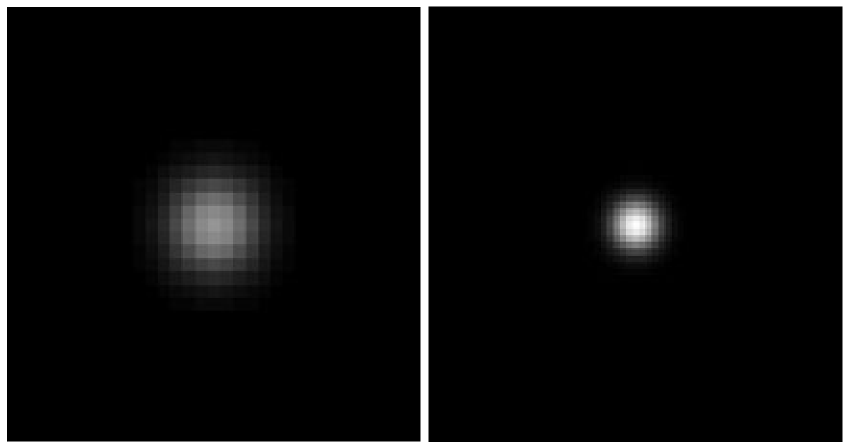


Fig.4: Simulations comparing a 4k "darker" system (left) with an 8k "brighter" right. Stars can be smaller and less pixelated in the high-res "bright" system.

Secondly, the discussion above is only valid for the centre of the dome. The average spectator sits closer to the edge, and a resolution up to a factor 2 higher than the estimates above would be needed.

Finding 5: An 8k-10k display today can be considered a "good" display with regard

(Continues on page 34)

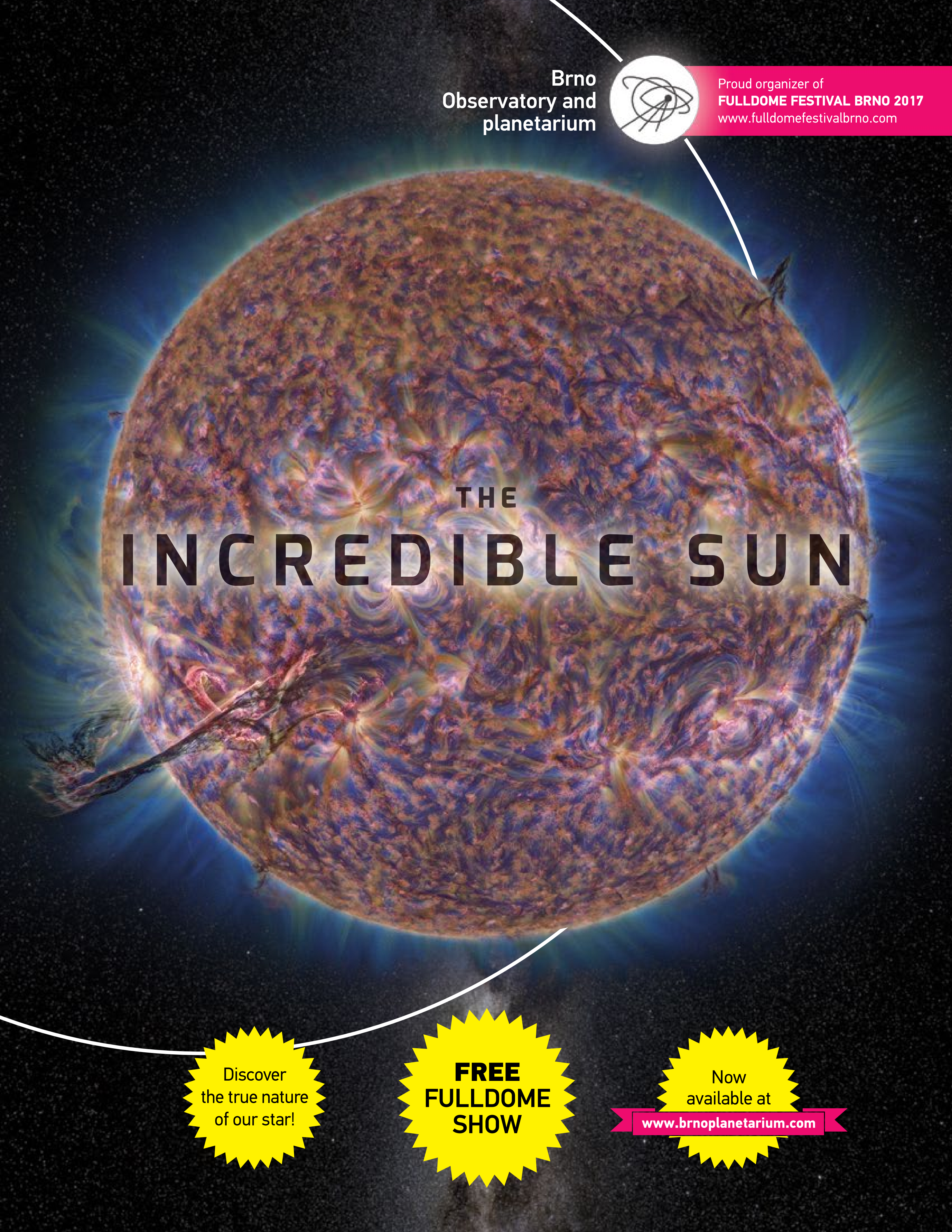
2 $\arcsin(8.46 \times 10^{-3}$ cm/40 cm$) = 12.12 \times 10^{-3}$ deg = 43"

3 180 deg/4000 px = 0.045 deg/px. Equivalent pixel size on a printed paper at 40 cm distance: 40 cm * sin(0.045 deg) = 0.031 cm. This corresponds to 1/0.031 px/cm = 31.8 px/cm = 80.85 px/inch, or DPI.

4 180 deg / 0.012 deg = 15k

5 The Fourier transform of e.g. a line on a background contains very high (spatial) frequency components. To avoid aliasing (the Nyquist–Shannon sampling theorem applied in the spatial domain), one has to sample the vector line at a very high spatial frequency when rendering a bitmap. This requires a high resolution.

6 It is true that most fulldome content today (2016) is still 4k, as the difference in production time for 4k and 8k CGI (computer generated imagery) frames is very high (far higher than a factor of 2). However, as argued in Voss (2012), the "sky" planetarium displays are not limited in the same way. Systems today can easily output planetarium real-time content in 8k (or even more). Also several (partially) 8k shows are already available on the market and the number can be expected to increase in the next years. Also note than an 8k system will show 4k content better than a 4k system.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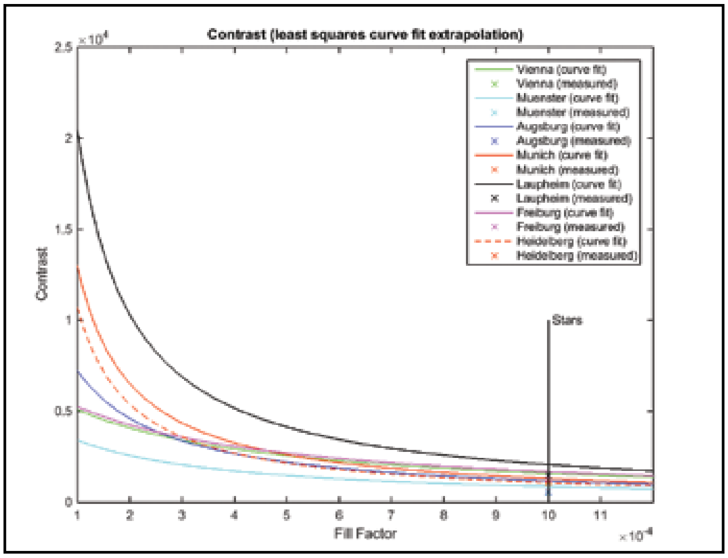

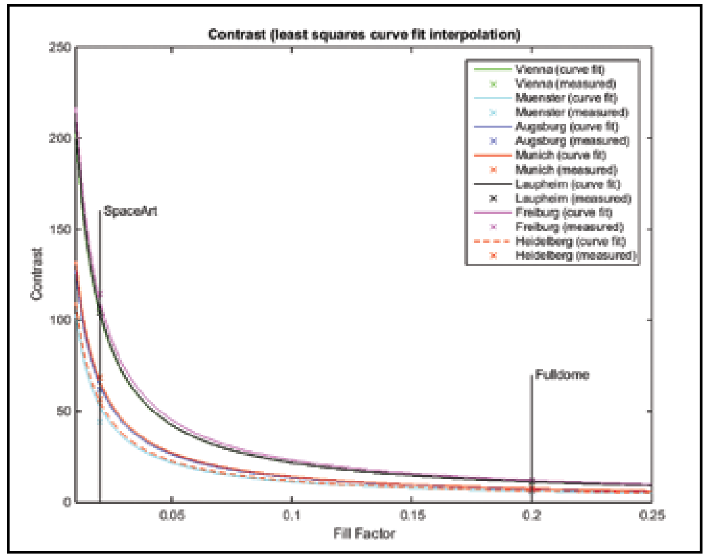

Fig.5: Effective intra-frame contrast in the dome. Projectors that offer an extremely high native contrast, or dark background, may perform poorly in terms of contrast when they are operated in a dome of high reflectivity. The underlying physics is published in the seminal paper by Ganter (2012). The measurements are from Paper I.

Note that unknown circumstances in the planetariums measured make it hard to compare the different installations: e.g. the age of the projection lamps, dust accumulation on the dome, dome size and funding available for initial procurement. Note also that the fit between theory and measurements deteriorates at low fill factors due to these unknowns. Hence we do not recommend using these measurements to conclusively compare between different vendors.

(Projection systems, continued from page 32)

to resolution. Arguably the resolution problem will only really disappear for all spectators in a dome when it becomes possible to achieve displays (and content) with much higher resolution, like 15k or even more, especially when vector content like stars, lines and text are displayed.

Contrast and black dome luminance

When developing a planetarium system, one should not select the projection system by looking at the projectors alone. One has to have a look at the entire system: projectors, dome, and also the human perception of visual stimuli. Cross-reflection causes bright content on the dome to create stray light that increases the brightness of content that is actually meant to be black.

Therefore, it is wise to decrease the reflectivity of the dome and to increase the projector's brightness accordingly. At first glance this might seem to be a waste of projector output brightness. But, in fact, it means that the second reflection of light on the dome is significantly reduced, and a fortiori the third and every following stray light reflection is reduced as well. In this way a better contrast can be achieved.

This also means that projectors that offer an extremely high native contrast, or dark background, may perform poorly in terms of contrast when they are operated in a dome of high reflectivity. For example, when a planet is shown against the dark background of space, the light scattered by a high reflectivity dome will increase the light level of the black areas of the dome—and the advantage of the superb native contrast that a high contrast projector offers can vanish. The measurements in Paper I (see Fig. 5) suggest that above a certain fill factor (i.e. when a certain fraction of the dome is filled with content), the native contrast of the projector no longer plays a significant role, and resources may better be invested in other aspects of the projections system, such as brightness or resolution.

Finding 6: Based on our calculations we recommend not focusing on projector native contrast, but on the resulting dome checkerboard contrast. We recommend selecting an on-dome checkerboard contrast of at least 6:1.

The caveats of the theory

One of the aims of Paper I and this, Paper II, was to arrive at a situation where we could provide a numerical way to calculate planetarium display output parameters from known equipment specifications. However, the measurements in Paper I showed that important assumptions in Ganter (2012) and Paper I itself did not hold. None of the seven domes turned out to be true Lambertian surfaces with an ideal "matte" or diffusely reflecting surface (with the same apparent brightness to an observer regardless of the observer's angle of view—i.e. isotropic luminance). Other important factors which vary between different planetarium installations are the different ages and output of the lamps at the time of the measurement (up to a factor of two), dust accumulation on the dome, different optical configurations (lenses, mirrors etc.) and possible backscatter of light from the seating area, carpet, railing etc. onto the dome.

An important weakness of the approach in Paper I is the limited sample size of just seven planetariums. Despite considerable uncertainties due to these unknowns, a template spreadsheet is included below[7] to illustrates the underlying theoretical principles. The unknowns and the limited sample size makes it unwise to use this spreadsheet as an engineering tool and caution is urged in interpreting the output values.

The parameters listed are (*parameters are deemed more important):

1. Planetarium content-Fixed Value

Three types of content in the dome were considered:

Stars: The classic content to project in an planetarium is a starry sky. One wants to have bright stars of small diameter on a background that is deeply black. Cross-scattering of light is nearly irrelevant as most of the projected content is black.

Space Art: One often also has rectangular, "slide-like" projections (image insets). These images are required to be bright, of high resolution and with vivid colours. Cross-scattering begins to become relevant, as the background black of the sky washes out.

Movies: In fulldome projections, which fill the entire dome with content, one has to find a compromise between brightness and checkerboard contrast. The dome reflectivity can be used to adjust this compromise in favour of brightness or contrast.

(Continues on page 36)

7 Can be downloaded from docs.google.com/spreadsheets/d/1PXOrBcF-FBVA_eppaj7MqmJ6S0Vy2QJGnh6ptyk8ZKo/edit#gid=6


NARRATED BY LIAM NEESON
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EARTH
Exploring Earth's Climate Engine
Public Choice Award
Short Films
Espinho Immersive Film Festival 2011
Golden Star Award
South Korea
Planetarium Fest 2012
Award Winner
Marine Biosphere
Jena Fulldome Festival 2011
Finalist
Jackson Hole
Science Media Awards 2012
SPITZ CREATIVEMEDIA
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SPITZ
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mbruno@spitzinc.com
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(Projection, continued from page 34)

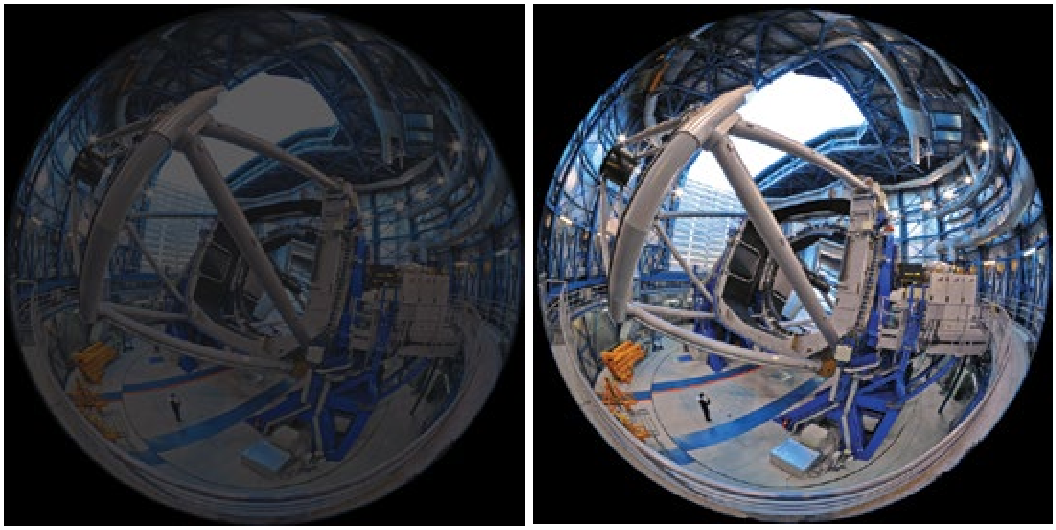

Fig.6: A physical simulation showing the contrast and the brightness of two display types. Left: low contrast, high brightness, low dome reflectivity system, displaying a slightly lower contrast than the input image. Right: High contrast, low brightness, high reflectivity system with low effective contrast as a result of cross-scattering. The low-contrast, high brightness, low dome reflectivity system performs better, as it is much brighter and has a better contrast. The simulations were calculated based on the formulas in Ganter (2012), assuming a dome that is perfectly Lambertian (which, as argued, may be an oversimplification). Image credit: ESO/S.Brunier

2. Native contrast-Input Value

The contrast that a projector offers at its output lens (the ratio of illuminance between a fully saturated white image (RGB level 255 in 8 bits) to the residual background emission of a black image (level 0), without any dynamic control of its lamp brightness. The planetarium setting is not taken into consideration. Note that there is a considerable simplification implied here, as no distinction is made between sequential (inter-frame) contrast and ANSI (intra-frame contrast), a concept that also applies to the projectors themselves.

3. Native brightness (lumens)-Input Value

The light output brightness of a projector. The dome is not taken into consideration. Note that this value might be significantly lower than the one published in the projector data sheet owing to lamp deterioration, special projection lenses, dust accumulation on the dome or the like.

4. Corrected brightness (lumens)-Calculated Value

Because the amount of lamp degradation in the measured systems was not known, the native brightness was corrected to fit with the quite reliable luminance measurements.

5. Native resolution per projector (Megapixels)-Input Value

The number of pixels of a single projector.

6. Number of projectors-Input Value

The number of projectors in the planetarium.

7. Blending efficiency (%)-Input Value

The number of pixels that actually appear on the dome is lower than the sum of all pixels of all projectors due to the overlap of the projection fields, reducing the number of actually usable pixels. This is reflected in the blending efficiency, which is 100% for no overlap.

8. Dome diameter (m)-Input Value

The diameter of the dome.

9. Dome aperture (degrees)-Input Value

Usually 180° (a half sphere). This would have a lower or higher value if the dome occupied less or more than a hemisphere.

10. Dome reflectivity (%)-Input Value

The reflectivity of the dome surface (typically 30-70%). In general, the lower, the better the checkerboard contrast (resulting from less cross-scattering).

11. Fill factor-Fixed Value

The fraction of the dome that is filled with content, depending on the type of content in 1. above. It is a very low value for starry sky, up to 0.2 for movie content. The maximum possible value for the fill factor would be 1, but this is not a realistic value under normal circumstances, as it would mean a completely lit dome. For fill factors 0.2 and above, the native contrast of the projector plays a vanishing role.

12. Dome area (m2)-Calculated Value

The area of the dome as a function of diameter and aperture.

13. Dome resolution (Megapixels)-Output Value

The number of usable pixels on the dome.

****14. Dome diameter resolution (pixels)-Output Value***

The average number of pixels along all half great-circles, after edge blending. Calculated by Pi * sqrt (N/2*Pi), where N is the total pixel count on the dome (assuming a homogenous pixel density).

15. Pixel resolution (arcminutes per pixel)-Output Value

The angular size of a pixel, as seen by a visitor located at the centre of the dome. Recommended to be 1 arc-minute or lower.

16. Illuminance (lm/m2)-Calculated Value

The brightness that the dome is illuminated with. Not to be confused with the reflected luminance.

17. Dome amplification (%)-Calculated Value

The fraction of the incident light that is to be added to the incident light to account for the increase in brightness due to cross-scattering.

****18. White dome luminance (cd/m2)-Output Value***

Luminance when a completely white frame is projected. This value accounts for the entire optical system: projectors and dome.

****19. Checkerboard contrast-Output Value***

A checkerboard-like pattern is projected (black and white rectangles, so 50% of the dome area is black and 50% of the dome area is white), and the brightness of the black and white areas is measured. The ratio of these values is the checkerboard contrast. This is an important quantity, as it takes cross-reflection within the dome into consideration.

20. Dome contrast-Output Value

One does usually not show checkerboard patterns on a dome, but rather real-world footage, such as the starry sky or an all-sky image. In such footage, the dome is not 50% white and 50% black, as with the checkerboard pattern, but rather a ratio described by the fill factor. Therefore, the contrast is described as a function of the fill factor. Note: the dome contrast does not take the projector's limited contrast into account.

21. Black level-Calculated Value

The inverse of the projector native contrast. It describes the ratio between the black luminance and the white luminance.

22. Corrected fill factor-Calculated Value

The fill factor, as described above, has to be corrected. This is because the imperfect black levels of the projectors make a contribution of light on top of the actual content. The corrected fill factor, therefore, will never be 0, but can still be 1 when the dome is completely lit. In a projection of a completely black frame, the corrected fill factor is just equal to the black level described above.

24. Effective contrast-Output Value

The dome contrast did not take into consideration that the projector has imperfect black levels. The effective contrast does take this into account. It describes the contrast of the entire optical system: projectors and dome.

****25. Black dome luminance (cd/m2)-Output***

Parameter		A2 (corr)	Vienna	
1. Planetarium content		... Movies	... SpaceArt	... Stars
2. Native projector contrast	C_p		10000	
3. Native brightness (lm)			5000	
4. Corrected brightness (lm)			2500	
5. Native resolution per projector (pixels)			9,830,400	
6. Number of projectors			2	
7. Blending efficiency			59%	
8. Dome diameter (m)			8.5	
9. Dome aperture (degrees)			180	
10. Dome reflectivity	r		55%	
11. Fill factor	f	0.2	0.02	0.001
12. Dome area (m2)			113.49	
13. Dome resolution (pixels)			11,600,00	
*14. Dome diameter resolution (pixels)			4,269	
15. Pixel resolution (arc-mins per pixel)			2.53	
16. Illuminance (lm/m2)			26.00	
17. Dome amplification	A		38%	
*18. White dome luminance (cd/m2)			6.28	
*19. Checkerboard contrast	C_{cd}		6	5.0
20. Dome contrast	C_d	14	133	2,637
21. Black level	B_L		0.0001000	
22. Corrected fill factor	f_c	20.01%	2.01%	0.11%
23. Effective contrast	C_{eff}	14	130	1,934
*24. Black dome luminance (cd/m2)			6.28E-04	1.57E-03

Table 1: Template spreadsheet for a representative planetarium, Vienna Planetarium, used to calculate important planetarium display parameters. The two red cells contain the measurement values. The checkerboard contrast is 20% overestimated in the calculations whereas the black dome luminance is quite far off (140% underestimated). In the three other best-characterised domes the measurements of checkerboard contrast deviate from the calculations by between +17 and +34%, and black dome luminance by between -9% and a whopping -4485%.

Value

Luminance when a completely black frame is projected. This value accounts for the entire optical system: projectors and dome.

Conclusions

Anyone building a planetarium display is encouraged not to look only at projector specifications but at the entire optical system: the projectors, the dome, and the eye.

In an ideal world, a planetarium display would have just one projector, located in the centre of the dome. The dome would be relatively grey (relatively low reflectivity, for example: 30-50%). The white dome luminance would be at least 5 cd/m2 and preferably something a bit closer to a DCI compliant cinema (48 cd/m2, SMTPE, 2011).

The resolution calculated as the average number of pixels along all half great-circles, after edge blending, would be at least 8k and possibly 15k. The resulting on-dome checkerboard contrast should be at least 6:1.

A backlit OLED display with less cross-scattering problems would, in some distant future, provide a much better experience.

During this work we ascertained that planetarium display systems have a number of unknowns that have not yet been properly modelled or measured. They include factors like:

- Deviation from true Lambertian surfaces
- Different ages and output of the lamps at the time of the measurement (gives up to a factor of two different light output in the same installation)
- Varying dust accumulation on the dome
- Different optical configurations (lenses, mirrors etc.)
- Possible backscatter of light from the seating area, carpet, railing etc. onto the dome.

With the limited sample size of just seven planetariums in Paper I, more measurements are needed to improve our physical understanding of these, and possibly other parameters.

(Continues on page 48)

Get ready to chase the shadow

Using the 2017 solar eclipse to teach, market, and promote planetariums

Short-term event, long-term results

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Often, planetariums can play an important role in anticipating or responding to current events in the sky. An eclipse, a comet, a rocket launch, or even a new science fiction movie premiere can mean that the planetarium has an opportunity to both educate and to advance its own standing within the community, sometimes with a positive financial result!

In this article, I will focus on the example of a total solar eclipse, since one will sweep across all of the contiguous United States on August 21, 2017. My hope is that everyone in America will be ready for that eclipse, and will not miss opportunities due to lack of preparation. If you are not from America, don't relax, because these suggestions can be applied to other special events that will be coming to you soon!

For any short-term event, one must set goals in advance, and then make sure that no opportunities are overlooked. For a solar eclipse, such as the total solar eclipses I "hosted" in planetariums in 1979 and 1991, there were 3 main goals:

- Public eye safety
- Astronomy education (moon phases, etc.)
- "Selling the planetarium" through various marketing efforts.

Stress eye safety

First, eye safety is the critical issue at any solar eclipse. Even if you are lucky enough to be in the path of totality, you still have hours of partial eclipse to experience. And for the vast majority of people who are not in the path of totality but who hear the media and internet abuzz with eclipse talk, it is even more important.

Teach everyone that the lens in their eye acts just like a magnifying glass that can focus sunlight to set a piece of paper on fire, and that they don't want that to happen inside their eye. Although the pain caused when the eye's iris muscles strain to close off the eye forces

Facing page: An animation from the Scientific Visualization Studio at NASA's Goddard Space Flight Center. Go to svs.gsfc.nasa.gov for more. Right: The author demonstrating his hula hoop method of explaining why eclipses do not happen ever month. All other images provided by Ken Miller.

one to look away from the sun on a normal sunny day, during the partial phases of the eclipse, when the sky begins to darken, the eye is fooled into thinking that it is looking at a dim scene, and relaxes the iris muscle, letting in too much light and potentially damaging the retina.

The best and easiest way to ensure eye safety is to explain about and sell (or give away) safe solar filter glasses or hand-held viewers. Sold by several reputable companies, these paper-framed glasses or viewers use aluminized Mylar™ or proper neutral density plastic to protect the eyes and are cheap and effective. Or, teach your community how to use the effective "home-made spot mirror" viewing technique shown and illustrated in box #1 (which is not the frustrating and virtually useless cardboard box pinhole viewer shown in old texts).

A chance for collaboration presents itself; work with a local hospital or eye care professionals to urge them to teach about the eye and how it works, or suggest that they purchase a number of safe viewers imprinted with your (and their) logo. Contact them early, to be sure that they parallel your eye safety suggestions.

Lacking good eclipse viewing techniques from trusted sources, the media will repeat old file stories and scare tactics used in previous eclipses. We'd much rather have knowledgeable families safely outside observing this natural wonder, instead of forcing children to hide inside during the eclipse to watch it on TV!

Teach more science!

With eye safety taken care of, you have an excellent opportunity to take advantage of the event to teach more science. People want to know what's happening, why it's important, and why everyone is getting excited about it. Use all of your tools to tell them. Naturally, use your planetarium and its unique projections to show the geometry of an eclipse and to simulate or show real footage of an eclipse.

But also feel free to use other tools in your bag of educator's tricks. Use models, music,

(Continues on next page)

Box #1

Free, safe eclipse viewing for your community

In my opinion, the worst and least effective way to attempt to protect your community's eyes is to perpetuate the myth that a pinhole projection cardboard box is a good way to view the eclipse.

While the illustrations in many books make it look simple, anyone who has built the pinhole projection box realizes that the tiny "image" produced inside is totally unsatisfying and unconvincing, especially to any self-respecting 10-year-old, who will immediately turn around and look at the sun through the pinhole. Wrong, wrong, wrong.

Please do NOT suggest or tolerate anyone else suggesting the cardboard box/pinhole projector technique. It doesn't work, can lead to eye damage when used improperly, and maybe, worst of all, deprives the person with the box of the chance to see the partial phases of a solar eclipse.

Instead, if people cannot get their hands on safe solar filter glasses or viewers, try what I call the "Miller Mirror Technique." Every household has the raw materials: a small pocket or hand mirror, paper, and dirt or sand or clay in a box to hold things in place.

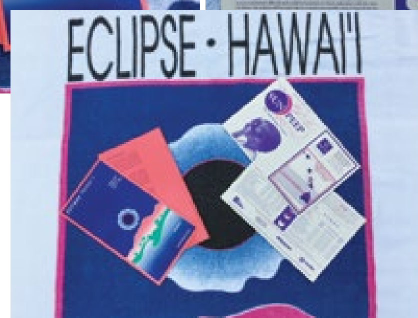
Cover the pocket mirror with paper, except for about a small coin-sized hole. Just for fun, and to convince your audience that they are really seeing an image of the sun, make that hole in the shape of a triangle, not a circle.

Then place the covered mirror in the container of sand (rice works too) so that it is held steady, but can be re-positioned easily. Reflect the sun's light off the mirror at least 40 ft (12 m) into a shady area—the darker the better. A good way is to shine the light through an open doorway into a darkened room in your house, and onto a white wall or sheet of paper.

Inside, in the shade, you'll see an image of the sun which is not a tiny little blip, but an image the size of a soccer ball or larger! And yes, the partial phases can be seen perfectly. On a day with large sunspots, you can even see them using this technique. No lenses required, no chance for eye damage while sitting inside the house, yet you've got it all... for free! Try this yourself on any sunny day, and you'll never tolerate a cardboard box again.

This technique works especially well for schools or preschools, where an adult outside can position the mirror, while another teacher inside can discuss what's happening using the large image on the wall. An added side lesson to be learned is about the Earth's rotation, as the person outside will need to re-position the mirror every few minutes to keep it pointed in the right direction.

A sample of merchandising material. Photos by author.



kinematic motion activities, and any other thing you can think of to teach moon phases and eclipse seasons. (See box #2)

So that brings us to marketing surrounding the short-term event. For me, this has always been the fun part. In terms of fundraising, eclipses and other short-term events have been the most effective work I've ever done.

You can do it too

Most planetarians are familiar with fundraising via philanthropy. That is, asking people to give out of the kindness of their hearts and see what happens. This may be through a grant proposal to a foundation or agency, or simple begging, but there is never any guarantee of getting funding.

Instead, for exciting short-term events like eclipses, I urge planetarians to think of marketing their planetarium, not just begging. Marketing is "the selling of products or services in such a way as to make them desirable." You see it all around you. Advertising, promotions, gimmicks, colorful packaging—marketing.

To market your planetarium, first decide what you want to do for and with your community. Then think how that can be done through goods and services you can sell. And finally, identify who would want to help you in your efforts, and what's in it for them? This is not begging, this is selling something that somebody really wants.

For example, with the eclipse of July 11, 1991 in Hawaii, the Bishop Museum Planetarium designed a logo, did some planning, and then called a media/press conference 366 days before the big eclipse. One year and one day ahead, we supplied TV, radio, and print reporters with video clips on video tape (this was the early 90's), eye safety filters, camera filters, eclipse science background sheets, detailed local timings and circumstances of the eclipse, and a list of events, exhibits, shows, and merchandise that the museum would present in the next year.

Their news stories ran the next day, which became known as E-Day minus 1 year, and continued for the next year, all mentioning the Bishop Museum Planetarium by name.

It's not too late to start

By the time you read this the 1 year out day has passed, but don't despair; get into gear and do your media day now! Oh, and be sure to mention "refreshments" and free sample solar viewers in your media day announcement. The media loves coffee, donuts, and freebies. (Don't we all?)

On our media day, everything handed out had our logo, contact phone numbers, and museum information prominently shown, staking Bishop Museum's claim to the title "Eclipse Central" for the coming year. Follow-up media days were also done one month, 2 days, and 1 day before the big day. All of this truly did make the museum the "Go-To Place" for the eclipse, and positioned us well for the marketing blitz that was to come.

Four travel industry companies were approached to use the big eclipse planetarium show and exhibit the museum had planned as part of their advertising campaign for the year leading up to the eclipse.

Seeing the media coverage already coming out, they recognized that using the museum's eclipse activities as one of their adver-

(Continues on page 43)

Box #2

Strike while the iron is hot: teach moon phases!

Eclipses are the prefect "teachable moment" to add moon phases lessons. Yes, there is a lot of solar science and coronal detail that can be taught, and I'll leave that to the reader. But remember that the vast majority of your audience members (of any age) don't really understand moon phases or why there isn't an eclipse once a month. So let's teach them now, when they are open to learning something new.

In a planetarium, or any very dark room, I use a 2-inch (5-cm) Styrofoam™ ball stuck and glued atop a small stick to represent the moon. Audience members' heads represent Earth. At the center of the room, an 8-inch (20-cm) white plastic lamp globe represents the sun.

The Styrofoam balls are available in hobby and craft stores, but be sure to get the smooth, closed-cell type, which give a much sharper terminator line and last longer in daily demonstrations with children than the rough, open-cell type. The white plastic lamp globe is available in most home improvement stores, and I simply put it atop a cheap floor lamp with a 150-watt bulb inside.

Projecting images of various moon phases on the dome, one by one, I ask the audience to hold their Styrofoam ball at arm's length and turn in such a way that they see (from their Earth/head): a waxing crescent, then gibbous, then full, and finally new moon phase. Round and round they go, realizing that there is a sequence that the moon phases follow.

But why no eclipses every month? For that, I use two hula hoops, one yellow for the sun, and one gray for the moon. My head is the Earth, and these two hoops around my head represent the locus of points that the sun and moon seem to occupy through time. Tilt the two hoops slightly apart, and then explain the whole concept of eclipse seasons where the two hoops intersect. It works, and audiences of all ages will go home to explain all about the eclipse to their neighbors and family.

“Like sitting inside a giant eggshell”

Dr. Jeffrey Kirsch - Reuben H. Fleet Science Center

NanoSeam

Perfect projection only happens with a perfect optical surface. NanoSeam is the only dome made without folds or overlaps. It’s how we make a dome that’s perfectly seamless. As the largest optical element in your theater, the dome shouldn’t be a compromize. Spitz’s attention to quality is the reason we’re the world leader in projection domes.

A new generation to hook on eclipses

Jay Ryan
Cleveland, Ohio USA
AmericanEclipseUSA.com

After many years, the 2017 Total Eclipse of the Sun over the USA is rapidly approaching! Everyone in the American astronomy community has been eagerly awaiting the return of this rare spectacle to the Continental United States.

Yet, at the time of this writing, there is still a low level of awareness of this awesome phenomenon among the general public. There has been very little media promotion for the eclipse, even though it promises to be one of the biggest news stories of 2017.

This has made it very difficult for those of us engaging in eclipse outreach to the public. Many people are more interested in "supermoons" than the upcoming eclipse. Why? Because they heard about supermoons in the media, but they have not been hearing about the eclipse!

Some help to spread the news

In order to assist the astronomy community in our efforts to raise awareness of the eclipse, I have been creating a series of eclipse-oriented educational cartoons. This cartoon feature is called Generation Eclipse. They provided illustrated explanations of various phenomena of eclipses in general, with emphasis on the 2017 USA eclipse in particular.

The title "Generation Eclipse" is dedicated to the young people of today, particularly current school-age students who were born in the 21st century. Many of us grew up in the 20th century, the "dark age" of American eclipses. There has not been a total solar eclipse over the USA since the 1970s, and not a "coast-to-coast" eclipse in a century. For this reason, most Americans under 50 have never experienced a total solar eclipse, and most fail to understand and appreciate the significance of the most awe-inspiring spectacle visible from planet Earth.

However, a "golden age" of American eclipses about to begin! (See article from Fred Espenek that follows on page 44.) Young Americans of the early 21st century can expect to see fivetotal solar eclipses over the continental USA within the next 35 years—in 2017, 2024, 2044, 2045 and 2052. The eclipse of 2045 will be the greatest eclipse in 1000 years over American soil.

And today's kids who live to a ripe old age can expect to see even more eclipses in the late 21st century, after we 20th century types are all long gone. Total solar eclipses will be a defining feature of American life for today's youth, an ongoing source of wonder and inspiration throughout their lifetimes. You've all heard of the Baby Boomers, Generation Xers, and the Millennials; today's American youth will truly be Generation Eclipse.

A "SkyWise" style

Generation Eclipse is similar in style to my "SkyWise" educational cartoon that ran in *Sky & Telescope* from 1997 through 2001. I am offering this new cartoon for free to planetariums and astronomy clubs for use with their own eclipse outreach efforts, for inclusion in newsletters, flyers, social media, or other promotional materials.

Some might recall my other educational comic strip titled Starman, which was similarly distributed for free in the mid-90s to 150 planetariums and astronomy clubs in the USA and around the world.

It is especially hoped that teachers will use Generation Eclipse in their classrooms, so that their titular students will learn and prepare for this first eclipse of their lifetimes. Perhaps it will be helpful to the kids in persuading their unsuspecting 20th century parents to take them to see the eclipse next August.

Planetarians are encouraged to share the cartoon with their teacher colleagues and in any educational circles. The strip is available at our website: americaneclipseusa.com/category/generation-eclipse.

Cartooning is a "user-friendly" format for communicating basic information about eclipses. It is a visual medium that can be used to quickly communicate some concepts of astronomy better than than typical text-based articles with complicated verbal explanations. Cartoons are eye-catching and easy to consume, having a low demand requirement for the casual reader. For these reasons, cartoons like Generation Eclipse tend to be read.

Everyone is encouraged to share

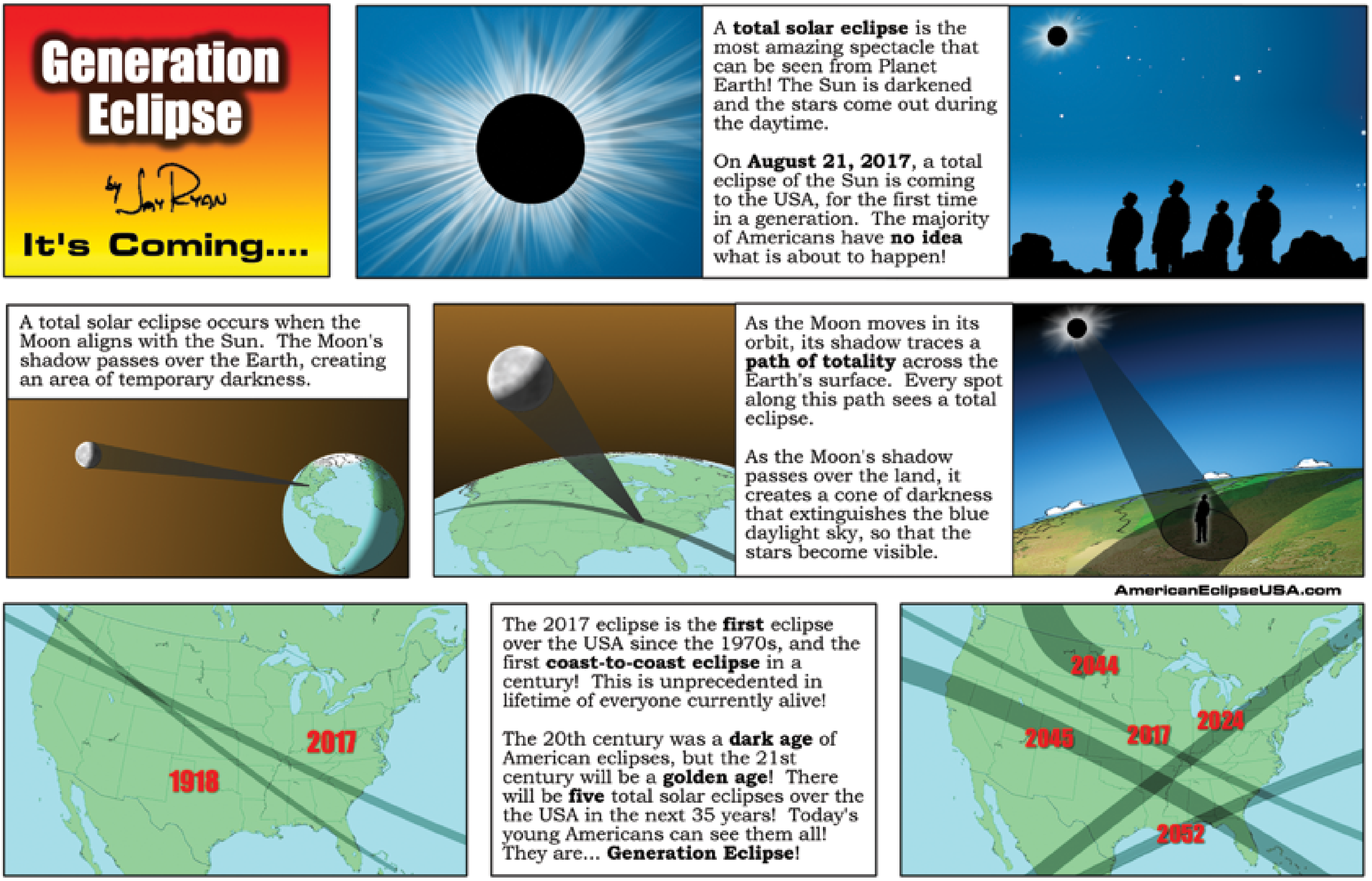
Everyone is encouraged to share this strip in its original, unmodified form on their websites and in social media to help promote the eclipse. A 300 dpi file is available by request that that can be reproduced as a half-page, 5.5" x 8.5" image for use in print publications. Permission to reproduce Generation Eclipse is extended to educational organizations and other non-profits.

For-profit publications such as magazines and newspapers are encouraged to contact me directly to request special permission for reproducing Generation Eclipse.

There will be one or more new Generation Eclipse cartoons each month, with an expected total of 20 by Eclipse Day 2017.

The topics will include the celestial causes of eclipses, safe viewing, and ideal locations for observing the eclipse. Please drop an email through our site at AmericanEclipseUSA.com for more information. ☆

Jay Ryan is an astronomy popularizer in Cleveland, Ohio, and a former contributing editor to *Sky & Telescope* magazine. Jay recently gave a presentation titled "Illustrating the Eclipse" at the Eclipse Workshop of the American Astronomical Society in Carbondale, Illinois. He is currently working on a popular illustrated ebook for explaining the mechanics and phenomena of eclipses.



(Short-term event, continued from page 40)
tising outlets would be very cost-effective in reaching hundreds of thousands of residents, and also be a feel-good item for their corporate image.

The four companies each committed $50,000 of their advertising budget—not their philanthropic fund—to the museum. In turn, their logos, acknowledging their support, went out on every printed item and press release for the next year.

Next, the museum began to use its identifying eclipse logo on merchandise. T-shirt sales netted $156,000 profit. Some 312,000 safe solar filters with Bishop Museum logos were sold for a total of $460,000 net profit. I wrote a small "Eclipse Hawaii" booklet in a single weekend that sold 21,000 copies for an $81,000 profit.

Posters, postcards, baseball caps, sweatshirts, t-shirts, fanny packs, patches, beach towels, golf shirts, cloisonné pins, and even specially-minted silver and gold coins were produced and sold, many by manufacturers who simply bought the logo license and endorsement from the museum, and then sold products through their regular outlets.

The total merchandising profit—not gross proceeds, but net profit—was $1,320,000. This is in an island state with a total population of less than 1 million people, from Oahu, an island that was not in the path of totality.

In addition to merchandising, of course the museum also sold eclipse tours, mounted a 3,000 sq ft (914 sq m) exhibit, did outreach activities using 5 Starlab inflatable planetariums on neighbor islands, and produced an original planetarium show which was seen by 57,000 visitors and Starlab attendees in 4 months.

You might say, "Wow, but that was you big guys. I'm just a little operation." However, the Bishop Museum planetarium was only a 30-ft (9-m) dome with 76 seats and a staff of 3 plus 4 part-timers hired as the eclipse fever got hot. We got help from an army of volunteers, and the museum's gift shop and public relations department, but the power of the eclipse and our early marketing efforts took over and carried us on a wild ride.

The eclipse day went off just fine. It was cloudy where I was, but the entire state and its visitors had a great time, protected their eyes, learned more about the sun and moon, felt that they had received good value for the money they spent, and retained a very positive attitude toward the museum.

That positive attitude and the larger public image that the museum gained resulted in more than 4,600 family memberships being sold, and a few months after the eclipse, official designation as the Hawaii State Museum of Cultural and Natural History. That designation brought partial, annual state funding for the first time in history.

You too can market your planetarium around short-term astronomical events. Think marketing and what you have to sell, not philanthropy, and what you can beg for. Excite those who have marketing and advertising money and they will help you get the word out. And look at other events in your community that are heavily marketed. See what is working, and jump in. Happy marketing! ☆

Ken Miller headed planetariums in the Seattle, Washington area; Reno, Nevada; and Honolulu, Hawaii for 23 years. In 1990 he met Mr. Ryuichiro Goto, president of the GOTO Inc. planetarium firm, during a post-IPS conference tour to the solar eclipse in Helsinki. Some 10 years and a few eclipses later, he was invited to join GOTO as their North American liaison, and today continues to enjoy both planetarians and eclipses.

Just how rare are eclipses across the United States?

Fred Espenak
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Editor's note: Fred Espenak's name should be familiar to planetarians everywhere, and especially to those in the United States. A retired astrophysicist from NASA's Goddard Space Flight Center, he became NASA's expert on eclipses and was responsible for hundreds of thousands of pages of information and data about every upcoming eclipse (and even about eclipses of the past). Preparation for a dome program about eclipses was not complete until you had Espenek's information on hand.

Espenak graciously permitted this reprint of a post to his Portal to the Universe blog, which originally appeared on 11 February 2016, to help *Planetarian* readers get ready for the 2017 eclipse. You can read it online at www.astropixels.com/blog/2016/02/total-solar-eclipses-in-the-usa.

With interest rapidly building for the upcoming total solar eclipse in the USA on 2017 August 21, I became curious about the rarity of total eclipses in America. The very first total eclipse I witnessed was on 1970 March 7. The path of totality crossed the southeastern USA and included portions of Florida, Georgia, North and South Carolina, Virginia, and Nantucket. Another total eclipse was visible in the Pacific Northwest (Oregon, Washington, Idaho, Montana, and North Dakota) on 1979 February 26.

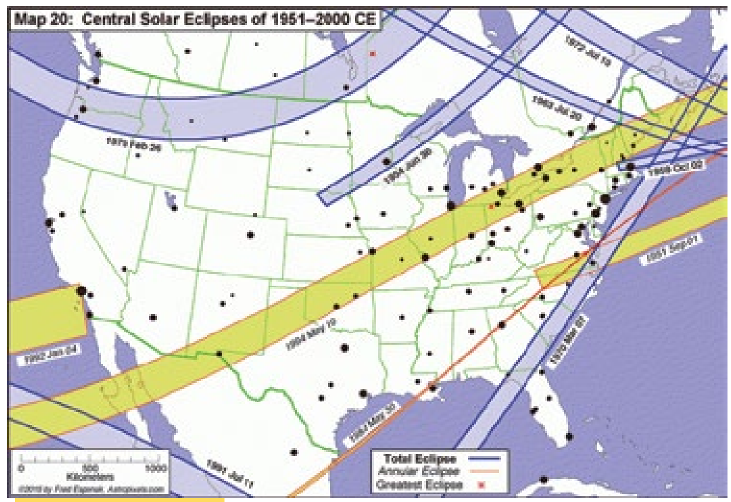
Although a total eclipse was seen on the Big Island of Hawaii on 1991 July 11, no other total eclipse was visible from the lower 48 states of the USA between 1979 and 2017–a lapse of over 38 years!

Few in latter half of century

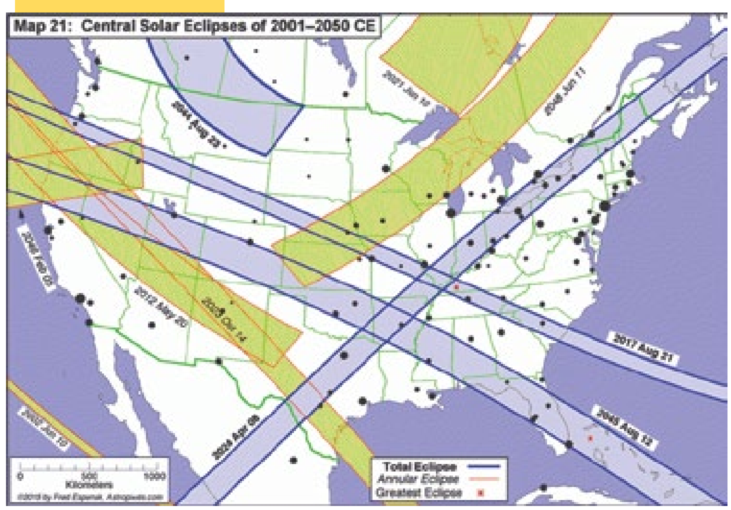
Map 1 shows the path of all total (and annular) eclipses through the continental USA during the last 50 years of the 20th century. Besides the 1970 and 1979 eclipses, the only other USA total eclipses during this period were on 1963 July 20 (Alaska and Maine) and 1954 June 30 (Nebraska, South Dakota, Iowa, Minnesota, and Michigan).

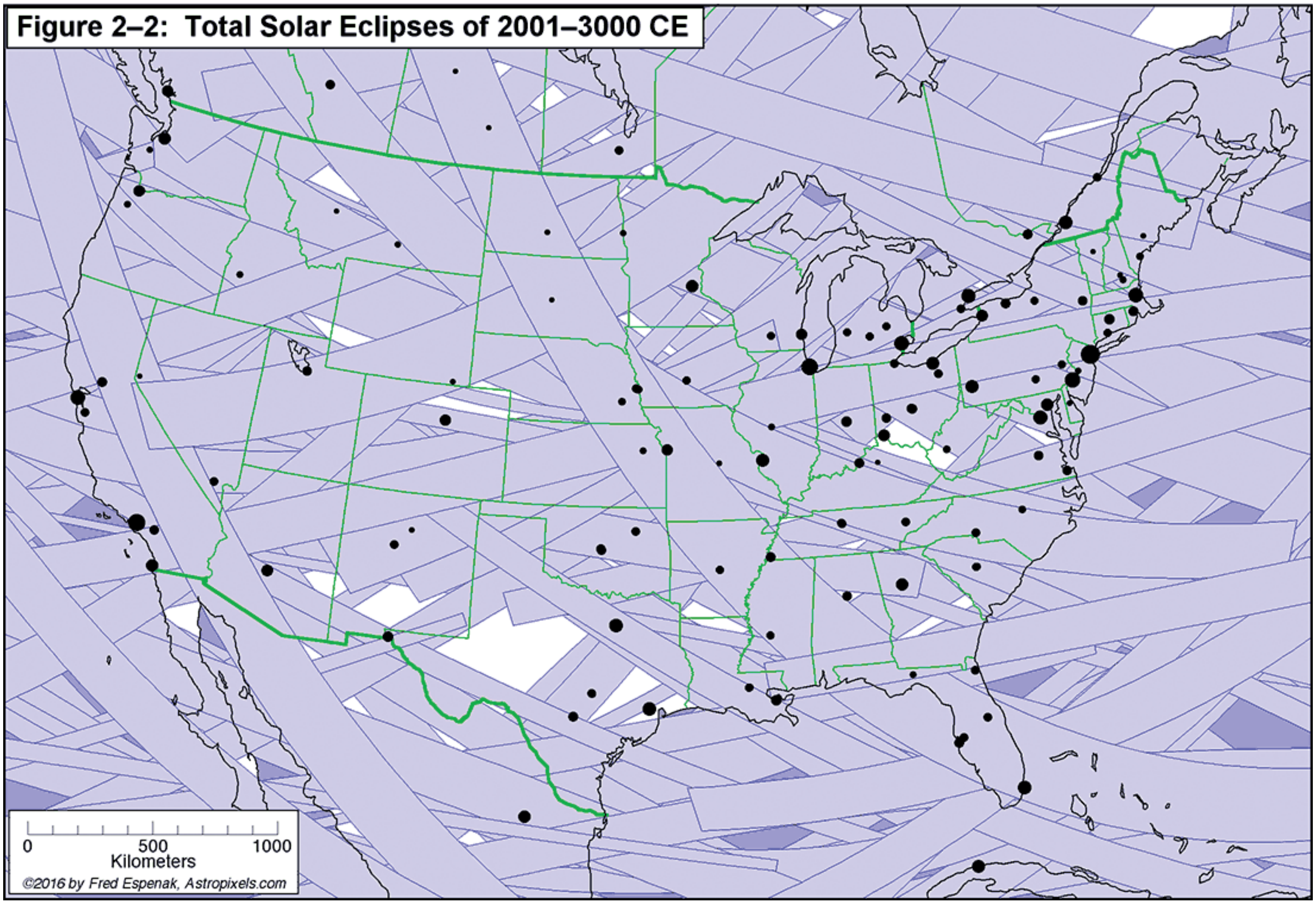
Map 2 shows all total (and annular) eclipses through the continental USA during the first 50 years of the 21st century. Looking beyond 2017, the next total eclipse through the USA is on 2024 April 8 and crosses 13 states (Texas, Oklahoma, Arkansas, Missouri, Illinois, Kentucky, Indiana, Ohio, Pennsylvania, New York, Vermont, New Hampshire, and Maine).

The total eclipse of 2044 August 23 crosses Montana and North Dakota. It is followed one year later by the total eclipse of 2045 August 12, which also crosses 13 states (California, Nevada, Utah, Colorado,



Map 1 (Above) shows the path of all total (blue) and annular (yellow) eclipses through the continental USA from 1951 through 2000.
Map 2 (Below) shows the path of all total (blue) and annular (yellow) eclipses through the continental USA from 2001 through 2050. Images courtesy the author and *Atlas of Central Solar Eclipses in the USA.*





Map 3 shows the result of plotting the path of every total eclipse from 2001 through 3000.

Kansas, Oklahoma, Texas, Arkansas, Mississippi, Louisiana, Alabama, Georgia, and Florida). Although a total eclipse occurs on 2033 March 30, it is only visible from northern Alaska.

If we only count total eclipses visible from the lower 48 states, we have 4 eclipses from 1951 to 2000, and 4 more from 2001 to 2050. Put another way, there are 8 chances to view a total eclipse from the USA in the period spanning just over a single lifetime. And that's not even considering the fact that cloudy weather will likely hide half of them from view! Rare events indeed, and one more argument not to miss the Great American Total Eclipse of 2017.

But what if we look many centuries into the future? Does every one of the lower 48 states get a total eclipse in the next 1000 years? Map 3 shows the result of plotting the path of every total eclipse from 2001 through 3000. The country is almost completely covered by eclipse paths.

Nevertheless, there are few unlucky locations that do not get a total eclipse over the next 1,000 years. Two examples include western Texas and southern New Mexico. Fear not, because they will all eventually fall within the moon's shadow sometime. You just have to wait long enough.

There is something compelling about the pattern of eclipse tracks crossing familiar places many hundreds of years in the past and future. ☆

Fred Espenak is a retired astrophysicist from NASA's Goddard Space Flight Center and was the agency's expert on eclipses. Known as "Mr. Eclipse," he is the author of numerous eclipse books, including T*otality-Eclipses of the Sun* and *Thousand Year Canon of Solar Eclipses: 1501-2500*. An avid eclipse chaser, he has participated in dozens of eclipse expeditions around the world. Patricia Totten Espenak is a retired chemistry teacher and amateur astronomer who has traveled widely with her husband, Fred, to view various celestial events. She has experienced 17 total solar eclipses.

Eclipse books and publications

All available through astropixels.com/pubs/index.html; each book also available in color or standard black and white.

- *Atlas of Central Solar Eclipses in the USA*
- *Eclipse Bulletin: Total Solar Eclipse of 2017 August 21*
- *Road Atlas for the Total Solar Eclipse of 2017*
- *Get Eclipsed: The Complete Guide to the American Eclipse* is an easy-to-read, family-friendly, inexpensive 2017 eclipse guide for everyone, co-written with Pat Expenak.
- *TOTAL Eclipse or Bust! A Family Road Trip* is a book for the entire family. The story follows a typical family on a road trip to see the 2017 total eclipse; along the way the children learn all about the how and why of eclipses in a friendly way. The book also provides basic information about how to view a total solar eclipse and where to go for America's great eclipse on August 21, 2017. Written by Pat Espenak.







Museum is hosting a night of fun and games

to bring out the geek in all of us! Marvel at




round astronomy programs at the Museum.



If you geek it, they will come

Bringing new (and some really unusual) faces into the dome

Jason Heaton
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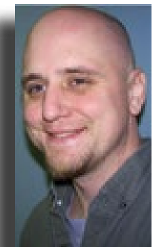

In 2015, The Boonshoft Museum of Discovery, in Dayton Ohio, put together a fun and engaging way to bring new faces into our planetarium and museum. This event, titled GeekFest, not only brought back existing customers, but many first-time visitors as well.

The Boonshoft's version of GeekFest had many elements of a comic book convention, but included astronomy and elements of science fiction. The event, modeled after an event of the same name at the Mayborn Planetarium in Texas, was very successful for the Boonshoft Museum in its first year, and even more successful this past year, in 2016. The first year saw over 500 unique visitors of all ages. This year was even more popular, with almost 800 attendees.

The backstory

The Boonshoft Museum, in addition to its many science programs, has had success with many different types of alternative programming: laser shows, musicians in the planetarium, Valentine's Day programs under the stars, and even wedding proposals.

Why offer alternative events? Because many museums, science centers, and other venues must "think outside the box" with different types of programming to bring new guests, or revenue, into their planetariums. After attending a Western Alliance Conference in Killeen, Texas, I was exposed to a Central Texas College event, GeekFest.

The Mayborn Planetarium at Central Texas College was a unique place in its own right, and after returning from the conference, I looked up their programs online. Their event, GeekFest, demanded attention. I urge you to check it out for yourself. At the time of this writing, an online search for CTC Geekfest should bring up a myriad of interesting results and pictures.

After researching their program, I realized that this event could also be successful in Dayton. I contacted the director of the Mayborn Planetarium, Fred Chavez. Fred was extremely willing to share any and all information about the success of CTC's growing event. Over the past decade, their event has grown exponentially into a multiple-day event with celebrities, authors, artists, and so much more.

What is GeekFest anyway?

The event we held in Dayton was definitely different from the event in Texas, but the nature of the core clientele was the same. To put it bluntly, they are self-proclaimed geeks.

The first ever GeekFest at the Boonshoft was a combination of many individual events. It included a video game competition, a costume contest, designer strategy board gaming, a classic video game arcade, telescope viewing, local vendors (such as comic book and gaming stores), and special programs in the planetarium. These included science programs, a geek-flavored Jeopardy style trivia game, and a program centered around planets featured in science fiction, particularly those of *Star Wars*.

The second year built on the success of the first year, while adding new features, such as live action-role playing "giant board games," a LAN-based starship bridge simulator game (perhaps resembling the one in *Star Trek*), an expanded costume contest, panels and discussions with local artists and cosplayers, and a variety of children's activities.

Meanwhile, the Central Texas College will set to hold its own 2016 event in August, with activities such as a "Yule Ball (for Potter fans)," Steampunk On A Budget, How To Self-Publish, and a cake creation contest. (This is a very abbreviated list of their current offerings. Please see their website at www.starsatnight.org/geekfest for an amazing array of unique activities).

GeekFest can be whatever you want it to be. The goal is to embrace and invite the already-existing community of "geeks" in your community.

Organizing GeekFest

While the Mayborn Planetarium's GeekFest event has blossomed into a three-day event, we at the Boonshoft decided to host an event

(Continues on next page)

Here and facing page, some of the many faces that turned out to enjoy the Boonshoft GeekFest. All photos courtesy the author.

for one evening only.

After putting together a few ideas for activities in and outside of the planetarium, we approached a few local businesses, such as comic book and video game stores and even an advertising agency. Several of these companies attended as vendors. A local card-trading store volunteered a video game console so that we could play games on the planetarium dome between programs. One business brought 3d printers and virtual reality games to demo for the audience.

Emboldened by our own research and the many discussions with the director of the Mayborn planetarium, we set a date in 2015. We advertised with flyers handed out to our vendor partners and on social media. We offered quality door prizes that were submitted by our vendors to be given away at our event in exchange for vendor space.

We encouraged guests to come in costume and participate in the costume contest. We invited cosplayers, such as our local stormtrooper garrison and steampunk group, to join us for the evening. We asked local food trucks to supply food for the evening.

After the success of the first year, we discovered that the Boonshoft's event attracted local authors, costume and figurine designers, and even professional artists that had worked for major video game studios.

Discussions with the Mayborn planetarium had prepared us ahead of time, letting us know that once the word got out, people and businesses would contact us wanting to be a part of future events.

Get in touch with your geeks

Whether you are living in a densely-packed city or in a sparsely populated community, it is almost guaranteed that you have an infestation of geeks living in your midst. Here are some things you should know before venturing into their territory:

They will defend certain movies, TV programs, and celebrities to the death. Do not speak ill of the television series *Firefly* or B-movie actor Bruce Campbell.

They have already found a place that they call home. They may frequent an internet cafe, a local comic book shop, or even a library or church, where they do battle in the form of tabletop gaming.

Do feel free to approach any one of them, as they will be glad to talk to you about their craft.

This last suggestion is the approach I took when seeking to learn more about the geeks in my own community. We talked to the owners of local comic book shops, searched online for communities of popular video games, and approached local "cosplayers," people who dressed as or mimicked the lifestyle of genres such as steampunk or superheroes. Everyone I talked to was very supportive. Talk to your community. Get out there and ask what is popular. Find out what people are watching and listening to. Your community may be home to people who excel at self-publishing books or creating new and exciting board games. Arts and craft events, maker fairs, and other comic conventions are great places to meet local talented individuals.

Whatever you discover about your community, you may also find out that the planetarium already holds a special place in the geek heritage.

The astronomy connection

Fantasy and sci-fi have always been a main staple of nerd-dom. Embracing the science fiction aspect is a great way to get started. A simple way to incorporate astronomy into such an event might be to do a live star talk discussing "bad astronomy" in a specific movie.

We discovered that people in attendance were hungry for science, and not just science fiction. They were just as interested in the regular planetarium shows as they were in our special evening programs.

Fellow planetarian Joe Childers and I spoke about GeekFest at the Ohio GLPA meeting this year, and discovered that other Ohio planetariums were already hosting smaller events similar to our GeekFest event. Some were holding small video game contests, while others were hosting designer board gaming on weekend nights.

Though hosting such an event was quite a challenge, GeekFest at the Boonshoft brought in new faces, new partnerships, and an awareness of our planetarium to new segments of our community. ☆

Jason Heaton is secretly a major geek and thinks all movies would be better if they had at least three robots as main characters. He also is the assistant director of astronomy at the Boonshoft Museum of Discovery in Dayton, Ohio.

(Projection systems, continued from page 37)

Acknowledgements

We would like to thank all the many vendors and individuals who assisted and provided insight to this paper and Paper I: Max Rößner, Claude Ganter, Evans & Sutherland, Sky-Skan, Zeiss, Sciss, Kirk Johnson, Staffan Klashed, Daniel Arnberg, Pietro Luigi Rinaldi, Marco Cosmacini, Volkmar Schorcht, Stefanie Neuhäuser, Wilfried Lang, Dieter Schwab, Markus Steblei, Glenn Smith, Ryan Wyatt, Antonio Pedrosa, Steen Iversen, Jack Langley, Robert Hurt, Thomas Kraupe, Stephan Leitenmeier, Björn Voss, Susanne Hüttemeister, Helmut Schüttemeier, Sebastian Ruchti, Werner Kiesle, Gerhard Cerny, David Gruber, Luca Ciprari, Marc Horat, Markus Pössel, Otto Wöhrbach, Gabriel Stöckle, Gerhard Hartl, Daniel Schwefel, Tim Florian Horn, Jürgen Rienow, and Eduard Thomas. Thanks to Peter Grimley, Nikita Marwaha, and Ryan Laird for editorial support.

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Spitz Institute Student Scholarship Program

How "Not to Scale" T-shirts helped introduce students to the planetarium community

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The 2016 Spitz Summer Institute group photo. All photos courtesy Spitz.

This year marks our second year hosting a student scholarship at Spitz Summer Institute, our two-week professional development summit for planetarium educators. The scholarship program quickly has become an important part of Spitz's Summer Institute.

During Week 1 of institute, held July 11-15, we had the great pleasure of working with Ross Campanella, a 17-year old student entering his senior year at Manheim Township High School in Manheim, Pennsylvania.

And it all started with a T-shirt.

Above: Ross Campanella with a Spitz A1 in the lobby of Spitz Headquarters. Right: the T-shirt that started it all.

Long before we started thinking of ways to bring students into the planetarium profession, institute attendees were clamoring for event memorabilia. "After years of hearing, 'We need institute T-shirts!' we starting thinking it was a pretty good idea" said Joyce Towne of Spitz. "That's how the Not to Scale commemorative T was born."

The phrase "not to scale" was inspired by Dr. Dave Bradstreet. His astronomy demonstrations liberally play with sizes and distances of objects, for better teaching and clarification of how objects relate in space.

"It's definitely the institute catchphrase now," said Brad Rush, Spitz applications engineer and institute instructor.

As we pondered this new commemorative shirt, we asked ourselves if selling them to institute attendees could somehow benefit the planetarium community. Our brainstorming eventually led to the creation of the Institute Scholarship, a yearly program that would be funded by sales of "Not to Scale" shirts. The "T-Shirt Fund" pays for a student's institute registration, lodging, and meals so they can fully participate in the first week of Summer Institute.

Here's how it works

High schools and universities are invited to nominate students who have strong interests in astronomy and who are highly active in their planetariums. Planetarium professionals send a brief background and description of the nominated student. We invite each nominee to share their story, and ask them to write an essay explaining why they feel they should be a part of the annual institute.

Ross Campanella was nominated by Dave Farina, astronomy instructor and planetarium manager at Manheim Township High School. His impressive resume included work as an operator in the school's SciDome planetarium and participation in the Manheim Township Astronomy Club, for which he became president in 2015.

Ross has also developed four original shows for the Manheim planetarium: three astronomy-based programs and one earth-science show (his "Winter Sky Constellations" program was featured as a cover story in the "Living" section of the *Lancaster Daily News*). "His ability to inspire audiences, his passion, and his curiosity continue to grow," says Farina. "It's obvious he's in this for keeps."

All that, and an A student too

On top of these accomplishments, Ross maintains an A average at Manheim Township High. Among many other scholarship nominees who submitted applications—all impressive and qualified—Ross was a clear standout.

"We were struck by the hands-on, self-motivated nature Ross demonstrated in his home planetarium," Chris Seale of Spitz said. "A phone call sealed it for us-—Ross was enthusiastic, engaging, and clearly inspired by the opportunity to further pursue his aspirations in the planetarium field."

"When I heard that I had won the scholarship, I was so excited," said Ross. "I'd be at Spitz, in state-of-the-art planetariums, with fellow astronomy/planetarium nerds all day; that's my idea of a good time."

Ross continued "When I arrived at the faculty there were extremely friendly and

(Continues on page 68)


NATIONAL GEOGRAPHIC PRESENTS
ASTEROID
MISSION EXTREME
Narrated by
Sigourney Weaver
NATIONAL GEOGRAPHIC
Sky-Skan
LOCKHEED MARTIN
NATIONAL GEOGRAPHIC STUDIOS presents a SKY-SKAN PRODUCTION ASTEROID: MISSION EXTREME Narrated by SIGOURNEY WEAVER
Written by ANNETTE SOTHERAN-BARNETT & MOSE RICHARDS Exec. Producers BROOKE RUNNETTE & STEVEN SAVAGE Produced & Directed by ANNETTE SOTHERAN-BARNETT
Lead Animator TROY WHITMER Post Production SCOTT WYMAN Music & Sound Design PIP GREASLEY & DALE CORDEROY
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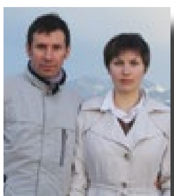
Siberian astronomers share their experience with monthly stargazing events



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Stargazing at Glubokaya in January, 2016. Photo by Vladimir Smirnov

"Beyond the Dome" was one of the key topics for the IPS2016 conference held in Warsaw on 19-23 June. Three sessions were devoted to the topic with categories like planetarium exhibitions, building community engagement, and the category we wish to share with you, called special events: stargazing etc., best practices, formats, and challenges.

The information presented by the authors of this article about regular stargazing for a wide audience caused a great interest from our colleagues. A wish to share this experience has become the reason to publish a series of articles concerning our stargazing successes in this journal.

Since August 2015, visitors of Irkutsk Planetarium have had opportunities to see deep sky objects through a telescope. Binary stars, open and globular clusters, nebulae, and even galaxies are extremely attractive objects to observe. But it is not simple to organize stargazing activites on a regular basis.

Finding the place

While searching for an appropriate area for the stargazing, we chose a site 72 km southeast from Irkutsk towards Lake Baikal where the Milky Way is visible every clear night. The southern horizon is open, while the west and east sides of the sky are protected against light by the Siberian forest (taiga). Any automobile can reach the place by the paved road M-55.

Every empty moon period a group of stargazers meets at the 24-hour café in the village 1.5 km on the way to the viewing site. According to the weather forecasters, we can rely on at least 250 clear sky nights per year. The altitude of the place is 914 m above the sea level.

It was a great surprise for us to learn that the founders of the village had named it "Glubokaya," which means "deep" in Russian.

When you begin an activity such as this for the visitors of your planetarium, you should be sure that you can provide it for every celestial event and offer it regularly during empty moon periods. So, first of all, you need to find individuals who are ready to work without any schedule and willing to get up in the early morning or work at night mainly on weekends.

Since this activity is an emotional procedure, the lecturers should have overwhelming knowledge of their hemisphere and be able to target their instruments to any celestial objects: the GoTo system is precise in this work, but if a lecturer can't tune a telescope manually to the object, everything goes wrong.

It is much more efficient if two specialists conduct the observation: one with knowledge of the constellations, and the other who can explain what is within the field of the view of the telescope, such as Messier objects, for example.

Promote the events

After each show in the planetarium the lecturer reminds the audience about the future stargazing events in advance. Those who are interested in participating can join groups via Viber, WhatsApp, or Telegram applications for further coordination.

A week before the observation period we post the news about the event at the Irkutsk Planetarium website and its social media accounts. Journalists from local TV, radio, newspapers and news agencies insert the necessary information into their schedules, and the sky becomes a newsmaker even better than the top news in mass media.

Conducting observation all the year round requires reliable equipment that can operate under severe conditions. The mounts should be massive enough and have minimum plastic parts. Telescopes should also be repairable and transportable. We think that stargazing is worth providing with at least an 8-inch telescope.

The GoTo system helps professional astronomers to switch from one object to another more quickly, and it is "routine" work for them. But the audience does not care any "routin.e" They are looking for "magic" in the starry sky, and if you can target the telescope to the object invisible by an eye and show something amazing for the people, you will reach the goal and everyone is happy.

Before going to the stargazing place we put into the car the 8-inch Klevtsov telescope, which is based on an equatorial mount, manufactured by the Novosibirsk optical plant, and a self-made 12-inch Newtonian device based

(Continues on next page)

on a Dobsonian mount. The first telescope shows planets, binary stars, and open and globular clusters, and the second performs the spectacular images of the deep sky nebulae and galaxies. We use 3 eyepieces for 6 different magnifications.

The paved road to the stargazing site. July, 2016. Photo by Anton Petrov

Financing issues

If you have a regular budget for this activity, then you don't have a headache about how to manage your work, but if you are less lucky, you have to be resourceful to perform your beloved activity. If you take into account the planetarium as a whole, you will see that your PR and advertisement made by the sky as newsmaker can be one of the most efficient instruments for the promotion of your enterprise.

We have developed and budgeted this activity to reimburse our operational expenditures and get some reward.

A year of experience

Everyone knows about the International Sidewalk Astronomy Night (www.sidewalkastronomers.us/id265.html) which usually takes place in the first quarter of the moon after vernal equinox. This event gathers a lot of people; it is popular and free. But do only bright planets and the moon gather people around a telescope? And will anybody pay for stargazing through telescopes? It turns out that they are willing to do this, and we have confirmation of this desire.

At our first event, at 23:59 on 13 August 2015, when the sky was bright with lightning, we put the telescope on the ground at the village Glubokaya. We had advertised via website the information about the stargazing event and mass media spread out the news in the community. Immediately 20 people responded and came to the place.

By July of 2016 we have already conducted 12 observation series, each running 5 nights on the average. According to our registration, we have showed deep-sky objects to more than 600 people to this point. Every one of them paid a fixed price for participation in stargazing.

We have showed the objects of the four season's starry sky, all the planets (except Neptune), and two telescopic comets. A couple of planetary alignments took place early morning at 4 or 5 a.m.

At one point the temperature at the observation place was 30°C below zero. In spite of this fact, the maximum number of the people gathered for one night for observation was 75. The longest observation lasted 7 hours, from 11 p.m. until 6 a.m.

So: we have realized that people are interested in observing deep sky objects and celestial events on a regular basis.

We hope to continue sharing our experience in the stargazing process in a series of future articles.

Planetarium for stargazers

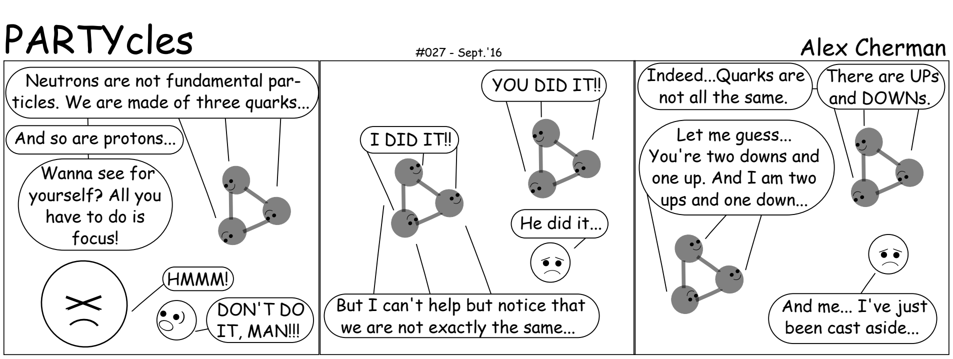
You know that the planetarium is a place where people can get a scientific point of view on celestial objects. Stargazing with telescopes is a good opportunity to confirm this. Some of those who visit our observations become conductors of these ideas because they enjoyed the light of stars and galaxies

Irkutsk Planetarium and Noosfera Museum were founded in February, 2015. This complex is named after scientist Mikhail Schadov from Irkutsk, who initiated the idea to organize a private planetarium. Now this complex is the only private planetarium in Russia. The investor of this project is the group of companies METROPOL. ☆

The first Mexican-Siberian planetarium connection?

At one of the IPS2016 lunches we had a talk with our Mexican colleagues and table mates. It turned out that Enrique Fonte Vazquez and his wife, Jessica Pilar Gonzalez Abad, had tickets to Irkutsk in their pockets!

They made the trip on Baikal lake, visited the Irkutsk Planetarium, and spent one night under the Siberian starry sky! It is obvious how IPS conferences bring stars—and planetarian—closer. We are inspired.

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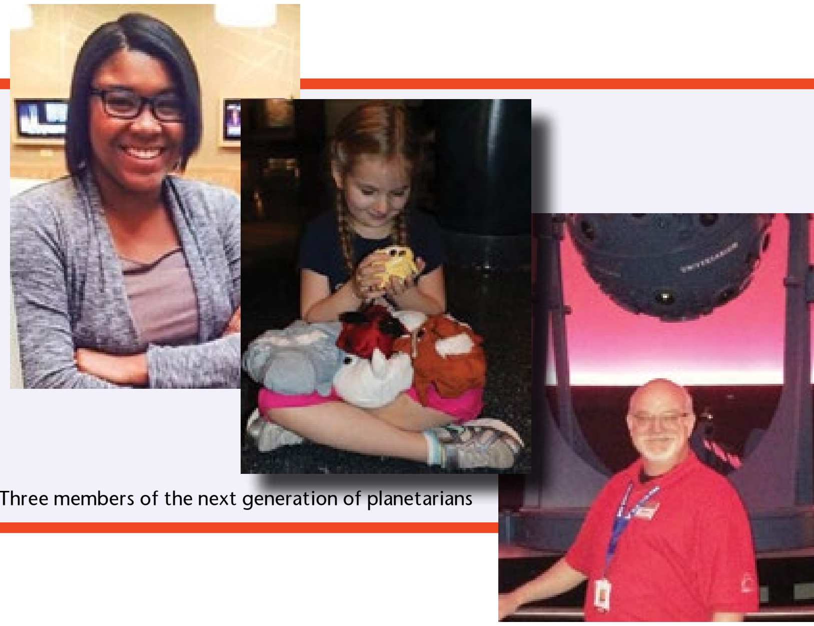
CALIFORNIA ACADEMY OF SCIENCES

Working in the planetarium field is an exciting and desirable career path that often times lends itself to a lifelong vocation.

As many staff choose to grow with their planetarium, perhaps even retiring from the same planetarium in which they were first involved, it becomes imperative for the experienced generation to start preparing the next generation of planetarians.

This paper will explore different options that veteran planetarians can use to usher in new planetarians, and that new planetarians can use to gain the experience and professional development they need to grow.


Three members of the next generation of planetarians

Encouraging
The next generation of planetarians

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Who is the next generation?

Really, the possibilities are endless when trying to answer this question. The next generation of planetarians is quite a diverse group: toddler fascinated with the projector who could grow up to work in a planetarium, a retiree who always wanted to work in a planetarium but never knew how, the teacher who is burned out on classroom politics but still wants to educate, a college student who is looking for work study credit, an astronomy major who doesn't want to go into research.

The sky is the limit when it comes to why people may want to make working in a planetarium their new vocation. It is the job of veteran planetarians to make sure there is a next generation, and that they stay in the field.

When should we start working?

The short answer to the question of when one should start working with new and potential planetarians is: now. As one often hears, there is no better time than the present. It may seem easy to think that someone is too young or too new to start helping them craft their career or calling in the planetarium community, but, in reality, the confines of age and how "green" one may be should not be the determining factor. One can always start small and grow from there if the new planetarian is willing and seems ready for the challenge of bigger challenges and responsibilities.

One of the best times to start working with a potential new planetarian is when he or she is a young visitor. If the child (which, for the purposes of this paper, includes toddlers through high school seniors) takes an interest in space science and the projector, a current planetarian should offer to nurture that curiosity. This can occur simply in offering answers to questions the child has, to showing the child how the projector works, to (if allowed by the planetarium's rules) letting the child control the projector with guidance from the planetarian. These are the kinds of experiences the child is not likely to forget, and that will potentially ignite an interest in staying in the planetarium field (or at least space science) as the child becomes an adult.

As soon as a new staff member (including volunteers and interns) is hired, veteran staff should begin working with them. Some new planetarians may not have the idea solidified that their new position could become a lifelong career.

Many planetarians start out needing a job and taking a position as an usher or in the bookshop. With time, however, they may be destined for much more, including a lifetime in the planetarium field. Without the support and guidance of veteran staff, though, a new potential planetarian may never realize their abilities within the institution, and they may move on to something new without either party, the new planetarian or the planetarium, benefiting from what they could have offered the other.

Why should we do this?

The planetarium community has a large number of seasoned veteran and newer veteran members who have much to offer. It can be easy to overlook the fact that one day the torch will need to be passed on when so many planetarians love their vocations to the point of not wanting to retire. Add to this thought the fact that the community has some excellent talent as well, and it becomes a quiet voice in the back of the mind that one day, there will be a new generation to carry on the work of the previous generation.

Without active engagement, however, it is quite possible that new planetarians will give up and move on to something else, and the next generation to carry the planetarium torch will be small at best. Even worse, if nobody is encouraged to grow and learn how to step up in the field, when the head of the planetarium leaves, especially if she was fantastic at her job, the planetarium will flounder and perhaps fail because nobody will be capable of taking over. This is seen time and again in the business world. According to Jim Collins (2001), the greatest leaders will nurture new staff and help mold successors so that no matter how great the planetarium was under the veteran planetarian's time at the helm, it will continue to be great afterward too (25-27).

Thirty years of (just some of the) McDonnell Planetarium staff and volunteers, past and present. All pictures provided by the author.

How can we capture potential planetarians and nurture them?

Despite of *South Park's* satirical episode (1998, season 2 episode 11) where the planetarium projector brainwashes visitors to love the plane[t]arium, planetariums do seem to have an innate ability to capture those who set foot under the dome. Brainwashing isn't needed keep new planetarians, just time. One of the biggest things that a veteran planetarian can do is be a mentor for a newcomer to the community. Each mentor and mentee need to choose how much involvement they want to have, but even an informal mentor can make a huge difference.

There are a couple ways to look at mentorship and how it grows. From an outsider perspective as well as to someone new in the planetarium field, planetarians can seem almost like rock stars. Manipulating the universe for visitors is something really special and cool. There's almost a mysterious and romantic aspect to the idea of working in the dark, perhaps as a disembodied voice and controlling the stars for the audience's enjoyment; or to rendering new objects discovered or launched into space.

Due to having a "cool job," and often times higher degrees, planetarians are also sometimes placed on pedestals. The intrigue surrounding the position can be a good starting point for encouragement.

From rock star status stems a deeper mentoring relationship. As time goes on, this becomes very important for the new planetarian. Having a guiding star who is actively mentoring them and entrusting them with new responsibilities over time is huge for a new planetarian. By enabling leaders within the new staff to make choices and act, the entire planetarium becomes stronger, and the veteran planetarian can be assured that if he or she leaves or retires, the entire planetarium will not fall apart without them as well (Gittell, 2003, p. 16-17).

Thus, mentoring and empowering new planetarians are also great ways to prepare a successor when the day finally comes. This level of mentorship also comes with a mutual trust and respect and leads to professional growth – not just for the new planetarian, but also for the veteran planetarian, as he or she will be constantly striving to do and be the best for their mentee.

A good mentor will see the strengths of the new planetarian and encourage them, while gently trying to help strengthen weaker areas. The mentor will also encourage professional development, getting the new planetarian out into the field to meet other planetarians and see other domes and projectors. This could include more responsibilities over time, going to conferences, writing journal articles, and going to and presenting workshops.

Positive atmosphere

One of the biggest things that can encourage staff (both new and veteran) to stay is a welcoming environment. Planetarians who feel they are part of a caring team or family are going to be more likely to want to stay in the field. A lighthearted atmosphere, when appropriate, can help prevent burnout, which will also help keep staff member in the field. Finally, if a planetarian feels like the team is doing something for the greater good of visitors and the institution, they are going to be more likely to stay in the field if not become a "lifer" in their current planetarium.

Honesty and trust also go a long way in reaching planetarium staff. As seen in *The Southwest Airlines Way,* the leaders of Southwest listened to their employees and they were honest with the staff about what was going on in the company. They created trust in the company and amongst staff. When staff members can trust the leader(s), they are more likely to produce good work (Gittell, 2003, p. 5).

Even more importantly, when planetarians (especially new planetarians) can feel that trust amongst each other and feel like they belong, then everyone will be able to handle difficult situations as well as the good situations with greater ease. This then contributes to the success of the planetarium and the greater good of the institution.

Conclusion

Right now is an exciting time to be a planetarian. With technological advancements for both projectors under the dome and for the instruments used to study the universe, it should be a given that the next generation of planetarians would want to further the planetarium community. Veteran planetarians have a duty to support, mentor, and encourage new planetarians to ensure the continued success of the planetarium field. By nurturing the talents and curiosity of visitors and new staff, and adding to the core team of a planetarium, the legacy of that planetarium will continue and inspire new visitors and new potential planetarians for generations to come.

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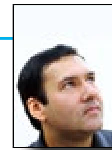
Based on a paper presented at the Great Lakes Planetarium Association Meeting in Grand Rapids, Michigan, 14-17 October 2015.



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The Data2Dome Project: A consolidated, data-driven content distribution system

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Robert Hurt, Infrared Processing and Analysis Center
And the IPS Science and Data Visualization Task Force

Rationale

Space science and astronomy are attractive subjects to both students and the general public. Contact with these subjects has a positive effect on students' interest in science and scientific careers, and on public support for science and technology. In addition, the importance of science museums to scientific learning is well known. Museums are among the main sources that people rely upon for learning about science and technology (Falk, 2007).

Planetariums are important venues where the public can get excited about science, and as learning environments they have a proven advantage over classrooms and other venues. Yu et al. (2015, 2016) found that immersion in a dome theatre leads to greater learning in university students. The wide field of view reduces the cognitive load for spatial understanding, and the stimulation of the peripheral vision leads to greater attention.

Looking at estimated annual attendance figures for planetariums around the world (school shows, public shows, concerts, laser shows, counted together) reveals some striking numbers. It is estimated that in 2014, almost 110 million people visited the 4111 planetariums around the world (Loch Ness Productions, 2015)[1]. And this number may be on the increase (for comparison in 1995, an estimated 75 million people visited the then existing 2613 planetariums around the world).

Not only is attendance high, but planetariums are also among the science-related activities and attractions that people would most like to visit. A study conducted in the UK reported that one in five (20%) UK citizens had an interest in visiting a planetarium, which contrasted with 12% who expressed an interest in visiting a museum or a science centre (Mori, 2005). Nevertheless, when compared with attendance at other cultural institutions such as public libraries, art museums or zoos/aquariums, attendance at science/technology museums ranks lower (National Science Board, 2014)[2]. For example, 27% of Europeans visited a zoo/aquarium in 2005 whilst 16% visited a science and technology museum (European Commission, 2005).

From the visitor's point of view, an ideal exhibit is one that makes the subject come to life, can be quickly understood, and is memorable (Alt and Shaw, 1984). One way to achieve this in a planetarium is to communicate authentic science as soon as possible after it happens.

The Data2Dome (D2D) project[3] is aimed at streamlining the flow of content from research institutions to planetariums, offering audiences a unique opportunity to access the latest data from space in real time. Its innovative character makes possible the development of new,

1 Estimated numbers are only based on visitors' attendance at 10% of the world's domes (independent of dome size), so the extrapolation to a global attendance estimate should be done with caution.

2 Acknowledging that planetarium domes are not always attached to science museums.

3 www.eso.org/d2d

Discussing the Data2Dome concept at IPS 2016: From left, Lars Lindberg Christensen, ESO; Max R. Rößner, ESO; Ka Chun Yu, Denver Museum of Nature & Science; Björn Voss, Planetarium Münster; Kevin Scott, Evans & Sutherland; Glenn Smith, Sky-Skan; and Mikael Karlsson, Sciss. Photo by Frank-Michael Arndt.

Astronomy is a dynamic discipline. New press releases, images, videos, and data are being published every day. However, this flow of exciting new content typically is not integrated in planetariums; rather than bringing the latest science into the dome hours or even minutes after it is published, new data is typically presented days or even weeks later—and often not at all, given the many barriers to getting them into the dome.

As a result, the planetarium, usually seen as the local centre of astronomy competence, lags behind blogs, newspapers, TV and other media. The **Data2Dome (D2D)** project is aimed at streamlining the flow of content from research institutions to planetariums, offering audiences a unique opportunity to access the latest data from space in near real time.

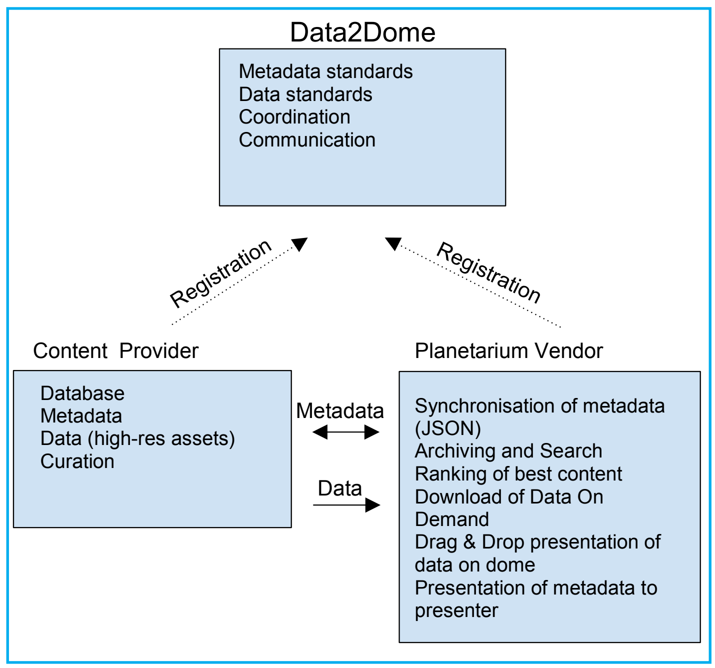
engaging ways of communicating complex topics with a global focus, compared to other methods of demonstration in planetariums. D2D can be a powerful tool to establish audience engagement as both a means of learning and a means of affecting relevant change in visitors' interest and appreciation for science. Ultimately we believe D2D will help attract broader audiences to the planetariums.

Several reasons have been identified for the delay between the availability of new science and its use in planetariums:

- Manual work: Bringing content into a planetarium system typically requires a significant amount of manual work with laborious content pipelines: copying content onto the system; distributing it to the render nodes; slicing; writing scripts to actually display the assets; and so on. Some planetariums, like Morrison Planetarium (see Tell, 2016) and Adler Planetarium (SubbaRao, 2016) go to considerable lengths to collaborate with scientists on presentations that involve importing and visualising research data. These are, however, one-off events that take days, if not weeks, of manual work, and except for the Domecasting in Uniview that Adler Planetarium offers on occasion, they are not easily shared with the community.
- Content import not standardised: The pipelines and work procedures for importing content are typically very vendor-specific, resulting in difficulties with delivering content across the system boundaries in an easy and seamless way.
- Lack of consolidated data access: Astronomical data on the internet are usually distributed across many different research institutions' websites. As a result, it is not easily found and easily escapes the attention of a planetarium operator.
- Lack of connectivity: Planetarium systems might not be connected to the web, because of, for example, security or performance concerns.
- Content is not well-served: The planetarium operator has to gather background information concerning a particular data item, such as a newly-published image or tabular data. The learning curve for the operator may be steep, or the operator might simply not have time to read a comprehensive scientific paper that describes the data product.

Philosophy

The philosophy of the D2D project relies on a combination of staff curation of assets (the model used by American Museum of Natural History's Digital Universe, see Abbott et al. 2004) as well as crowd-curation plus a ranking system on the side of the vendors. It also relies on distribution via the internet, on standardisation of formats and process, and on consolidation of data or metadata in online databases. The project is partly arising from the efforts of the IPS Science & Data Visualization Task Force[4] . The European Southern Observatory (ESO),



ESA/Hubble, Adler Planetarium, Planetarium Münster, and Planetarium am Insulaner, Berlin have pledged resources to implement D2D.

The Data2Dome webpage will be the central point of contact for the project: www.eso.org/d2d.

Vision

D2D is a system whereby astronomy data is seamlessly integrated with today's real-time fulldome planetarium systems. Content, and metadata describing it, are fed via a reasonably fast internet connection (at least 10-20 Mbit/s) into the planetarium system automatical-

(Continues on next page)

4 www.ips-planetarium.org/?page=visualization

ly, significantly reducing the workload for the planetarium operator.

Every morning, planetarium presenters around the world will be able to access a menu that will allow them to select interesting news and fresh datasets—news, sky event data, historical event data and more (see the use cases below)—and mark up the full datasets and metadata for download for possible inclusion in show segments during the day. Some of these items may be under embargo and will only be shown when they are public. In some sense the presenter can be seen as an "astronomical weatherman," being able to report on fresh events almost as they take place.

Data

The system will be capable of sharing the following standard asset types:

- Descriptive metadata as support for the presenter: concise, well-written descriptions of the content, credits, license, embargo date, links to more information, etc. for the planetarium lecturer. This probably will be written in English, but can be translated with machine-translation and further improved through crowd-translation. The Astronomy Visualization Metadata Standard (AVM, Christensen, 2005, Hurt et al., 2007) has been chosen for this. This standard describes metadata tags in the header of an image file containing information such as position, orientation and size of the image on the sky, a popular description of the content resource, credit information and the like.
- Flat videos
- Flat images, including planetary maps, images of sky objects, all-sky panoramas/fulldome images
- Fulldome videos
- Audio, including interview clips, sounds, music
- Show sequences, including presentation metadata

Implementation

The D2D project determines the standard of the metadata (AVM), the format for the exchange of the metadata (JSON) and data, and approves the Content Providers. D2D also communicates any changes to the standards and new Content Providers with all stakeholders.

The Content Provider maintains a database of metadata and data.

Example use cases

The following are use cases which are currently being implemented by content providers. The number of events is the number of data items that are available at launch. The increment per year means the number of new data items added per use case per year.

A new press release

An Earth-like extrasolar planet is announced by NASA.

Within hours a human curator finds the press release interesting and features it.

The D2D JSON file is automatically updated within minutes to contain the new press release metadata.

Soon after (to be determined by the vendor) the news will appear in the the D2D presenter menu under News.

The release has the necessary metadata to characterise the content, and points to data/high-res assets (at least an image).

A lecturer thinks this is relevant news, flies to the host star in the planetarium system, downloads assets and presents them to the audience.

- Number of events: —
- Increment per year: 3500
- Implementation: This use case will be implemented by the Portal to the Universe[1] (PTTU) module of D2D (PTTU is a content provider, a project sponsored by ESO, ESA/Hubble and the IAU). Press releases from all astronomy and space organisations are crawled and syndicated by PTTU.

1 portaltotheuniverse.org

Updated sequence for a solar system show

For a planetarium show about planets, a regular update segment will be developed by the producer, in the form of a real-time show sequence. This is then distributed and shown on different fulldome systems.

Presentation metadata tags are used to describe how the media of the update sequence should appear on the planetarium dome.

Using the D2D tools, the sequence package—data and a metadata file describing the sequence—are distributed to the planetariums.

The presenter picks the most recent update, downloads the data/high-res assets and metadata file, and the local planetarium software automatically translates the presentation metadata into its native scripting language (or similar) and runs the sequence.

- Number of events: —
- Increment per year: 10-20
- Implementation: The presentation metadata are planned to be implemented by LWL-Planetarium Münster (Björn Voss) and Planetarium am Insulaner, Berlin (Jürgen Rienow).

Sky event

Tonight is a lunar eclipse!

The event appears in the presenter menu.

As it is ranked highly, the presenter bring this event up in today's "Sky at Night" shows. The associated assets (images, flat videos and fulldome videos) are downloaded, automatically distributed to all render nodes of the planetarium system, and available for instant presentation. The lecturer is supplied with background information concerning the event, such as the times of key milestones.

- Number of events: Around 600 (for the period 01.01.2017–31.12.2018)
- Increment per year: 300
- Implementation: This use case will be implemented by the AstroCalendar module of D2D. AstroCalendar is a project of ESO, for the ESO Supernova Planetarium & Visitor Centre[1] (a new planetarium at ESO's Headquarters in Garching bei München).

1 supernova.eso.org

The Content Providers must guarantee that data and metadata are free to use by the planetariums (preferably under a Creative Commons Attribution licence; see Davies & Christensen, 2016). This content will need to be curated so that the best (most relevant and most interesting) data are provided. The metadata are made available in a JSON file. Example Content Providers are: ESO, NASA Spitzer, NASA Chandra, NASA/ESA Hubble, Gemini, Keck, Keck, ESA, NOAO, NRAO, NAOJ, NASA.

The Planetarium Vendor will (through a Vendor Cloud solution) synchronise the JSON file as often as necessary, provide an interface that allows the presenter to search and filter the metadata instantaneously, and then download the presenter's chosen asset on demand in any size needed (the JSON file has deep links for different format/sizes). The metadata are archived and ranked so that the best content is most visible at any given time.

The data assets are automatically sent to the render nodes, sliced if necessary, and installed at the appropriate location for easy display (at the default location of the dome, i.e., the "sweet spot," with the default size if not specified otherwise). The planetarium presenter is also offered a text summarising the content on a console screen. Example Planetarium Vendors are: Digistar/E&S, Dark Matter/Sky-Skan, Uniview/Sciss, Powerdome/Zeiss, SkyExplorer/RSA Cosmos, Mitaka/NAOJ, OpenSpace, World Wide Telescope/AAS.

Conclusion

Space science and astronomy are attractive subjects to both students and the general public. Planetariums are important venues where the public can get excited about science and as learning environments they have a proven advantage over classrooms and other venues. One way to make the subject of astronomy come to life in a planetarium is to communicate authentic science as soon as possible after it happens.

The D2D project is aimed at streamlining the flow of content from research institutions to planetariums, offering audiences a unique opportunity to access the latest data from space in real time.

Several use cases are being implemented, by Content Provides such

(Continues on next page)

The Chelyabinsk meteorite

An important event like the Chelyabinsk meteorite takes place.

It happens too fast for a press release to appear, but a blog contains a link to a high-res video of the Chelyabinsk event.

The D2D blog JSON file is automatically updated within minutes to contain the new press release metadata.

Soon after (to be determined by the vendor) the news will appear in the the D2D presenter menu under News.

Owing to its importance and topicality, the asset soars in the ranking.

It is quickly discovered by presenters worldwide.

The asset is displayed on domes worldwide hours after the event.

- Number of events: a few.
- Increment per year: a few
- Implementation: This use case will also be implemented by the Portal to the Universe module of D2D (blogs can also be featured in D2D).

Historical event

It's 20 July .

The D2D menu highlights the anniversary of the Apollo 11 moon landing.

The planetarium operator brings up this event in today's "Sky at Night" shows. The associated assets (images, all-sky images, flat videos and fulldome videos), are downloaded, automatically distributed to all render nodes of the planetarium system and available for instant presentation. The lecturer is supplied with background information concerning the Apollo 11 moon landing.

- Number of events: Around 300.
- Increment per year: 5
- Implementation: This use case will be implemented by the AstroCalendar module of D2D. AstroCalendar is also a project of ESO, for the ESO Supernova.

Videos (flat and fulldome): ESO

The presenter needs a video of a 3D flyaround of a globular cluster.

Presenter searches the metadata in the Vendor Cloud, and finds a ESO fulldome video[1].

The 9.4 GB 4k-frames data package[2] is marked for download and are displayed on the dome after a few hours.

- Number of items: Around 3000
- Increment per year: Around 150.
- Implementation: This use case will be implemented by ESO.

Videos (flat and fulldome): HST

The presenter needs a video of the super-Earth 55 Cancri e.

Presenter searches the metadata in the Vendor Cloud, and finds a Hubble flat UHD video[3].

The 100 MB Ultra HD H.265 frames data package[4] is marked for download and is displayed on the dome after a few minutes.

- Number of items: Around 1100
- Increment per year: Around 50.
- Implementation: This use case will be implemented by ESA/Hubble for ESA.

1 www.eso.org/public/videos/globularcluster
2 Downloaded directly from media.eso.org/public/archives/videos/dome_4kmaster/globularcluster.zip
3 www.spacetelescope.org/videos/heic1603a
4 Downloaded directly from www.spacetelescope.org/static/archives/videos/ultra_hd_h265/heic1603a.mp4

Images: HST

The presenter needs an image of the interesting Wolf-Rayet object WR 124.

Presenter searches the metadata in the Vendor Cloud, and finds a Hubble image[1].

The 3.8 MB 1300-pixel image data[2] are marked for download and are displayed on the dome after a few seconds.

- Number of items: Around 5000
- Increment per year: Around 200.
- Implementation: This use case will be implemented by ESA/Hubble for ESA.

Images: ESO

The presenter needs an image of the interesting Flame Nebula.

Presenter searches the metadata in the Vendor Cloud, and finds an ESO image[3].

The 145 MB 7000 x 9000-pixel image data[4] are marked for download and are displayed on the dome after a few minutes.

- Number of items: Around 11,000
- Increment per year: Around 600.
- Implementation: This use case will be implemented by ESO.

1 www.spacetelescope.org/images/potw1533a
2 Downloaded directly from www.spacetelescope.org/static/archives/images/original/potw1533a.tif
3 www.eso.org/public/images/eso0949a
4 Downloaded directly from www.eso.org/public/archives/images/original/eso0949a.tif

as ESO, ESA/Hubble, Adler Planetarium, Planetarium Münster and Planetarium am Insulaner, Berlin.

In the medium-term, presentation metadata could be added with indications of how the data/high-res assets should be presented. This would be most useful for news items involving multiple images or media, e.g. crossfades of images of the same object at different wavelengths, at different times, or simply side-by-side arrangements of images that are related to each other. Another example would be the astronomically correct positioning, and perhaps zooming, of images of celestial objects. Furthermore, such presentation metadata could be employed even beyond the scope of D2D, allowing users to exchange very simple show sequences between planetarium systems.

It is planned that D2D will be expanded in the future to also include 3D models, catalogue data (point clouds, including event data), spacecraft trajectories, streamed video (e.g. from a telescope), and more.

In the longer term, a glorious vision would be to be able to exchange show sequences between planetariums systems involving the full real-time functionality of the planetarium software, presenting exciting data in aesthetically pleasing ways. This would require a meta-scripting language that can be translated to the individual proprietary scripting languages of each vendor.

In summary

We invite all Planetarium Vendors to a) set up a cloud solution which synchronises the content metadata (in JSON format) as often as necessary, b) provide an interface that allows the presenter to search and filter the metadata instantaneously, c) download the presenter's chosen asset On Demand in any size needed, d) archive and rank the metadata, e) send the data assets to the render nodes (sliced if necessary), f) show them at the default location of the dome, and g) provide the planetarium presenter with a textual summary of the content on a console screen. We encourage all new Content Providers to get in contact with the D2D project, and to set up JSON files according to the specifications on the D2D web page.

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Glossary

Asset: The type of content provided by the D2D system (metadata, images, videos etc.)

AVM: Astronomy Visualization Metadata Standard. A metadata standard that describes how metadata tags in the header of an image file can contain information such as position, orientation and size of the image on the sky, a popular description of the Content resource, credit information and more.

Client: The planetarium presentation or planetarium production system of a community member.

Cloud: A model for enabling ubiquitous, convenient, on-demand access to a shared pool of configurable computing resources like storage and computing.

Community: The ecosystem comprising all planetariums, companies and other institutions contributing to the planetarium world.

Content Provider: A (research) institution producing content, intended for dissemination through the D2D system.

Data: The high-res assets that will be presented on the dome: large images, video (incl. fulldome) and other data.

Data curator: A person or institution that ensures that the data available through the D2D system is up to date, scientifically accurate and aesthetically pleasing.

JSON feed: JavaScript Object Notation is an open-standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs. It is a way to store information in an organised, human-readable, easy-to-access manner.

Metadata: Data (typical human readable text) that provides information about other data.

Meta-scripting language: A scripting computer language. It is possible to translate between different scripting language and the meta-scripting language back and forth in an unambiguous way.

Planetarium presenter: The person who lectures a planetarium show and interacts with the audience.

Planetarium software: A software rendering a simulation of the Universe as a function of time and the observer's location. Examples: Digistar, Dark Matter, Uniview.

Presenter menu: A window on the graphical user interface of a PC at the planetarium presenter's console. The interaction of the planetarium lecturer with the D2D system is done through this window. All content assets available in the D2D system are displayed in this window, subject to certain, user-defined filter rule such as object name or newness of an asset.

Script language: A structured computer language that allows to arrange media assets (videos, images, sound, 3D models, camera movements) to specify a planetarium show.

Sky tonight live show: A typical planetarium show or show segment, often lectured live, presenting the starry sky as it can be seen from the planetarium's location at the day of the presentation.

Vendor: A company which sells or implements planetarium hardware, software, content and systems.

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The past through the future

Carolyn Collins Petersen
IMERSA Communications Coordinator

The world of immersive cinema continues to expand beyond the "traditional" fulldome and large-format screens of the world. Recent developments that all of us in the fulldome community are watching include the growth of virtual reality (VR) and augmented reality (AR). I've discussed these in prior columns as they continue to make inroads into our homes and classrooms.

This rise in new technology comes 20 years after the introduction of fulldome systems at the 1996 IPS conference in Osaka, Japan where GOTO first introduced its Virtuarium, and 18 years after the 1998 conference in London, where Sky-Skan introduced its early fulldome system. At both, attendees were dazzled with the future of our medium–a future you and I are experiencing now with the expansion of products by Evans & Sutherland, Digitalis Education Solutions, e-Planetarium, Konica-Minolta, Zeiss, the Elumenati, SCISS, RSA Cosmos, Sky-Skan, Spitz, Starlab, and others.

The pace of change continues. As this column is written, I note the introduction of a product that uses the smart phone in your hand to give a view of the sky and overlays a "heads-up" display to explain what you're seeing. It's called Universe2Go (universe2go.com) and is available now. Chances are that more such products will show up in the coming months.

Granted, we've had astronomy apps on our phones and iPads and computers for years. I've personally worked on one called StarMap (star-map.fr), and there are many others out there. Universe2Go is taking the next step, uniting VR/AR and astronomy. It will be interesting to see where it goes, but these move squarely into the astronomy-based territory that fulldome theaters and planetarium facilities are used to occupying.

With the rise of astronomy apps and computer programs, the stargazing territory of the planetarium has made the leap to the larger marketplace. Planetariums still offer these same things for audience experiences led by live presenters, so I don't think the addition of VR/AR will affect our domain as much as we might fear.

In addition, most theaters offer pre-rendered content that explores all the nuances of many sciences: astronomy, physics, astrobiology, planetary science, and others. There is also a growing collection of arts-based shows available, which theater operators and audiences are coming to appreciate. You can see a complete listing of shows at The Fulldome Show Compendium (www.lochnessproductions.com/lfsc/lfsc.html) as well as at the Fulldome Database (fddb.org) to appreciate the great depth and breadth of shows "out there."

Fulldome festival time

The rise of fulldome content has led to another important phenomenon: the fulldome film festival. There are a number each year, bringing together content, judges, and audiences to see and give awards to new shows. They have their roots squarely in the realm of such festivals as Sundance, Cannes, and others (although perhaps not as fancy as those). I see the rise of festivals as a way for our fulldome community to learn what's out there and honor those who do a good job at their craft. I've judged for the Jena festival, and more recently for several rounds of the Jackson Hole Wildlife Film Festival (JHWFF).

This year I focused my attention on regular HD offerings in the "Earth and Space Sciences" division. There were dozens of shows ranging from productions by NOVA, NHK, National Geographic, and a range of independent producers. On the immersive side, the festival had ten fulldome entries, two digital 3D shows, and two IMAX 3d presentations.

For JHWFF, the criteria for judging science videos are spelled out quite well, ranging from writing, cinematography, technical execution, camerawork, soundtracks and so on, to overall impact. It usually takes me two times through a video to get a good feel for its achievements. It's time well spent; I almost always learn something new from each one.

The criteria for fulldome shows are the same–after all, cinema is cinema, and there are rules of storytelling and technical achievement that are common to all forms of media. Complicating matters are the requirements of the dome, which impose peculiar restraints on the filmmaker. Similar ones fall upon the creators of VR and AR. In the end, a good story is a good story, and what we're judging is how well it's told (and how it affects the audience).

Winners of Janus awards at the Jena FullDome Festival join with the festival organizers on the final gala evening of the festival. Credit: Jena FullDome Film Festival

This past summer's fulldome festivals included the first-ever ImmersiveFest in Madrid, Spain (held May 18-21), the Jena FullDome Festival, and the Brno Fulldome Festival. The Fiske Fulldome Film Festival took place in August (more on that in the next issue), and the Fulldome UK festival is slated for November 4-5, 2016.

Fulldome in Jena

The 10th Jena FullDome Film Festival was held 26-28 May with the theme "Frameless Frenzy." Its signature award is the Janus trophy, for


Left: Mike Bruno (left) and Brad Thompson from Spitz Creative Media accept the award for *Solar Superstorms* at the Brno Fulldome Festival. At Right: Ryan Wyatt accepted the award for *Incoming!* for the California Academy of Sciences. Photos courtesy Brno Planetarium.

the double-faced Roman god of beginnings and endings. The festival honors both seasoned producers as well as student works, with an emphasis on short films.

The winners spanned the world with creative works ranging from artistic endeavors to science topics. This year, the Janus awards for short films were awarded to *Cernunnos* (First-year Students Award), *Scalarat* (Creative Award), *The Shadow* (Performance Award), *protokoll_001* (Audience Award), *Aurelio* (Emphasis on Emotion Award), *Clockwork Ocean* (Best in Science Visualization), *Samskara* (Special Awards Best Short Film), and *Intensional Particle Dome Installation* (Frameless Frenzy Award).

Full-length films receiving recognition were *The Secret World of Moths* (Award for Use of Innovative Production Technologies) and *We Are Stars* (Directors Award), along with a healthy list of honorable mentions, which you can find at the festival site (fulldome-festival.de).

Jena FullDome Festival organizers Micky Remann, Volkmar Schort, and Jürgen Hellwig announced Janus-like beginnings and endings of their own. Micky mused on the future of the event at this year's festival "Ten years is a long time for a festival and we have seen so many changes in the fulldome world that we've asked ourselves, "What is that we've done?" he said. "Where are we now and what can we do in the future? Is there a future?"

The answer to that last is "ye.s" Next year's festival will be a "resurrection," with the three founders still taking part, but with a new organizational structure to promote the art, business, and future of fulldome.

With funding from a foundation set up by Ernst Abbe Stiftung (the owner of Jena Planetarium), a newly-reorganized Jena FullDome Festival will take place on May 17-20, 2017. The foundation's event will be open to cosponsors from around the world, and as soon as the details are finalized, the rejuvenated festival will move forward toward its future.

Fulldome in Brno

The Fulldome Film Festival Brno, 15-17 June, hosted 152 planetarium and fulldome fans and producers from around the world. This one may set a record for endurance: 66 shows were shown over a span of nearly 27 hours and 25 minutes of dome time!

According to Ryan Wyatt, who attended this year's festival as well as last year's inaugural event in Brno, the venue offered many comforts outside the dome, as well. "Luckily, festival attendees also had the opportunity to relax and network in the comfortable environs of the Brno Observatory (with lovely views of the city and surrounding park)," he wrote. "The observatory staff supplied visitors with name badges that included Czech phrases to help us ask for a beer or find our way back to the planetarium."

As mentioned on page 14 in this issue, the three top winners at the Brno Fulldome Festival were Solar Superstorms, The Man from the 9 Dimensions, and Incoming!

IMERSA at IPS 2016

The board of directors of IMERSA attended and presented at the IPS meeting in Warsaw this past summer. The conference offered many interesting and beneficial presentations, and the board conveys its deepest appreciation to Maciej, Monica, and the entire IPS 2016 team for staging a wonderfully successful event. Of interest to fulldome producers was a fascinating session, "360 Composition," convened by Warik Lawrence (Melbourne Planetarium). Speaker Aaron Bradbury (NSC Creative) explored the effectiveness of cinematic conventions in the dome, with numerous original images and conceptual illustrations.

In the same session, Max Bielecki (University for Social Science and Humanities) and Katarzyna Potęga vel Żabik (Copernicus Science Centre) shared their ground-breaking research about audience eye motion in relation to composition, tracking viewers' attention around the dome.

IMERSA was pleased to participate presenting two sessions: "A World of Immersion" (session organized by IMERSA), and after a decade of effort, "Release of First Planetarium Industry Standards & Future," a session organized by AFDI and convened by Benjamin Cabut. (See box on next page.)

Save the date

Plans for the next IMERSA Summit are already underway. The dates are February 22-26, 2017, and the location is the Denver Museum of Nature and Science. It will continue our conversations between all the sectors of the fulldome market: equipment vendors, content producers, artists, and others. Save the date now! Watch the website at imersa.org for more information. ☆

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AFDI introduces next-generation fulldome standards

IMERSA board members Michael Daut, Ryan Wyatt, and Dan Neafus report on an initiative that first began under the IMERSA aegis. The Association of Fulldome Innovators (AFDI) was founded at the IMERSA Summit in 2014, when representatives of four leading fulldome equipment vendors agreed to meet together to discuss and implement standards for the community. The founding vendors of AFDI are Evans & Sutherland, Sky-Skan, SCISS, and RSA Cosmos. Since AFDI's founding, four other supporting equipment vendors have joined AFDI: Zeiss, Goto, Konica-Minolta, and Fulldome.Pro. AFDI is operated under the auspices and supervision of IMERSA.

AFDI's vision is to define and implement shared standards for fulldome technology vendors. AFDI is uniquely positioned to do this, since the members are all vendors that can leverage their experience designing systems to define and implement shared standards into their individual platforms.

IMERSA Board member Michael Daut (left) discusses the AFDI standards work in progress at IPS 2016 in Warsaw. With him are Glenn Smith, Sky-Skan Europe; Per Hemmingsson, SCISS; and Benjamin Cabut (RSA Cosmos). Credit: Daniel Neafus/ IMERSA

The first steps toward standards were discussion in the session "Release of First Planetarium Industry Standards & Future" at the IPS 2016 Conference in Warsaw.

To date, AFDI has delivered two significant specifications to the community:

- metadata specs for the delivery of fulldome shows, and
- a "universal" MPEG2 2K×2K video encoding specification. Both specs have been published to www.imersa.org/standards/afdi-dome-standards-group.

Specs help to deliver assets

The metadata specs were designed to help producers deliver fulldome assets (dome originals, audio, etc.) to distributors or film festivals for encoding. Metadata indicates frame counts for dome originals, number and format of audio channels, frame rate, 2D versus 3D, etc., to make content transport more efficient and more understandable by the recipients.

This simplifies and standardizes the transport of show assets. RSA Cosmos is creating open source software to allow the community to create the metadata, and the AFDI vendors have committed to implement a metadata reader into their slicing and encoding software.

In order to facilitate the delivery of fulldome trailers and/or fulldome show screeners directly from producers to theaters, AFDI has developed a "universal" MPEG2 encoding specification for 2K×2K fisheye videos that will play back on most fulldome systems regardless of the vendor.

AFDI has specified 36 Mbps and 20 Mbps bit rates for these videos, and producers may choose to add a "watermark" onto the imagery to discourage piracy, especially of full-length screeners. In addition to the published spec, all AFDI vendors have agreed to implement the AFDI 2K×2K encoding specification as an option in their individual encoding software packages.

During the AFDI session at IPS 2016, the audience was able to see samples of video and grids encoded using this specification. AFDI will post sample encoded videos and grids soon for community members to test on their systems.

What's up next?

The next big priority is to establish a shared encryption standard for the entire community that will be implemented by all equipment vendors. This standard will allow shared encryption keys and site license keys for the community.

AFDI vendors are working on encryption methods so that content can be used throughout the community, and will establish best practices for decryption of videos that the individual equipment vendors can implement in their own systems (using established standards). This effort is supported by all AFDI equipment vendors.

Progress may seem slow, but it is happening. AFDI is aligned to achieve and deliver shared standards, but it will take time, since this is a volunteer effort that is on top of regular business activities for each vendor. Stay tuned for great new developments.

To suggest AFDI priorities, please email info@imersa.org, and to help with extended standards initiatives, please email Ryan Wyatt at ryan@imersa.org. ☆

Carolyn Collins Petersen

Ross Campanella (left) working with Spitz's Brad Rush on the Spitz SciDome system.

(Spitz scholarship, continued from page 50

loved to answer any questions I had. The facility was amazing, and being in the domes was like a dream come true. The most influential person that I met was Dr. Bradstreet from Eastern University. I had a lot of conversations with him and he was able to give lots of good advice."

During his week at institute, Ross was introduced to hours (and hours) of interaction with the SciDome digital planetarium system, including intensive hands-on sessions with SciDome's simulation software. Over the four-day week Ross expanded his understanding of lesson creation, fulldome show automation, earth-science education, and techniques for making sophisticated astronomy shows with Starry Night.

"All in all I learned a lot from going to Spitz and made many new connections," says Ross. "I'll return someday, hopefully from my own tilted 40 ft. planetarium with 4K projection. Who knows, but I do know I'll be back, and it'll be out of this world." ☆

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Animals not in the celestial zoo

Jessie Shanks

It has been a busy summer. I picked up a lot of great ideas and got to do some great networking at IPS 2016 in Warsaw. One of the other projects I have been working on is with some of my students.

Birth of a student project

Several years ago I attended a WIMPS (Wisconsin, Iowa and Minnesota PlanetariumS) meeting at Minnesota State University at Moorhead and saw their presentation ***Sky Zoo.*** It was a partnership between the planetarium and their local zoo. Two years ago, I decided to do an adaptation using my local zoo and invited some students to help as a group project. The kids decided to focus the show on constellation animals and their real life adaptations.

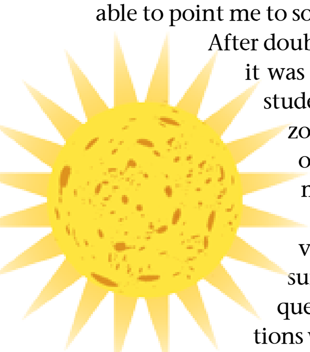
10 months later: It took some time. Organizing 7th and 8th graders into writing teams so they could decide on what they wanted to contribute took longer than I thought it would. After brainstorming the list of animals they wanted to work with, the students used a five-paragraph organizer (www.studenthandouts.com/3web/FiveParagraphEssayOrganizer.pdf) to create some standardization between groups.

It felt like forever, but there finally was a script that we could work from. The teams had to be reconfigured, as the older students went off to high school and new students were brought in. While this change of membership did change the dynamic of the groups, they were still able to work with the scripts.

I was fortunate that no one had issues with assorted animals like snakes and naked mole rats.

I teach Astronomy, I don't deal with the living

I found myself saying this a couple of times when kids would ask me questions about their animal that they couldn't find with research. I had previously met with the zoo's educational outreach director to develop a procedure for them to meet with the zoo caretakers. She was able to point me to some reliable and age appropriate resources.



After double-checking our facts and selecting our narrators, it was time to start recording the audio segments. The students decided to record the interviews with the zoo staff members because while they had an idea of what would be said, they thought it would be more authentic to just having them read a script.

Part of the script required the students to interview the same staff members in the winter and the summer. The kids really only needed to ask about 4 questions, but found that they would ask 10-12 questions when the time came. When we brought the video back, it meant they were able to eliminate some questions and maintain the flow of the story.

Do you see what I see?

When we were collecting videos we used a variety of cameras that were borrowed from other departments and schools. While this was a good cost-saving method, it did cause some problems when cameras were not set the same preferences. For example, we were using a FLIR camera to look at the heat dissipation off of assorted mammals and reptiles and the video was recorded at 24 fps instead of the 30 fps of the rest of the presentation.

The sad thing was we didn't notice the problem until we rendered the rough draft of the presentation. After speaking to a couple of experts we came up with a plan to correct the issue instead of going back and doing an additional take at the zoo.

The students have about 90% of the winter portion of the presentation done and I finished correcting the frame rate problem with the summer video as well as a couple of resolution issues. As we approach the start of the next school year, I have to say we are further along than I thought we would be, but a couple of areas are still well behind schedule. I think making this a student coproduction has lengthened the production time, but it has been worth it: the students are feeling a lot of ownership in the presentation.

Lesson plan

I actually had trouble preparing this section of the article. I wasn't short for ideas, but noticed that all the topics on my brainstorming page would fit in the category of "start of the school year." So I jumped ahead in my plan book toward the middle of the second term and landed on my unit "All the Small Things."

It is a fun lesson that uses my area's moderate to heavy snowfall to give us an ample supply of samples. Younger students go out and gather 300 ml of snow that will get analyzed for micrometeorites. My older students use about 500 ml of snow to make "comets."

Quick Comets

- 500 ml snow
- 10 ml sand
- 5 ml aquarium gravel
- 1 ml potting soil

Students mix the four ingredients together outside to prevent/minimize melting, then shape them into a form that they think will best survive the heating from our artificial "sun." Once the mix is shaped, the student places it on an upside down cup in a pan (to catch the water and debris).

Our artificial sun is a 500-watt halogen work light aimed at the "comets" from 3 meters away. The students go into the planetarium for a show after documenting the size and shape of their comets.

Afterwards, they repeat this process and observe changes to the comets. This normally takes about 60 minutes and by the end the students can make some predictions for what causes comets to break up after only a few passes around the sun. It is also useful for opening a discussion on how the shape altered the melting rate.

There is also something funny about a comet shaped like a snowman. ☆

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Lots of great LIPS during Warsaw conference

By the time this is published, nearly three months will have passed since IPS 2016 in Warsaw, Poland. My thanks and congratulations to our hosts at the Copernicus Science Centre! It was a beautiful facility, and I enjoyed my time there tremendously. It was exciting to see how busy the science centre was with public visitors; the science centre is obviously a valued community resource.

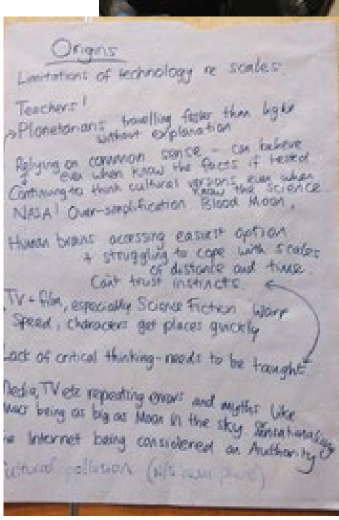
I was happy to see a renewed emphasis on live programming at IPS 2016. Several of the workshops had a LIPS flavor, and some were organized and presented by regular LIPS attendees.

I want to thank Dr. Rob Cockcroft of McMaster University (Canada), Dr. Keith Davis of the University of Notre Dame's Digital Visualization Theater (USA), Kaoru Kimura of Japan Science Foundation, Patty Seaton of the Howard B. Owens Science Center (USA), and Dr. Jenny Shipway of the Winchester Science Centre and Planetarium (UK). I had the pleasure of presenting three workshops with these talented people, and I know that the participants enjoyed the workshops as well.

The workshops that I co-presented were (in chronological order):

- "Audience Perspectives in Live Shows." Rob, Patty, and I led small and large group discussions in this workshop. Conversations centered on the advantages of live, interactive programs over prerecorded; the advantages of prerecorded shows over live; challenges of live programs; challenges of prerecorded; and a discussion about using a blended approach (mixture of live and prerecorded).
- "Targeting Different Learning Styles." Keith and I first reviewed with the whole group the seven different learning styles identified by the US-based Institute for Learning Styles Research (print, aural, visual, haptic, interactive, kinesthetic, olfactory). Participants then worked in small groups to design activities targeting each learning style for a popular planetarium topic (seasons, for example).
- "Local vs. International Misconceptions." Rob, Jenny, Kaoru, and I led small and large group discussions on what the word "misconception" means, what misconceptions our planetarium visitors hold, and—taking advantage of the international attendance—which misconceptions seem to be localized versus universal.

If you want to know what ideas came up during any of the above workshops, please see the IPS 2016 conference proceedings.



Above, participants in the leaning styles workshop (photo by Keith Davis); left: notes from the misconceptions workshop (photo by Karrie Berglund).

Great feedback on other sessions

These were certainly not the only LIPS-style workshops or sessions at IPS 2016. However, given my additional role as a vendor, I unfortunately did not have time to attend many sessions. I heard great feedback about many other sessions and wished that I had been able to attend just about every session on the schedule.

Rob Cockcroft is a frequent LIPS attendee, and he sent these reflections on IPS 2016:

"After co-presenting two LIPS-style workshops (discussion-based sessions on the pros and cons of live and pre-recorded shows, and about astronomical misconceptions), I confirmed to myself—and I hope others, too—that there was a healthy interest in such workshops, especially when we were competing against a number of parallel sessions that included invited speakers.

"Participants were engaged in very lively conversations within their small groups, to the extent that it was sometimes difficult to bring the whole room back together to share their thoughts with everyone, a good problem to have!

"Contributors, from a variety of backgrounds, were able to share the conversation equally so that we enjoyed hearing a breadth of experiences. In both sessions, we had to cut short the pre-planned content because there was so much discussion generated with the initial topics."

Conducting research session

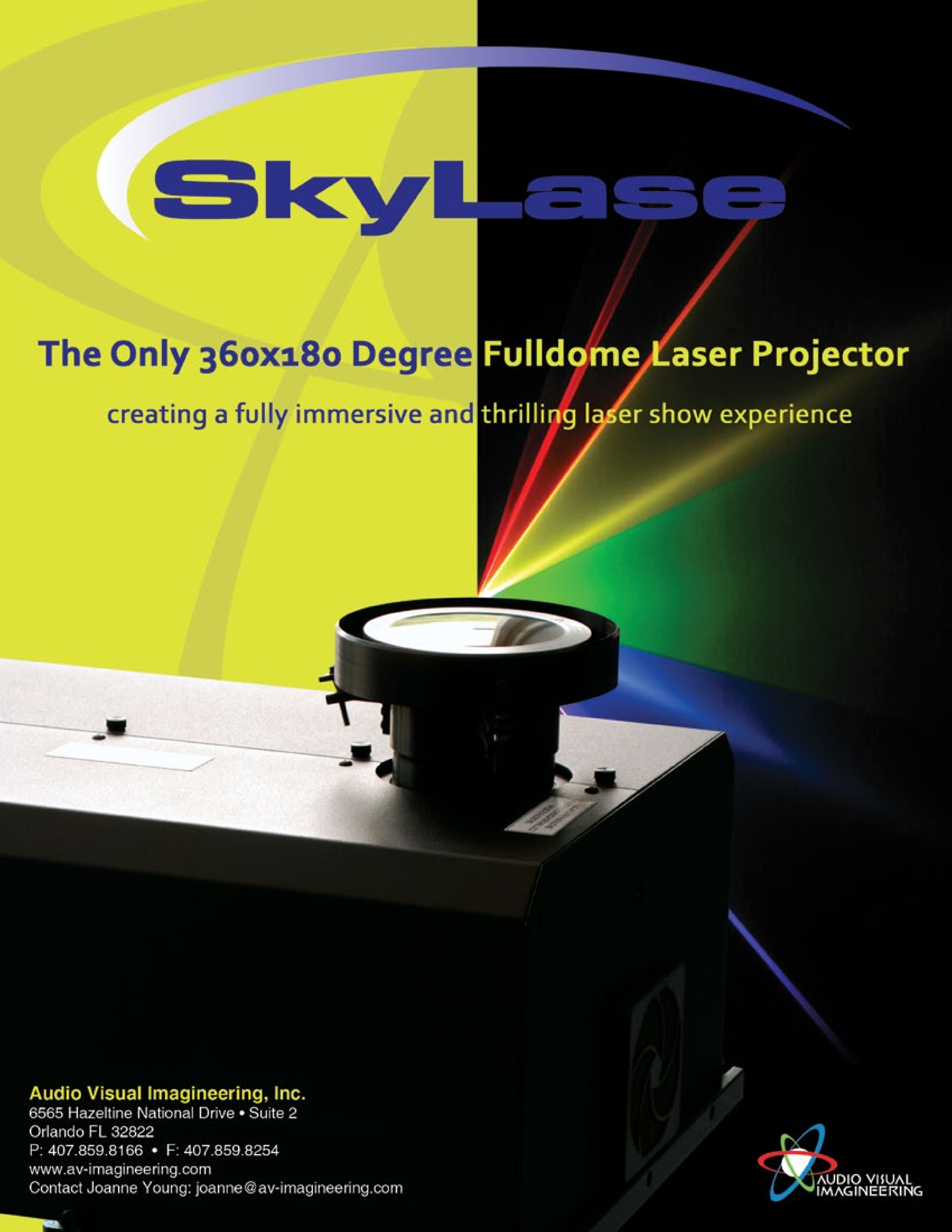
Another interactive workshop, that I enjoyed attending as a participant rather than as a co-presenter, was the "Conducting Research in a Planetarium" session by Julia Plummer, Shannon Schmoll, Ka Chun Yu, and Chrysta Ghent. After covering some initial information about how to go about planetarium research, we were encouraged to work in small groups to walk through the various stages of building a research proposal and the associated considerations we would have to make. Even though I already knew about most of the initial information presented, I still found it extremely useful to hear about other people's experiences and insights during the small-group discussions.

I'm very pleased and excited to see that Toulouse's IPS 2018 conference has live programming as one of its main themes; I look forward to learning about more live programming ideas and techniques in interactive workshops then!

Shining light on moon phases

Susan Button, another frequent LIPS attendee and past IPS president, sent these comments about the IPS Education Committee session

(Continues on page 72)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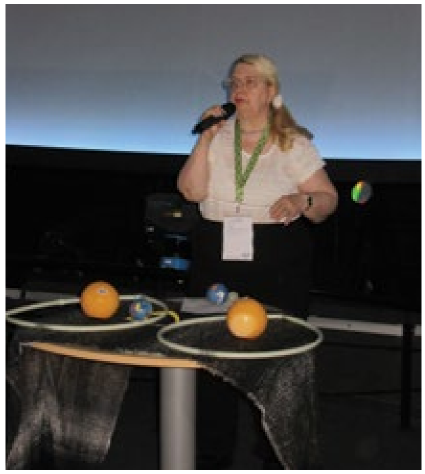
AUDIO VISUAL IMAGINEERING

titled "Shining Light on how to Teach Moon Phases in Darkness:"

"I really enjoyed the give and take in this session about the different ways we all approach the teaching of "why" the phases happen and the fact that people are really questioning how we can know if the students are really getting the concepts we teach. Many times we are teaching so that the students will give us the preconceived answers that we already decided were the "correct" answers.

"Just having students experience and share that from their different places in the dome, they see different phases can lead to deeper learning about the properties of light on a sphere and poses a problem for them to solve. Talk about an opportunity to seize the moment: this is an example of a naturally-occurring cognitive dissonance!

"Instead of persisting in trying to get everyone to see the same thing with our model, we can use this moment to have students do their own problem solving. When they can explain why each person sees what they see in the dome, they can be guided to figure out why, on the other hand, everyone on Earth sees the same moon phase and why satellites in space "see" phases of the planets."



Jeanne Bishop, left, and Paweł Ziemnick during the moon phases workshop. Photos by Susan Button.

Rob's and Susan's comments echo my own experiences. I am grateful to the Warsaw team for making a number of changes that I felt dramatically improved the IPS experience. The emphasis on live programming and the use of the domes for several attendee-led sessions (rather than only for vendor demonstrations) were two changes that I feel made a big difference in the quality of the experience.

On to the Vision202 survey

Many of you likely know that I also lead the Vision2020 team focusing on professional development (PD). The Vision2020 PD team compiled a survey to get feedback about IPS 2016 from those who attended. If you were at IPS 2016, I hope you had a chance to fill in the survey. Thank you to the 64 people who responded!

It was gratifying to me to see that so many attendees commented positively on the format of IPS 2016. There were several references to LIPS or live programming in responses to the question, "Which sessions or workshops [at IPS 2016] were most beneficial to you? Why?" Here are some sample answers:

- Ones dealing with learning in planetariums and how to conduct research.
- Teaching moon phases and misconceptions session.
- The sessions on live use of data sets in the dome and interactive presentation in the dome.
- Vendor sessions and panel discussions. I'm finding when presenters engage their audiences, better results are produced.
- Those dealing with research and interactive education workshops.
- Pedagogy, learning, new free softwares, demonstration of new shows, workshops.
- Sun dome (the main dome in the science centre) live presentations—each presenter showed how their live presentations worked and provided good ideas.

Here are some suggestions from the survey for future sessions/workshops that pertain to live programs/LIPS:

- I do like opportunities where live and interactive planetarium engagement is discussed. Any opportunities where a LIPS-type workshop can be held at the IPS level would be beneficial to all of us.
- Focus on live navigation of data. Connecting to the audience.
- Make a textbook for live presenters.
- Interactive presentations in the dome.
- How to incorporate latest astronomy into a live show thread.
- Loved the emphasis on live, interactive programming. Would like to see more tips and tricks and techniques for live flying and more practical paper sessions that can help me out with day-to-day activities and shows. Maybe have a panel around "what's desired" in the planetarium world—what kinds of shows are theater managers and audience looking for, what's been most successful in their own facilities, what have they tried that hasn't worked. Would absolutely love some kind of open discussion forum, perhaps on different topics of interest—presentations, operations, production, attendance, marketing, schools etc.—rather than the sit-and-listen-to-the-presenter format that we're so used to.

I have not yet had a lot of time to delve deeply into the survey results. In the near future I hope to find time to look for trends between the IPS 2016 professional development survey, the March 2015 initial Vision 2020 professional development survey, and any other data I can get. I will write more about the Vision 2020 professional development team, its findings, and its plans in a future column.

One goal of the Vision 2020 PD team is to give guidance to help make IPS and its conferences as valuable as they can be. In the IPS 2016 professional development survey, we collected feedback not only on the recent conference (what people's goals were, what sessions/workshops were most beneficial, etc.) but also on what people would like to see at future IPS conferences. The full survey results have already been shared with IPS officers, Council, and the IPS 2018 host.

As Rob Cockcroft noted in his comments, the hosts of IPS 2018, Cité de l'Espace in Toulouse, France, have named live programming as one of the conference themes.

From the IPS 2018 conference announcement in the December, 2015 *Planetarian*:

"Planetarium Live! IN and OUTSIDE the dome" will be the first international laboratory of best live practices under and outside our domes, in all their dimensions and diversities. In order to be able to fully explore this theme, we plan to dedicate one of our two planetariums to this subject, and to use it for live planetarium sessions during all the conference."

You can read the full December 2015 article about IPS 2018 here: www.ips-planetarium.org/page/IPS2018Toulouse.

The IPS 2018 conference is shaping up nicely, and I can tell you from experience that Toulouse is a beautiful city with wonderful people. I am looking forward to visiting it again—more than 20 years after my first trip there.

Stay tuned for the next column for a review of LIPS 2016!

As always, please send comments or questions to me: karrie@DigitalisEducation.com. ☆

Seeking What Works
The IPS Education Committee

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Following Copernicus in Poland

Five past-presidents of IPS on the outdoor ledge at the top of the Copernicus Tower, Frombork, Poland. From left: David Weinrich, Martin George, Dale Smith, Susan Button, and Jeanne Bishop. All photos by or taken on behalf of Jeanne Bishop.

The IPS 2016 Conference in Warsaw was outstanding. From the standpoint of education, it was a great pleasure to have so many workshops, papers, and posters devoted to educational concerns . The Education Committee initiated some of these, but there were many more.

We had a very productive IPS Education Committee meeting as well, and new committee members and projects have been initiated. I will discuss the exciting new projects in future columns.

Also, please check the IPS website for project news and members. One very important ongoing project, which I have discussed in this column and which Oded Kindermann discussed in a paper at the conference, is the Video Collection Project. My own offering, a detailed video on teaching seasons to students age 10-11, is now available, and I hope that many of you who teach astronomy lessons in and out of the planetarium will also contribute to this archive.

Planetarian Editor Sharon Shanks has taken information from earlier columns about this project and organized it into a very helpful document that you also can find on the IPS website. (On the website, click "Committees," then "Ad Hoc Committees," then "Education." Or click on "Get Involved" and you can find the link there as well.) ips-planetarium.org/?page=EdCommVideo

For making a video, remember that 1) It can be short—5 minutes or so, or longer; 2) It can be done easily with just one other person who videos you with an i-phone; and 3) Although you should practice before taping, it does not need to be perfect. Video is not intended for use in a show but rather to learn others' presentation techniques and learn from them.

Following Copernicus' footsteps

Following the conference, a busload of us ventured north of Warsaw touring "In the Footsteps of Copernicus." In my last column, I discussed the story of the Copernican Revolution with suggestions for using it for programs. Some of the Copernican story came to life for me on this trip.

In Torun we saw Copernicus' childhood home, which is now a 4-floor museum. Frombork, where Copernicus lived and worked from 1509 until his death in 1543, was a special joy. Our group was treated to a program in the Copernicus Planetarium by Director Edith, who had spent 2 days preparing a presentation in English. The top of the Copernican Planetarium was covered with a cratered moonscape.

As we climbed the winding stairs of the Copernican Tower, a large but simply-made Foucault Pendulum centered on the floor above the planetarium dome, appeared smaller and smaller. The top floor of the Copernicus Tower opens to magnificent views of countryside.

Nearby we saw the home Copernicus occupied while in Frombork, where he made observations from a garden area. The Copernicus Museum contained some very interesting astronomy items from the time of Copernicus.

We also toured the adjacent Frombork Cathedral, which contains a memorial to Copernicus in the form of a section of the solar system. By this sculpture, one can peer below the cathedral floor to see the coffin of Copernicus, with bones reinterred after their discovery early this century.

Before IPS 2016, a fulldome festival was held in Brno, Czech Republic. I watched many fine shows, each a complete offering. For teaching purposes, I wonder if some fulldome presentations could be shorter, prepared with a particular age level in mind, and narrow in scope. If such modules were available, planetarium educators could match a classroom teacher request with a pertinent fulldome presentation, and then add live teaching to support it. I hope that fulldome show developers will consider this approach.

Challenges of different ages

In my own planetarium, this summer I am presenting different topic programs for a school camp. Each day I need to give four programs on a similar topic to students of different age: 5-7, 8-9, 10-11, and 12-13. The challenge is to make the presentation interesting and at the correct level for each group.

There are major differences by age in ability to understand concepts and analogies, in what is already known, in misconceptions, in vocabulary, in sense of humor, and in attention span. My solar system program for children ages 5-7 is very different from the one for students who are 12-13. There is no way that a single pre-recorded program would be appropriate for all.

A few ideas of things I consider and what is working with different ages:

Since very young children rarely understand the relationship between position of the sun and planets in the planetarium sky and a model as seen from space, I don't try to match the two perspectives for them. It is enough to see evening planets in the planetarium sky and see how telescopes and spacecraft make them appear large with great detail.

Also, I don't show distant planets like Jupiter close to the sun. Very young students lack the ability to picture Jupiter behind the sun, farther away. The youngest audiences enjoy personification and they are good at remembering facts. So after talking about several planets

(Continues on page 76)

and their characteristics, I ask a few children to pretend they are a planet and tell things about themselves. Others guess who they are.

Young children often have poorly-formed ideas about important planetary descriptive terms like "gas," "gravity," and "density," as well as undeveloped ideas of time and distance scale, so I must select words and analogies carefully.

Very young children do not understand the difference between a planet and a star or know the planets move around the sun, so a discussion of this is a good idea without trying to match a view of where the planets are in the sky with a model. An important concept about planets is that the sun shines on dark planets and makes them light. So I use a model to show how a dark ball is lit by a light. Young children can understand "reflected light." I let one student hold "the sun" and shine light on "planets" held by other children.

Old enough for modeling

For my two older groups, I discuss reflected light to see planets, but I also use a space model of the sun and planets. I discuss how the scale (along with other aspects of the model) is wrong and then relate the position of a couple of planets to their positions in the planetarium sky. The oldest students, at least at the time of the presentation, seem to understand, but the average student aged 12-13 is just beginning to be capable of this "projective view," a relationship between a space view and an Earth-based view.

The older groups have better science vocabularies, but they still have misconceptions. A few misconceptions that I have encountered are: there is no gravity in space, melt and dissolve mean the same thing, gas always is less dense (lighter) than solids and liquids, we see reflected light (and other waves) instantly after they leave a planet, people have traveled to planets, and the solar system formed in a smooth and nonchaotic way.

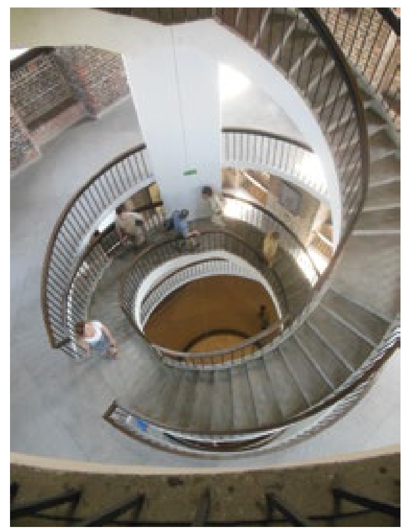
Since older students have developed a better idea of time, a discussion of the origin of the solar system is appropriate. I find that the older students have a great interest in how the solar system formed, so I devote some time to this.

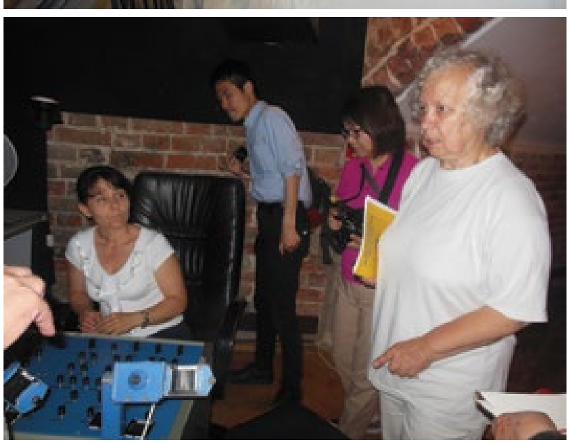
Of course, different film clips or slides are fine, but I have been using a magnetic board I have set up at the front of my planetarium to convey the nature of the early solar system. I was inspired to first try my own drawings and then a magnetic board for a number of topics after seeing Dr. Michael Turner's (University of Chicago; keynote talk at IPS 2012, Baton Rouge) chalk cosmology drawings. Creating a colored chalk drawing as one talks or moving items on a magnetic board seems to focus student attention better than any film or slide.

On my magnetic board I create collisions, some which reflect and some stick. I move large planets (Jupiter and Saturn) outward. Again, I need to discuss how the distance scale shown by the board is wrong and how time has been greatly condensed in the demonstration.

A surprise for me in presenting these different-level summer-school programs is this: Each group is responding best to a set of demonstrations and discussions that is not just a little different from what they expect or are used to in classrooms, but that also are fast-paced with a lot of different activities and information. I do not think fast-paced with a variety of information is the best way to learn a concept well, but it seems to be effective when the goals are to capture student interest and inspire instead of improve test results.

If we keep our goals firmly in mind, we can prepare the best programs for our audiences. I would love to see more planetarium research relating different types of goals to outcomes. ☆





On Left: The top of the Copernicus Planetarium dome, which has the topography of the moon. It is located at the base of the Copernicus Tower in Frombork, Poland. Below, Director Edith and her assistant Ewa Bloch the Copernicus Planetarium in Frombork, Poland, with IPS conference participants. On Right, from top: Sculpture of the heliocentric solar system commemorating Copernicus in the Frombork Cathedral. Next: Spiral steps to the top of the Copernicus Tower. Bottom: Shoichi Itoh and Jeanne Bishop with the IPS "In the Footsteps of Copernicus" tour at the home and gardens in Frombork, Poland, where Copernicus lived and worked until his death.

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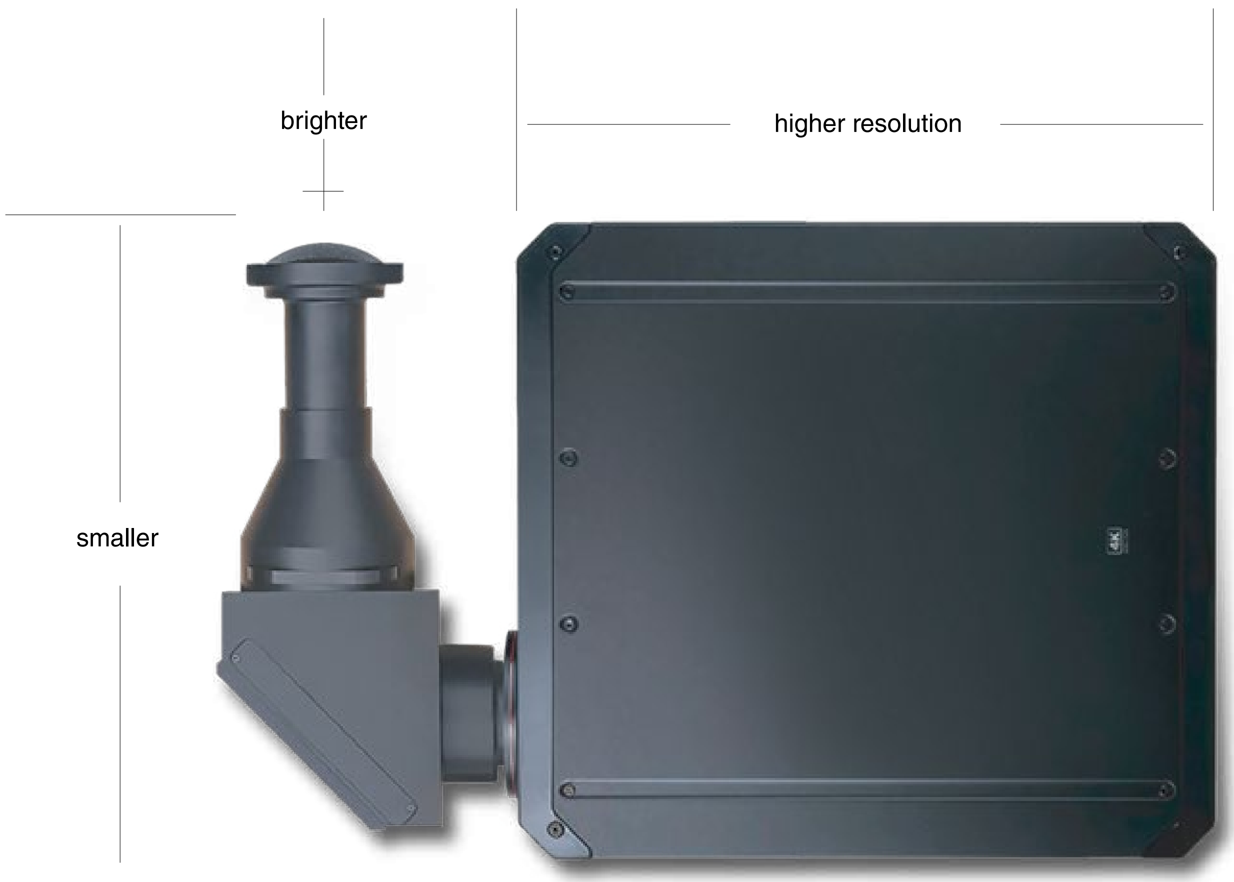

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(Factors, continued from page 29)

Areas for future research

There are several areas where this research could be extended. First, this study was conducted at a single museum with a limited number of participants. Expanding the study to include larger sample sizes may provide additional insights into the factors that influence planetarium educator teaching methods.

Another area of future research involves setting. As was revealed in the results of the study, there are key differences between fixed-dome planetariums and portable planetariums. It would be worthwhile to understand any similarities and differences of teaching methodologies between using different types of planetariums and planetarium programs.

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Give me the splendid silent sun with all his beams full-dazzling.

— Walt Whitman, first line of poem Give Me the Splendid Sun
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International News

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Dear fellow planterians

That the planetarium business is inventive, innovative, and constantly developing was proven once again at the wonderful conference in Warsaw, where I was lucky to meet some of you. Another proof can be found in the international news, which is filled with new events, new planetariums being planned, and conferences held, where experience is shared among planetarians. For this section I'm indebted to contributions from Shane Hengst, Rachel Thompson, John Hare, Bart Benjamin, Marc Moutin, Björn Voss, Loris Ramponi, Alex Delivorias, and Vadim Belov. We'll begin this tour around the world down-under.

Australasian Planetarium Society

The APS held its 2016 annual meeting at Space Place (Carter Observatory), Wellington, New Zealand on 4-5, April. They had a jammed-pack programme yet again, which included 14 planetarium shows, sixpresentations, the AGM, and the APS 2016 dinner.

The organisers also arranged great social events, such as a "Lord of Rings Valley Tour," a tour of the Wellington Museum's "The Attic ,"and a public talk titled "Navigation by the Stars." Sky-Skan showed the new Sony GTV-270 laser projector in both 4k and 8K configurations along with the DSPerfectSky Auto-alignment system—very impressive!

This year's generl meeting was chaired by first-time President Shane Hengst, who has taken over from now Past-President Warik Lawrance. Mark Rigby and Martin George have continued their positions as treasurer and secretary, respectively. One of Shane's goals is to increase and support the portable planetarium community.

APS. Participants of the annual meeting in front of Space Place, Wellington, New Zealand. Courtesy of Shane Hengst.

The society is continuing the tradition of generating the members' activity report from their respective institutions. A 30-page document was collated from reports received from nine institutions. This offered great account and gave insights to what institutional members were up to in last 12 months prior to attending the APS meeting. The best form communication of member activity, however, is still via the APS wordpress blog: apsplanetarium.com/aps-blog. Institutional members were encouraged at the AGM to share the blogs to their various social media outlets in order raise the awareness of the APS beyond the sphere of the Australasian planetarium folk.

Membership of APS has been growing. New members who attended the 2016 conference include the folk from OHU Domes, Astrid and Peter from Science Alive, and Oana Jones from the Perpetual Garden Planetarium.

Southwestern Association of Planetariums

The Southwestern Association of Planetariums is pleased to share exciting news from their region. On 31 May members met at the joint Southeastern Planetarium Association and Western Alliance Conference to draft new bylaws with help from Great Plains Planetarium Association. Members voted in approval of the bylaws and elected officers through e-mail ballot collected by GPPA President Jack Northrup.

The bylaws will be posted on the SWAP website (www.swapskies.org). New officers include President Levent Gurdemir, President-Elect Sarah Twidal, Secretary/Treasurer Rachel Thompson, Editor of Print Publications Beau Hartweg, and Webmaster/Social Media Coordinator Scott Sumner. Additional information will be forthcoming.

Southeastern Planetarium Association

The combined SEPA-WAC conference was hosted by the Gayle Planetarium in Montgomery, Alabama in early June. Nearly 150 attendees participated in four days of events. A record of 7 conference attendees received financial support to attend. Planetarium Director Rick Evans went the extra mile for what turned out to be one of the best regional conferences in many years.

The site for the 2017 conference will be the James S. McDonnell Planetarium at the St. Louis Science Center in St. Louis, Missouri. The so-called "Pleiades Conference" will be a combined conference of all seven US regions. Conference dates are 10-15 October 2017. Detailed information will be included in future issues of *Planetarian*.

A new slate of officers for SEPA was elected and will serve 2-year terms beginning 1 January 2017: President-Elect James Albury, Secretary/Treasurer Patsy Wilson, and IPS Council Representative John Hare. Continuing officers include Derek Demeter, who will move from president-elect to president, and Ken Brandt, who will move from president to past-president.

SEPA has reserved the entire accommodation facilities at Lake

Barkley State Resort Park for the total eclipse on 21 August 2017. The conference center is located in Land Between the Lakes in western Kentucky. The center has a hotel with 120 rooms with double beds, 4 executive suites, 9 executive cottages, and 4 log cabins.

The accommodations are available to SEPA members who are paid thru December 2017. Remaining accommodations, if any, will be available to anyone, regardless of regional affiliation, beginning later in 2016. The resort reservation's desk maintains a list of current SEPA membership so identify yourself as a SEPA member to qualify for the booking at www.parks.ky.gov/parks/resortparks/lake-barkley.

For membership applications, activities, and other SEPA events, visit the website at www.sepadomes.org.

Great Lakes Planetarium Association

Illinois. The Adler Planetarium in Chicago recently completed REEL Science, a program that paired the screening of a popular movie with a discussion of scientific concepts. In May, Adler "domecasted" the second Kavli Fulldome Lecture featuring Chicago astronomer Michael Turner to locations around the globe.

Over the summer, the Illinois State University Planetarium in Normal replaced its aging Lumiline dome lights with East Coast's Pleiades LED lighting system. Meanwhile, their 52-year-old Spitz A3-P/A4 was given a complete tune-up and their dome was repainted.

The Elgin School District Planetarium was set to show a public evening show titled "364 Days and Counting" on 22 August to kick off a year of promotion and safety tips for the solar eclipse. Also in planning is a project with AVI to give teacher sets of moon phase flashcards and little notebooks to first graders after their planetarium visit.

The Strickler Planetarium premiered *The Dark Matter Mystery* to the public this August. Director Stephen Case participated this past April in the Two Weeks in Italy for an American Planetarium Operator experience, presenting lessons in Assisi, Brescia, and Gorizia.

The William M. Staerkel Planetarium at Parkland College in Champaign once again ran children's matinees in June and July. The staff is looking forward to opening *Solar Superstorms* in September, since this is the 30th anniversary of the nearby National Center for Supercomputing Applications.

GLPA. Dr. David Hurd (left) was recently named Edinboro (Pennsylvania) University's Professor of the Year, and Dr. Dale Smith (right) has been awarded a Professorship of Service Excellence for his decades of service to Bowling Green (Ohio) State University, GLPA, and IPS. Both photos courtesy of Dale Smith.

The Dome Planetarium at the Peoria Riverfront Museum is excited that the museum's feature exhibit this summer is "Be the Astronaut." In the dome, they are presenting "Living in Space," about how astronauts lived in space in the past, present, and future. They also were set to call the ISS via ham radio, and offer Yoga Under the Stars, trivia nights, and "After Dark" programs.

Indiana. The Koch Immersive Theater in Evansville used its Digistar 5 system to bring together both art and technology when local artist Jenna Citrus presented a fulldome art display on the dome. The artist's works were displayed during a 22-minute evening program that also featured an original musical score.

Ball State University's Brown Planetarium had a busy end of the semester with two "surprise" music events. One event included a performance from the student-driven Chamber Choir, while the other featured senior Peyton Cox's electronic music choreographed to fulldome visuals. They will also debut their new production *Black Holes, Wormholes, and the Movies*.

At the planetarium at the Tipton Middle School, funds became available to purchase a fulldome projector.

In Merrillville, students of the Planetarium Club are working on slide shows for the planetarium waiting area. The planetarium's display case is being updated with three presentations that will feature the inner planets, the outer planets, and everything else in the solar system.

There is sad news from the Edwin Clark Schouweiler Memorial Planetarium in Fort Wayne. On 22 April, Director Alan Pareis was summoned to a meeting and told that the planetarium was being closed at the end of May. (The most recent news reports indicate the planetarium might be acquired by the Science Central science museum in Fort Wayne. –ed.)

Michigan. The John Glenn High School Planetarium in Westland, which closed for business approximately five years ago, is once again opening. They have upgraded from their Spitz A3 to the Digitarium Epsilon fulldome projector.

The Delta College Planetarium in Bay City has been developing new programming opportunities, from guest lecturers to an original program called *Dateline Mars*. Its experience with the new Statewide Astronomy Night in April enjoyed great public response.

The Longway Planetarium in Flint recently enjoyed some good views of the transit of Mercury with the public. The planetarium ran its second, updated version of its "Choose Your Own Adventure" program. The staff is still working on an educational show about forces and a Halloween light show.

The Kalamazoo Valley Museum Planetarium will offer *Secrets of the Sun* this summer, giving staff an opportunity to discuss the sun and the 2017 eclipse. Their in-house production of *Treasures of the Great Lakes* will be presented as their seasonal sky show.

At the University of Michigan's Museum of Natural History, the 30,000th bolt was tightened on the steel structure of the new museum sometime in early May, representing the half-way mark in the raising of the steel. Most of the recent dome programming has revolved around a new celestial navigation unit for the Navy ROTC program and a new geology component for their Geology Learn It, Do It programs.

Ohio. Two Ohio planetarians have been recognized by their universities for exemplary work. In Edinboro, Dr. David Hurd was recently named the University's Professor of the Year. In Bowling Green, Dr. Dale Smith has been awarded a Professorship of Service Excellence for his decades of service to BGSU, GLPA, and IPS.

The Bowling Green State University Planetarium recently had a lift system installed on its Minolta star projector by Free Fall Technologies. In April, the planetarium cooperated with the University's Philharmonia Symphony by showing photos of the planets during a performance of Holst's *The Planets*.

Gene and Pam Zajac in Put-in-Bay have used a large pizza circle cardboard as the sun and magnetic disks for planets to demonstrate transits, and Lois Wolf at Sandusky Planetarium has used a posterboard sun and tiny planets to show the scales to a large group of fifth graders.

Wisconsin / Minnesota. The Bell Museum of Natural History held its groundbreaking ceremony on Earth Day, 22 April and work began

(Continues on next page)

in May. The new building will open in 2018 on the University's St. Paul campus. It also has welcomed Denise Young as its new executive director. (See story on page 100.)

The Manfred Olson Planetarium at UW-Milwaukee celebrated its 50th anniversary on 23 April, and it also celebrated Juno's arrival at Jupiter with an ice cream social and special planetarium program *Journey to Jupiter* in July.

The Soref Planetarium in the Milwaukee Public Museum will run its original production *Did an Asteroid Really Kill the Dinosaurs* this summer, and in September will install five Christie Boxer projectors and upgrade to Digistar 5 from Evans & Sutherland.

APLF. Above, participants of the annual APLF congress gathered in front of La Coupole. At right, an aerial view of the historic centre. Both images courtesy of La Coupole.

Society of French Speaking Planetariums

Between the 20-22 May, APLF gathered near Saint-Omer, in the North of France, at the 3D planetarium of La Coupole. La Coupole is a World War II History Centre and is located at an old Nazi V2 base. Since 2012, the museum has been completed with a 3D (stereoscopic) planetarium.

For the first time, the meeting took place at a stereoscopic facility and the 70 participants had the chance to appreciate the pedagogical content of this technology. For example, with the 3D technique you can understand more easily phenomena linked to distances, like orbits or the constellations.

During the congress, extensive discussions took place about the collaborative sciences, like the Fripon Project dedicated to the search of meteorites; the reception of handicapped guests; and the French adaptation of international productions. The gathering ended with a visit tof the Audomarois Marsh, an important natural reserve honored by UNESCO (Man and Biosphere label).

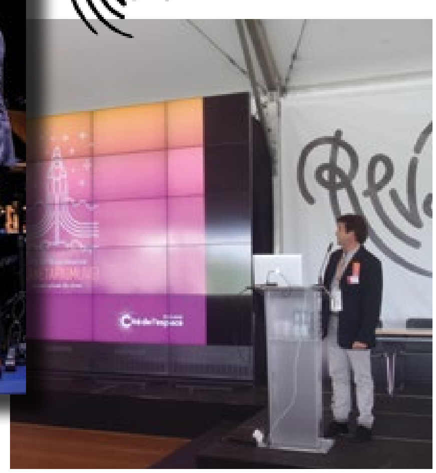
The next APLF Congress will take place in May 2017 in Paris.

APLF will participate in the Meetings of the Sky and the Space in November 2016 in the Museum of Science and Industry in Paris. This event facilitates meetings between amateur astronomers, scientists, enthusiasts of the sky, and presenters in astronomy.

IPS 2018 in Toulouse: c'est parti! IPS 2018 started in Warsaw at the gala dinner, during the handover where Robert Firmhofer, CEO of Copernicus Science Centre, transmitted the IPS Bird and Banner to Jean Claude Dardelet, vice president of Toulouse Metrople and Cité de l'espace. The Toulouse team was there around him, wearing European astronaut training suits, to give a first flavor of the next conference in Cité de l'espace, the largest European Science Centre dedicated to space and astronomy.

To organize an IPS conference is as serious as building a space mission, so the Toulouse team is working hard to make next IPS conference, the first in France, a memorable event. So get ready to get onboard that very special flight in 2 years, from 1-5 July 2018!

During the Warsaw IPS 2016 business meeting, a first presentation of the schedule and program of the conference was made by Marc Moutin, exhibition director at Cité de l'espace and IPS 2018 project manager, who introduced the graphic design of the conference. Beside the 2016 congress, a press conference was held at the French Embassy in Warsaw to present the attractiveness of Toulouse and the new big region called Occitanie, and to mention to the journalists the IPS conferences handover from Warsaw to Toulouse. The event was honored by the presence of Shawn Laatch, IPS president elect; Thomas



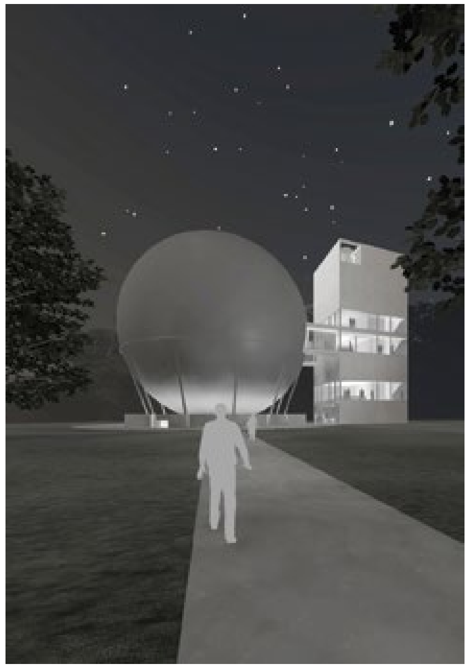
APLF. On left, the handover of the IPS banner from the 2016 hosts in Warsaw, Poland, to the 2018 hosts in Toulouse, France. Photo courtesy of IPS2016. At right, Marc Moutin of Cité de l'espace in Toulouse outlines plans for the 2018 meeting at the Warsaw IPS business meeting. Photo courtesy of P. Prieur.

Kraupe, IPS past president; and Martin George, chair of the Elections and International Relations committees.

Society of the German-Speaking Planetariums

Solingen, a city located close to Cologne in western Germany, will soon receive a new and unique planetarium installed inside a former gas storage tank. The city of Solingen is known as the "blade city" because many cutlery manufacturers are located here. But in Solingen, astronomy also has a long tradition, as it is home of one of the oldest public observatories in Germany, founded in 1924.

In August 2016, the private association operating the observatory was set to celebrate the groundbreaking for the construction of a new planetarium and a new observatory. Named after Galileo Galilei, the Galileum Solingen will be, presumably, the world's only planetarium in a disused, freestanding spherical gas tank. The gas tank was built in 1956, has a diameter of 26 m, and was taken out of service in 2009. In an international architectural competition, several options of how to convert "the bowl" into a planetarium with an observatory were examined.

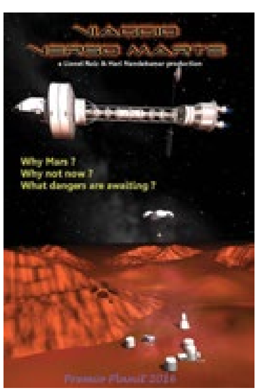


GDP. The Galileum Solingen as it will be constructed in 2016/2017, visualized by architects mvm+starke. Courtesy of mvm+starke.

In the winning design by architects mvm + starke of Cologne, the planetarium with a dome diameter of 12 meters and nearly 90 seats, will be built in the gas tank. Around the planetarium dome there will be a panoramic passage from which the unlit tank interior will be seen as a very "black hole." Next to the gas tank, a 7-floor building will be erected that will contain exhibition areas, conference rooms, offices, and a rooftop observatory. The entire project, supported by the German state of North Rhine-Westphalia, will cost around 7 million euro, of which nearly 3 million euro has been raised through donations and sponsorship.

The Galileum will be equipped with a Goto Chronos II Hybrid star projector and a RSA Cosmos fulldome video system, inside a 12-m Astro-Tec dome. The opening of the Galileum is planned for late 2017 or early 2018, realizing the Galileum slogan: "The sky is a sphere." In Solingen, it will be a 26-m steel sphere.

Italian Association of Planetaria



AP. Poster from *Voyage to Mars*. Courtesy of Lionel Ruiz.

The 2016 issue of the Planit prize, the yearly Italian contest for the production of a fulldome video that is open to everyone in the world, has been appointed to Lionel Ruiz (France) for the video *Voyage to Mars* (dubbed in Italian as *Viaggio verso Marte*). The scenario of the show was created by Hari Nandakumar from Sri Sathya Sai Space Theatre (India), on the basis of the success of the Indian Mars Orbiter Mission spacecraft. He asked Ruiz, who made a lot of fulldome pedagogical explanations, for help to make all the computer-generated graphics of the show in 2K format.

The Italian version of the show was made with some improvements in the visuals by the Planetario del Righi team for the Planit 2016 meeting.

There are, to date, 18 American winners of the "Two weeks in Italy" prize. The deadline of the next round is 15 September. All the prize rules are available at the IPS website at ips-planetarium.org/?page=italy.

The next national day against light pollution will be held on 29 October. Planetariums are involved through special events, public projections, and astronomical evenings, in particular the network PlanItalia, a national project promoted by PlanIt. The latest event of PlanItalia was held in June during the national observation of Saturn.

On the web site www.eufactor.eu, promoted by the European Commission, there are five stories of young Italian scientists. Each story is narrated through a 3-minute video clip prepared for students (16-19 years old) with the purpose of promoting enrollment in science and technology university courses.

One video describes the experiences of the astronomer Marco Micheli (educated at Scuola Normale di Pisa, then 5 years at the University of Hawaii and now working for the European Space Agency in Frascati, near Rome) that at the age of elementary school attended the telescope evenings at Specola Cidnea Observatory in Brescia, the first astronomical observatory for the general public in Italy. At the age of 14 he attended an astronomy course at the Serafino Zani Observatory, where he realized how amazing it is to discover new minor planets. "That is what I would like to do as a job in my life!" he said at the end of the experience, and the following years have been devoted to reach this goal. The video is a wonderful tool to involve young audiences at the observatory and the planetarium of the Brescia area.

In June the first edition of "Perugia 1416–The passage between the Middle Ages and the Renaissance," a historical review to mark the six hundred years since the rule of Andrea Braccio Fortebracci, was held in the city of Perugia. Andrea Braccio Fortebracci was an Italian condottiere (mercenary leader). His goal was to rule the beloved Perugia, which he conquered at the battle of Sant'Egidio on 12 July 1416.

IAP. The simultaneous projection on two flat screens of the night sky on 12 July 1416 and on 12 July 2016. Courtesy of Simonetta Ercoli.

The event was enlived by five areas of the old city centre, which organized many activities and competed for the prize known as the Palio 2016. As part of the event the StarLight... Handy Planetarium Association organized an event titled "1416...the stars of Braccio Fortebracci in the Porta Santa Susanna area."

The event was divided into three stages:

• The simultaneous projection on two flat screens of the night sky on 12 July 1416 (the date of Andrea Braccio Fortebracci's entry into the

(Continues on next page)

EMPA. Left: Large crowds wait patiently to observe the starry night with the telescopes of the Hellenic Astronomy Union, just outside the premises of the Eugenides Foundation. Courtesy of Aris Milonas. Right: A group of Chinese tourists visiting the Rijeka Astronomical Center. Courtesy of Rijeka Sport Ltd.

city of Perugia) and on 12 July 2016, and an illustration of the differences between the two skies.

• An explanation of the phenomena underlying the astronomical differences between the two skies.

• The presentation of the astronomy-astrology combination in the 1400s through the thought of two famous philosophers of that time: Marsilio Ficino and Pico della Mirandola.

The scientific explanation was accompanied by selected literary passages read by Claudio Massimo Paternò, and music from the fifteenth century played by Lucia Bellucci on guitar and Barbara Abati on flute.

The event was organized in collaboration with the Pietro Vannucci Academy of Fine Arts, the State Archives, the F. Morlacchi Conservatory of Music, the University of Perugia, the University for Foreigners, the University of Flavours, and other cultural associations, and benefited from the financial support of the Municipality of Perugia, the Fondazione Cassa di Risparmio of Perugia, the Umbria Regional Government, and the Chamber of Commerce.

European/Mediterranean Planetarium Association

Croatia. For the occasion of the International Astronomy Day on 14 May, Rijeka Astronomical Centre produced the interactive live show *Ten Reasons Why I Love Astronomy*, suitable for preschool children, while at the Center's Observatory, visitors could watch the various celestial objects that are visible above Rijeka for that month. Many school groups visited the Astronomical Centre as a part of their educational field trips.

Located in Kvarner Bay, in the northern Adriatic Sea, the city and port of Rijeka attract many tourists during the summer months. For this reason, the Rijeka Astronomical Centre includes in its regular program various planetarium shows, especially for their foreign visitors. This time it was *Two Small Pieces of Glass: The Amazing Telescope*, screened on Wednesday evenings, a show tracing the history of the telescope from Galileo's modifications to the launch of NASA's Hubble Space Telescope and the future of astronomy. In addition, in the period 19-23 July, each regular show was preceded by a 15-minute projection dedicated to the 47th anniversary of the Apollo 11 mission, which landed the first astronauts on the Moon.

The Astronomical Centre Rijeka also joined in celebrating the Asteroid Day on 30 June by showing the live show *Small Bodies of the Solar System*.

Finally, at the time of writing, the Rijeka Astronomical Centre is planning to participate in the exhibition Seventh Heaven of the Museum of Modern and Contemporary Art with various digital planetarium shows on the solar system, the sun, and the planets.

Greece. Further south, the Eugenides Planetarium in Athens celebrated the summer solstice on 21 Tuesday June with 2 free-of-charge screenings of its digital show *Hubble's Universe,* which highlights the Hubble Space Telescope's immense contribution in our continuing efforts to decipher the secrets of the universe. Each show was preceded by a talk of Aris Milonas, president of the Hellenic Astronomy Union, on the equinoxes, the solstices, and the seasons. Later in the same evening, visitors had the chance to observe the night sky, and especially Jupiter, Mars, and Saturn.

The Eugenides Foundation was honored to host the European Week of Astronomy and Space Science Conference (EWASS 2016) on 4-8 July 2016, organized by the European Astronomical Society (EAS) in collaboration with the Hellenic Astronomical Society.

This year, the Scientific Organizing Committee had selected a wide range of symposia and special sessions that covered nearly all fields of astronomy, including solar physics and space weather, stellar and galactic structure and evolution, cosmology, gamma-ray/X-ray/infrared and radio astrophysics and more, in addition to numerous plenary talks, prize awards, and exhibitions. On the occasion of EWASS 2016, Dr. Jason Spyromilio of the European Southern Observatory (ESO) gave a public talk titled "The Accelerating Universe" on 5 July. His talk focused on the history of the discovery (for which he was an active participant) and also how acceleration will affect the future of the universe.

Russian Planetarium Association

Kostroma. The research and practice conference "Planetarium: An educational class room, astronomical navigator and star theatre" took place on 17-19 May, on the occasion the 65th anniversary of the Kostroma regional planetarium. It gathered 30 planetarians. Many participants reported a high return due to the comparatively small group and the actuality of the program.

Much attention was given to the new forms of work, training aids, the practice of planning, equipment and buildings, and modernization of ZKP-2 projectors. The theatrical shows *Cold Fairytale* of the Kostroma planetarium and *Cat in Knee-boots* of Perm planetarium was shown with great success.

Nizhny Novgorod. The government of the Nizhny Novgorod region appointed the name of cosmonaut George Grechko to the Nizhny Novgorod planetarium on 25 March.

The head of the international group of researchers of meteoritic catastrophes of the recent historical past (Holocene Impact Working Group, or HIWIG), professor Dallas Abbott (Lamont-Doherty Earth Observatory of Columbia University, USA), gave a lecture on 11 May

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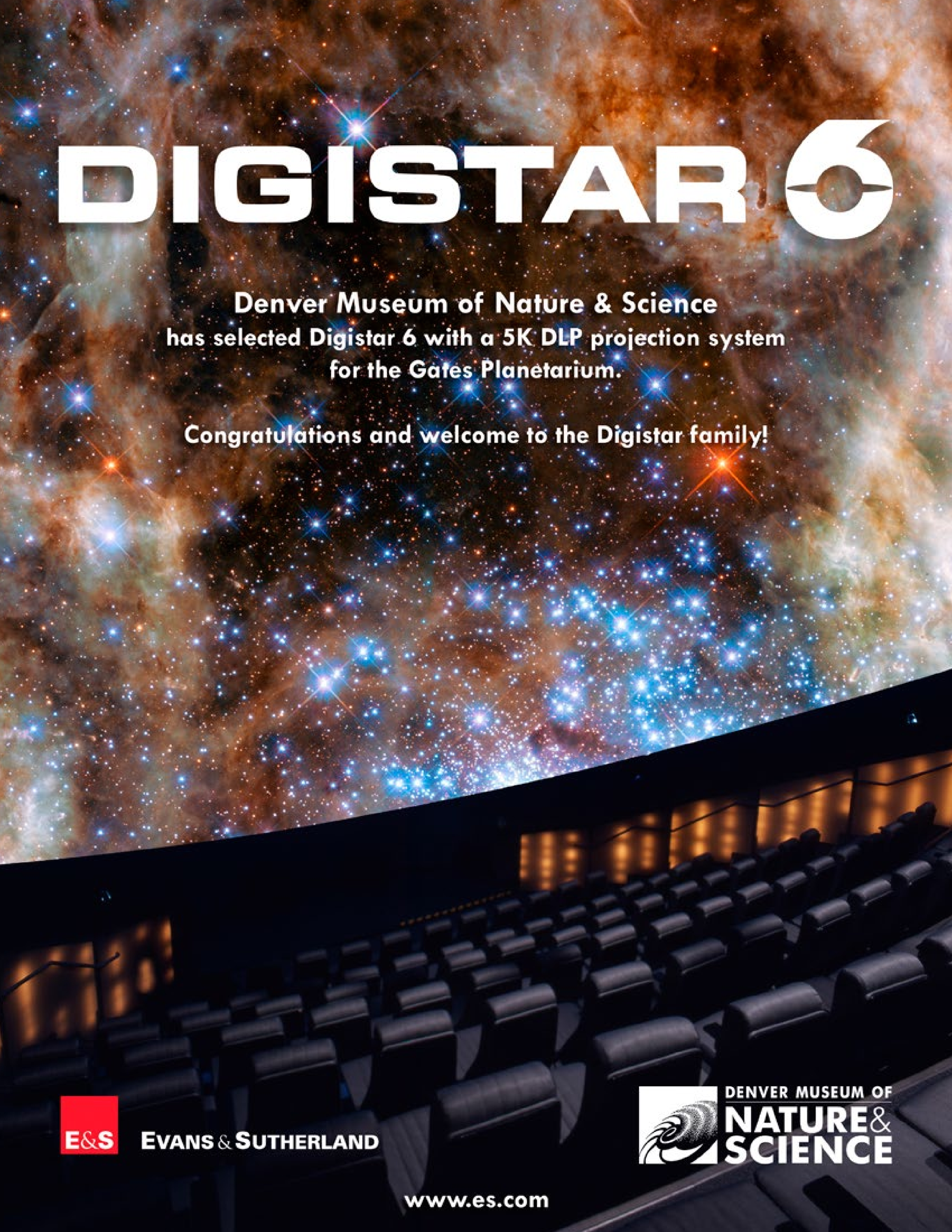
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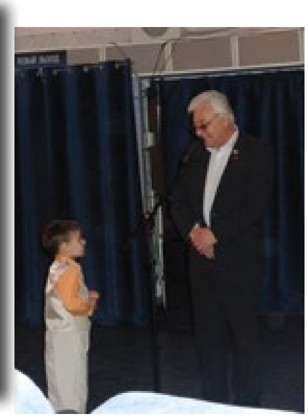
RPA. Top: A photo composition called "Pictures from the conference in Kostroma." Photo courtesy Alla Stephanenko. Bottom, left: A talk by Dallas Abbott in the Great Hall; photo courtesy Alexey Kiselev. Right: At Nizhny Novgorod Planetarium, Cosmonaut Y. Baturin answers a child's question. Courtesy of Vadim Belov.



in the planetarium with the title "Famous Historical Impacts." Two Russian objects—the meteoritic craters in the Nizhny Novgorod and Moscow regions—were in the focus of interests of HIWG.

The manager of the Laboratory for Tsunami Waves (Institute of Calculable Mathematics and Mathematical Geophysics of Academy of Science, Novosibirsk), Doctor Viacheslav Gusiakov, was present with a supplementary report. He declared that the row of climatic phenomena of the recent historical past can be explained by the influence of space impacts close to surviving civilizations.

On 13 May the Nizhny Novgorod Planetarium welcomed Hero of Russia Cosmonaut Yuriy Baturin for the second time. He is a corresponding member of Academy of Science, a doctor of legal sciences, writer and journalist, author of more than 300 scientific works on cosmonautics, physics, cybernetics, history and law, and he was at one time the advisor of President B. Eltzin. Y. Baturin gave a lecture called "State and Perspectives of Russian and World Cosmonautics."

On 14 May the guests answered questions participating in the children's astrocosmical A. Saharov's olympiad, and rewards were handed to the winners.

Samara. An event for building a fulldome planetarium was held on the International Day of Astronomy of 14 May in one of the areas of the city. Participants were schoolchildren, their parents and other citizens of Samara. There were theatre stages, performances of poets of the Samara club of book lovers, a quiz on astronomy, masterclass on the design of rockets, pictures on asphalt, observations of the sun in telescopes, and an exhibition-sale of books on astronomy on the program.

Yaroslavl. The latest school of lecturers of planetariums took place on 4-8 April, this time in Yaroslavl, at the Tereshkova Planetarium. More than 50 participants arrived from different cities, including scientists, lecturers and employees of planetariums, leaders of astronomy groups, teachers of astronomy, and other contiguous disciplines, all of whom actively engage in the communication of scientific knowledge.

Subjects were very wide: histories of astronomical errors; astrophysical results of the year 2015; dark matter in the universe; globular clusters; beginning of gravitation wave astronomy; the radio sky and enigmatic radio splashes; the birth, youth, maturity, and death of the solar syste;, the atmosphere of Earth (layers of cold and high clouds); problems of the ecology of the circumterrestrial space; the strategy of resource mastering of space; and the tasks of pilot-controlled cosmonautics.

Three new fulldome programs were shown: *Monsters of the Milky Way* (Irkutsk Planetarium), *Rozetta* (Society of the Spherical Cinema, Nizhny Novgorod); and *Small Bodies of the Solar System* (Tereshkova Center, Yaroslavl). ☆

(5192) Yabuki = 1991 CC
Discovered 1991 February 4 by T. Fujii and K. Watanabe at Kitami.
Named in honor of Hiroshi Yabuki (b. 1960), one of the leaders in developing automated planetarium programs at GOTO Optical Laboratory.

(5658) Clausbaader = 1950 DO
Discovered 1950 February 17 by K. Reinmuth at Heidelberg.
Named in memory of Claus Baader (1924-1995), German manufacturer of planetaria, domes and telescopes, and well-known mentor of amateur astronomers in the German-speaking countries. A design engineer by profession and self-taught in astronomy, Baader constructed a new type of a small desktop planetarium that is in use in schools in many countries throughout the world. In his later years Baader, together with his son and successor Thomas, was deeply concerned with the construction and development of observatory domes, astronomical telescopes and their auxiliary instrumentation for amateur and professional astronomers alike. Name proposed and citation prepared by L. D. Schmadel.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So much to report from busy Warsaw Conference

Congratulations to the organizers for delivering a very exciting conference at the Copernicus Science Centre and the Heavens of Copernicus Planetarium! I was delighted by this well-attended conference and the spirit of our colleagues who made it possible. The presentations, activities, and vendors were exceptional. There was plenty of time for networking and meeting with new and old friends.

Susan showing the love for IPS 2016, Poland, and the Polish football team! (Unless specified otherwise, all photos taken by or provided by the author)

I was able to connect with many portable planetarium directors and share concerns, successes, and interesting new initiatives.

Ironically, one session I was unable to attend was "The Mobile Dome Project" by Jaap Vreeling of the NOVA Information Centre in Amsterdam, Netherlands. NOVA, the Dutch research center for astronomy, started what has turned out to be a hugely successful project with a mobile planetarium.

Jaap wrote to tell me, "I think that it is worth mentioning that our 'NOVA mobile planetarium at your school project' will reach 200,000 visitors in October 2016. We started the project in February 2010 with two domes, and now we are working with three 5-meter portable domes.

"The volunteers giving the shows are all astronomy bachelor and master students active in the Universities of Amsterdam, Groningen, Nijmegen, and Leiden. We will soon write an article about the planetarium program, after the holidays." You can contact Jaap at J.A.Vreeling@uva.nl.

Reporting about the conference back home

Matthias Rode (derrode@googlemail.com, Bad Sooden-Allendorf, Germany) communicated with his mobile dome colleagues in Germany immediately upon returning from Warsaw to tell them about the conference. Here is a rough translation of what he expressed:

> The conference was themed Revolve. It has not been revealed to me definitively what exactly "revolve," the main word, meant. Probably it was intended that we play with the ambiguity of the term. Revolve, which can mean: revolve, rotate, overturn, spin, rotate, run around, turn around, renewed itself, run circling, turning something. I myself was 'renewed' mainly by a change in perspective. That was not always easy, as the conference language was of course English; when a German speaks with an American it is easier to understand, but if I as a German talk with an Italian who is speaking English, it is sometimes very difficult.
>
> There were about 500 planetarians from around the world in attendance; the American participants, of course, were represented in the majority. I found presentations from sponsors were held in 5 different locations and lecture programs were held at another 5 various locations. So you had to often opt for something. There were also several mobile planetariums present, so again and again we came together on the issues relevant to us. Unfortunately, I was there only for 3 days, but I can still take a lot of new impetus, for which I am grateful to the IPS Conference Team.
>
> In my perception, the fulldome video shows have reached a new level; there was a variety to see. In terms of quality, in the newer productions, there are more real fulldome elements in the pictorial representation which helps justify using them in the planetarium. With many older productions that was not really the case. There is also, in the newer shows, more links between the illustrated provided content and the fulldome medium; much of the content would not be possible in a standard format. There are generally a lot more content on the market, and of better quality than before, for example 4 years ago, and these new videos are easier for small dome facilities to obtain.
>
> All this has led me to expand the presentations I offer to my customers. I will try offering a comprehensive fulldome video program from which customers can choose. Also part of the idea is to offer a 28-minute video show and still attach a 20-minute segment that is live. I'm curious to see how this is accepted. It was very interesting to talk to other mobile planetarium directors and learn how we face common difficulties.
>
> I also discovered that, contrary to my opinion (that it makes no real sense to work with preschoolers in the planetarium), there are many good ways to work with students of this age. Success involves setting the proper environment and using age-appropriate techniques. We need to use entertaining characters and make the content related to their egocentric world. As a general principle, children must be involved with actions such as counting, pointing, singing, and discussing what they have seen during the demonstration. I can use some of these good ideas.
>
> Technical innovations of inflatable domes were demonstrated by a company called Quim Guixà, which is based in Barcelona, Spain (www.quimguixa.com). Unfortunately, there is no picture of this particular dome on the internet. The engineers have managed a dome built so that it is held up by closed air chambers. Something I have already repeatedly seen, but what I surprisingly found, was that an additional liner was installed on the inside of the air chamber system and, through crating a vacuum, the interior sheet provided a smooth and even projection screen.
>
> On another note, I have found a very new light-weight fabric, from a German company, which is very probably the best material ever seen to build an inflatable dome. First tests are very promising. I am going to produce one or more domes of this material between October and December. If someone needs a new dome, you should contact me because the more domes produced at once, the cheaper they are for the buyer. On request, I would very much like to send a material sample.

Thoughts about live presenting

Karrie Berglund (karrie@digitaliseducation.com, Bremerton, Washington) shared some thoughts with me about IPS 2016:

"It was refreshing to have some attendee-led sessions take place in the domes. Usually the dome schedules are monopolized by vendor presentations, but the IPS 2016 hosts made sure that didn't happen by adding two temporary domes. I admit that I was skeptical about the need for the two extra domes (and the big expense), but I now believe that was the right decision.

"I appreciated the amount of interest in and sessions/workshops relating to live programs. This was the most emphasis I have seen at any planetarium conference (aside from LIPS) since we started exhibiting in 2004. IPS 2018 has named live programs as one of its key themes, so this trend will continue at least that long.

"I also appreciated having the conference days end by 7:30 p.m. rather than going to midnight or later. Some of us need to actually sleep more than an hour or two per night!"

Oded Kindermann (okindermann@gmail.com, Jujuy, Argentina) also shared his thoughts:

"Hi everybody, it was great seeing you all, I agree with Karrie 100%, I actually attended all the session related to education and they were great, many different topics and things to implement in our domes.

"We enjoyed having sessions in the two beautiful geodesic domes in this IPS conference, and if they are considered as mobile planetariums, then I guess we could say that it was a very big step for us, the small guys. Speaking with a few big vendors, they told me that they didn't expect much from these domes, but they really enjoyed it.

"Finally, did you see the small dome made by a school that was set up just for us? They really deserve a big applause. They were able to make portable planetarium with a very small budget and they use it to teach astronomy."

Lionel Ruiz (lionel.ruiz@live.fr, Planetarium of Marseille, France) said he also agreed with Karrie and Oded's comments. He said, "Indeed something to continue in the IPS2018 in Toulouse. I have many original ideas to show during this event and I will be able to bring my material this time!"

Lionel also said he would be in touch with the students Oded mentioned who built their own planetarium to assist with making it safer and with a better digital projection system with easy to find cheap materials. (See information below about The Lhoumeau Sky-System open project.)

Wojciech Ziętek, one of the students involved in the project, will put together an article for us about the group's experience with this initiative. I look forward to learning more about the process, the difficulties, and joys, soon. The article will be printed in this journal in the future.

Top: These students, with the guidance of their teacher, built their own small mobile dome and set it up in the science center just for IPS 2016. I asked how long it took to put it up and they said "all day" because the original fabric they used would not pass the fire code so they had to make another outside shell on the spot! They were on hand to give "shows" to us and to science center visitors. Below: The dome on the right is made by Quim Guixà and has a special liner inside that is smoothly held in place by negative pressure. This is the dome that impressed Matthias Rode.

The Lhoumeau Sky-System

Lionel shared news of an open project that will allow you to put together a low-cost projector for small and medium planetariums and also has instructions for how to build a dome! Many locations are already using this kind of planetarium quite successfully and are listed on the website.

The website states that the planetarium consists of:

- A video projector with the best quality, luminosity, contrast and resolution you are able to find without a too high price.
- An optical device with a classical optic, a diagonal mirror and a fisheye lens.
- A computer with a decent graphic card and a large hard-drive.
- Software permitting the user to produce the sky with a fisheye projection, like Stellarium, the free open-source software.
- A remote control and a mouse for easier control in the dark.

For all the details, go to www.lss-planetariums.info.

Remember to contact the team of the LSS-group and me to share your experiences after building your own planetarium!

Evans and Sutherland and Sky Point

Working together, these two companies have developed a new projector for portable planetariums. It is called Digistar Lite. It combines the projector designed by Sky Point, a successful mobile planetarium manufacturer based in Italy, with E&S Digistar software.

The website states that "The Digistar Lite for portable planetariums will be available through E&S in the USA and Canada; through Skypoint in Europe and surrounding areas; and throughout the rest of the world via E&S and Skypoint local agents and distributors. Please contact E&S or Skypoint for addition information and pricing."

Learn more at www.es.com/news/featured/2016/2016-06-17.aspx. The new Digistar Lite products will be featured on the dedicated website at www.digitalplanetariums.com.

Rental movies

While visiting the vendors I learned that there are several movie rental options available for portable and small domes. Here are just two of those companies for you to contact if you want to explore that avenue:

Reef Distributions at www.reef-distribution.com; Loch Ness Productions at www.fulldomeondemand.com.

A different approach to interactivity in the dome

It was a pleasure to meet and talk with Daniel Fine about an exciting program involving play, interactivity, immersion, and performance by actors and puppets. Check out the video at vimeo.com/81645854.

The description reads, "Wonder Dome is a touring performance platform that brings traditional storytelling into the twenty-first century by inviting audiences of all ages into an interactive, 360-degree immersive dome where narrative can be encountered, explored and told by mixing ancient forms of live performance with cinema, gaming, HCI and cutting edge digital technology."

To read a little about the history of this project go to csi.asu.edu/ideas/the-wonder-dome-embodied-interactive-

(Continues on next page)

stories-in-an-immersive-environment, and to follow this creative venture, go to www.facebook.com/WonderDomeUSA.

Special portable planetarium in Pittsburgh

While talking with Sue and Buck Batson from the Pittsburgh, Pennsylvania area, I discovered that they are looking into starting a portable planetarium program as something to spice up their retirement. When asked what other portables were around the area they explained that there is a Digital Starlab being made available to city schools, owned by a chemical society. (Luckily Sue and Buck are moving out of the Pittsburgh area where they won't have competition!)

So I looked it up, and sure enough it is owned by scientists! This is what I found in a newspaper article:

"The portable planetarium, transported by volunteers and free to local school districts, is owned by PittCon, a nonprofit organization that runs an annual conference and exposition on laboratory science, cosponsored by the Spectroscopy Society of Pittsburgh and the Society for Analytical Chemists of Pittsburgh.

"The conference began in the 1940s, when Pittsburgh was thriving in the steel industry, said Don Antczak, planetarium committee chairman and a retired science teacher from the Hampton Township School District.

"Yet, PittCon, which draws between 15,000 and 18,000 people worldwide, hasn't been held in the Steel City since the 1960s.

"Several years ago, a Science Week was launched to offer workshops for local teachers and students in the conference's host city, Antczak said. In 2008, a portable planetarium was purchased for Science Week, held in New Orleans.

"PittCon leaders realized that other than during the annual conference, the portable planetarium simply sat in their offices, Antczak said.

"So, a group of volunteers were trained to teach a 30-minute program for Pittsburgh-area schools with the planetarium transported in the back of their cars."

Source: triblive.com/neighborhoods/yoursouthhills/yoursouthhillsmore/9251281-74/planetarium-portable-brentwood#axzz3pDNhPjzX.

European Meeting of Itinerant and Small Planetaria

I was very happy to meet again at the IPS 2016 conference with three of the hosts of past meetings of the European Meeting of Itinerant and Small Planetaria at IPS 2016. We remembered fondly all the fun we had together years ago. It has been 6 years since the last of these get-togethers. How about hosting the next one? If you are interested at all, please contact me right away while you are thinking about it!

Bard Spiral Tales of life, the universe and a few other things. By Chuck Rau

The Guest Equation:

$$N = R_* \cdot f_p \cdot n_s \cdot f_w \cdot f_u \cdot f_\$ \cdot L$$

where:

N = the number of people which might visit a planetarium;

and

R_* = the average number of residents of the planet

f_p = the fraction of those residents that have planetariums nearby

n_s = the average number of planetariums that can potentially support public shows

f_w = the fraction of planetariums that could support public shows that actually have content worth seeing at some point

f_u = the fraction of planetariums with public show content worth seeing, that actually go on to update their content and technology

$f_\$$ = the fraction of organizations that are financially supported (for the operation, staff, technology, production and marketing)

L = the length of time for which such organizations release detectable marketing signals into space

www.bardspiral.com

The first meeting was held in Brescia, Italy, in 1995. The following meetings were held in Strasbourg, France, 1999 and 2000; Nantes, France, 2005; Bratislava, Slovakia, 2007; Espinho, Portugal, 2008; Katowice, Poland, 2009; and Kallio, Finland, 2010.

Dr. Jacob Ashong needs 25 portable planetariums

You probably all know about Jacob and his wife Jane and their efforts to spread science education in Ghana. If not, please go to www.ghanascienceproject.net learn a little about them.

Jacob is now on a mission to spread science education even further across his whole country with mobile domes. There are many portable

Jane (left) and Jacob Ashong (center) enjoy talking with Ruth Coalson of NSC Creative during IPS 2016. Photo by Photo by Frank-Michael Arndt.

planetariums sitting in closets as the new digital planetariums replace the old analog versions. If you have any way to pass these or any portable planetariums along to Jacob he will certainly make excellent use of them! If you want to come over and teach for him for a while, he also would welcome that too! Please contact him with your ideas immediately at jacob_ashong2@yahoo.com.

International Day of Planetaria will focus on the work of mobile domes in 2018

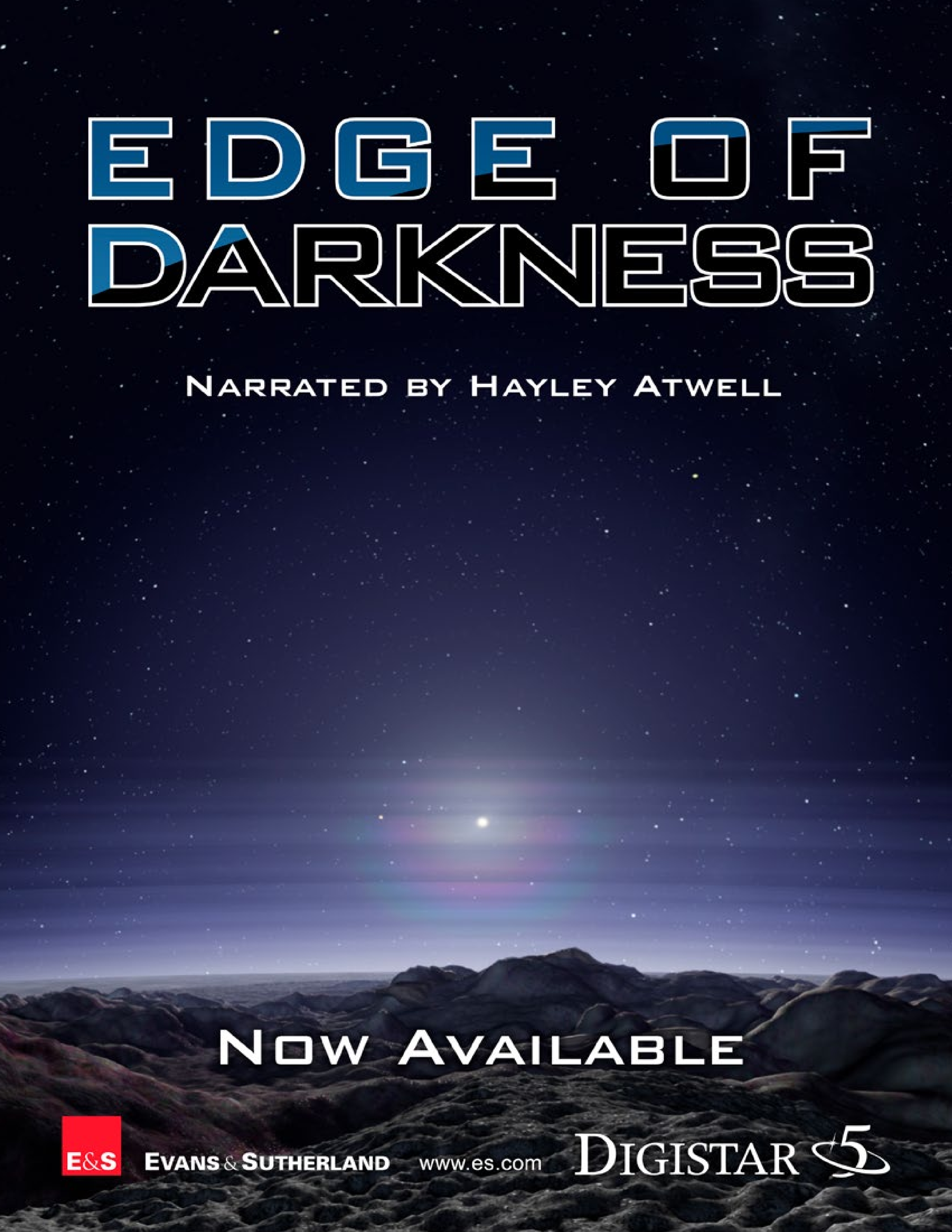
I will be telling you more about this event in future columns, but I am very excited to announce this world-wide outreach portable planetarium event. It will be a collaboration among several organizations, under the direction of IPS, with these goals:

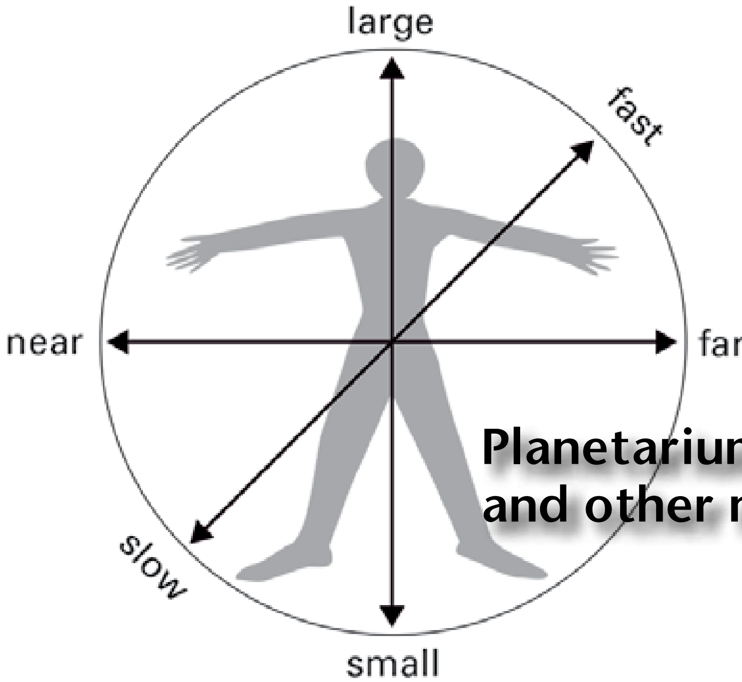
- To honor and encourage the excellent work of mobile planetarium educators.
- To promote IPS as a forum where mobile dome directors can learn from each other.
- To reward innovative approaches to science education in portable planetariums.

In addition, there are two new IPS initiatives in the works; see the full article on page 14. Briefly, they are:

Voices from the Dome: This project is designed to create a database of planetarians' voices, speaking in their native languages. Every planetarian can contribute to this copyright-free digital archive that will be made available on the IPS website. These audio files can be used during live planetarium shows.

IPS Cultural Exchange-A Week in the United States Contest: Each year for the next two years, 2 planetariums in the United States will host a planetarium colleague from another country. Applications are requested from educators or astronomers who work with any of the various models of planetariums and who are comfortable making presentations in the English language. ☆


EDGE OF
DARKNESS
Narrated by Hayley Atwell
Now Available
E&S
Evans & Sutherland
www.es.com
Digistar 5



Planetarium domes in the era of VR/AR and other mixed reality experiences

Based on a poster presented at the 2016 IPS Conference in Warsaw, Poland, 19-25 June.

Julieta Aguilera, Ph.D. (candidate)
University of Plymouth, United Kingdom
julietina@me.com

This poster describes perceptual aspects addressed by virtual and augmented reality (VR/AR) applications, and how these mediums reflect on the planetarium dome experience. Human senses are not equal in terms of space, and vision is the only sense capable of escaping Earth's atmosphere. Telescopes extend vision even further. The data comes back to us to be scaled to what we can experience with our body, creating a virtual model that is real, yet can never be realistic.

Understanding the capabilities and vocabulary of the human body, accumulated by being in the world, and how the different senses come together in perception is part of the artist's research. As VR/AR spread into public consciousness, allowing us to experiment with spatial and temporal abstractions, astronomy visualization in the planetarium dome is enriched, further enhancing our connection to the universe.

Immersive and interactive media

Planetariums are unique spaces. While film theaters show a movie where viewers are passive and paralyzed, in planetarium shows (the "hard core" ones), there is a live person navigating what you see and you can look around, similar to being driven in a car.

Early planetarium shows have been informed by film media, but today are also informed by interactive and immersive devices, accessible through widespread mobile device use, so agency, spatial depth, and time are better understood. These devices did not appear from thin air, but evolved from media such as planetariums.

Immersive devices evoke the natural world because we are here within it; media develops because we can match our tools better to our body. VR/AR is achieved by establishing a field that is large/close enough to feel surrounded, giving a sense of depth to measure distance and a representation of the self to understand a role, and connecting body motion to camera view or motion in the environment.

- In the past, murals provided a sense of immersion. Today large displays, planetariums, or head mounted displays like the Oculus or Vibe do that.
- In the past, dioramas and stereo viewers provided visual depth. Today visual cues in computer graphics do that.
- In the past, a narrator would walk you through a story. Today we have graphical representations of ourselves (avatars) to be in the story.
- In the past, optical illusions and perspective drawing drew windows into 3D spaces. Today we can track the movement of a person, from the GPS or gyroscope in a mobile phone, to motion tracking.

While not all these capabilities are afforded by a planetarium and a planetarium is not a VR environment, many people who come to planetariums have experienced some level of VR/AR, and therefore understand what they see in the projections differently from a person decades ago.

Perception

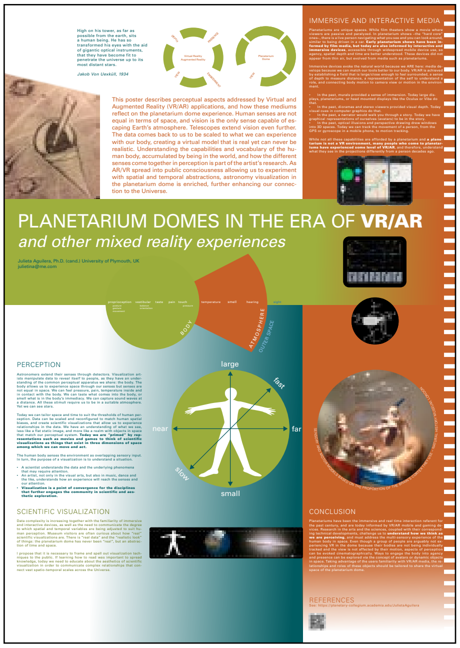
Astronomers extend their senses through detectors. Visualization artists manipulate data to reveal itself to people, as they have an understanding of the common perceptual apparatus we share: the body. The body allows us to experience space through our senses, but our senses are not equal in space. We can feel pressure, pain, temperature inside, and in contact with the body. We can taste what comes into the body, or smell what is in the body's immediacy. We can capture sound waves at a distance. All these stimuli require us to be in a suitable atmosphere. Yet we can see stars.

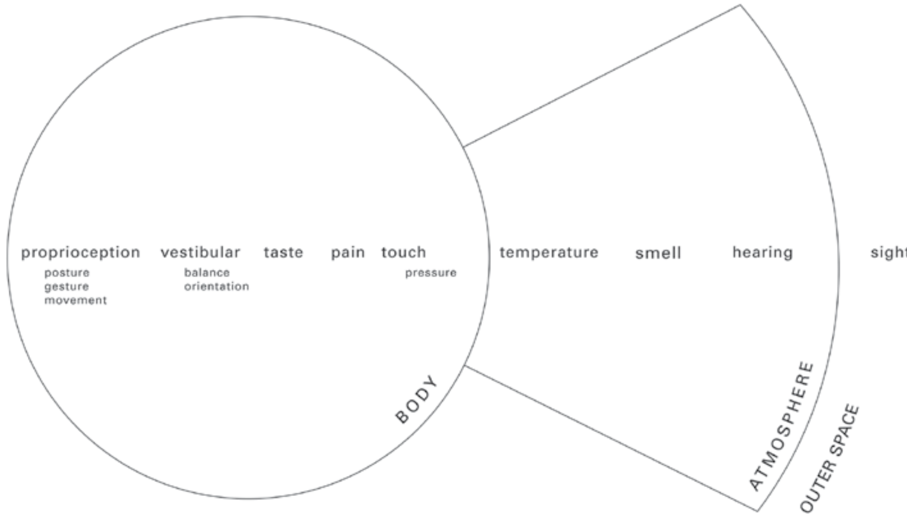
Today we can tailor space and time to suit the thresholds of human perception. Data can be scaled and reconfigured to match human spatial biases, and create scientific visualizations that allow us to experience relationships in the data. We have an understanding of what we see, less like a flat static image and more like a realm with objects in space that match our perceptual system. Today we are "primed" by representations such as movies and games to think of scientific visualizations as things that exist in three dimensions of space among which we can move and act.

The human body senses the environment

(Continues on page 94)


We Are Stars
with
Andy Serkis





as overlapping sensory input. In turn, the purpose of a visualization is to understand a situation.

- A scientist understands the data and the underlying phenomena that may require attention.
- An artist, not only in the visual arts but also in music, dance and the like, understands how an experience will reach the senses and our attention.
- Visualization is a point of convergence for the disciplines that further engages the community in scientific and aesthetic exploration.

Scientific visualization

Data complexity is increasing together with the familiarity of immersive and interactive devices, as well as the need to communicate the degree to which spatial and temporal variables are being adjusted to suit human perception. Museum visitors are often curious about how "real" scientific visualizations are. There is "real data" and the "realistic look" of things: the planetarium dome has never been "real," but an abstraction of time and space.

I propose that it is necessary to frame and spell out visualization techniques to the public. If learning how to read was important to spread knowledge, today we need to educate about the aesthetics of scientific visualization in order to communicate complex relationships that connect vast spatio-temporal scales across the universe.

Conclusion

Planetariums have been the immersive and real time interaction referent for the past century, and are today informed by VR/AR mobile and gaming devices. Research in the arts and the sciences, coupled with their corresponding technical developments, challenge us to understand how we think as we are perceiving, and must address the multi-sensory experience of the human body in space.

Even though a group of people are arguably not experiencing VR in the dome because their bodies are not being individually tracked and the view is not affected by their motion, aspects of perception can be evoked cinematographically. Ways to engage the body into agency and presence can be explored via the concept of avatars or dynamic objects in space. Taking advantage of the users' familiarity with VR/AR media, the relationships and roles of these objects should be tailored to share the virtual space of the planetarium dome.

See also planetary-collegium.academia.edu/JulietaAguilera. ☆

(Last Light, continued from page 104)

That's escape velocity from the comet! "And if there are any Australians in the audience—no jumping eight centimeters just because you can."

Base-jumping from the 100-meter cliffs at the landing site would be an exercise in slow motion. Holding his arms wide, he pretended to jump from that cliff, checking his watch every few minutes. It would take 20 minutes before you finally landed, he said. And you wouldn't even sprain in ankle.

During Rosetta's long voyage out to the comet, the craft hibernated. Everything was turned off except for the fuel-line heaters and an alarm clock.

That's probably why Philae's harpoons failed to fire, and the craft bounced slowly from its planned landing site (a boring dusty flat place chosen by cautious engineers) to a precarious one-lander-foot balanced on a cliff wall, partly in the shade, a much more interesting site. The scientists were ecstatic.

Social media sites were abuzz during the whole mission. The image with this column shows the Cheops pyramid Photoshopped onto the comet's surface. "ESA couldn't release such an image," he said, "but we had friends in the BBC who could."

"Think about it," he said. "Primates barely out of the jungle landed a robot millions of miles away. All the BBC anchors stood up and cheered the landing. The last time that happened was when Jeffrey Archer was sent to gaol.[2]"

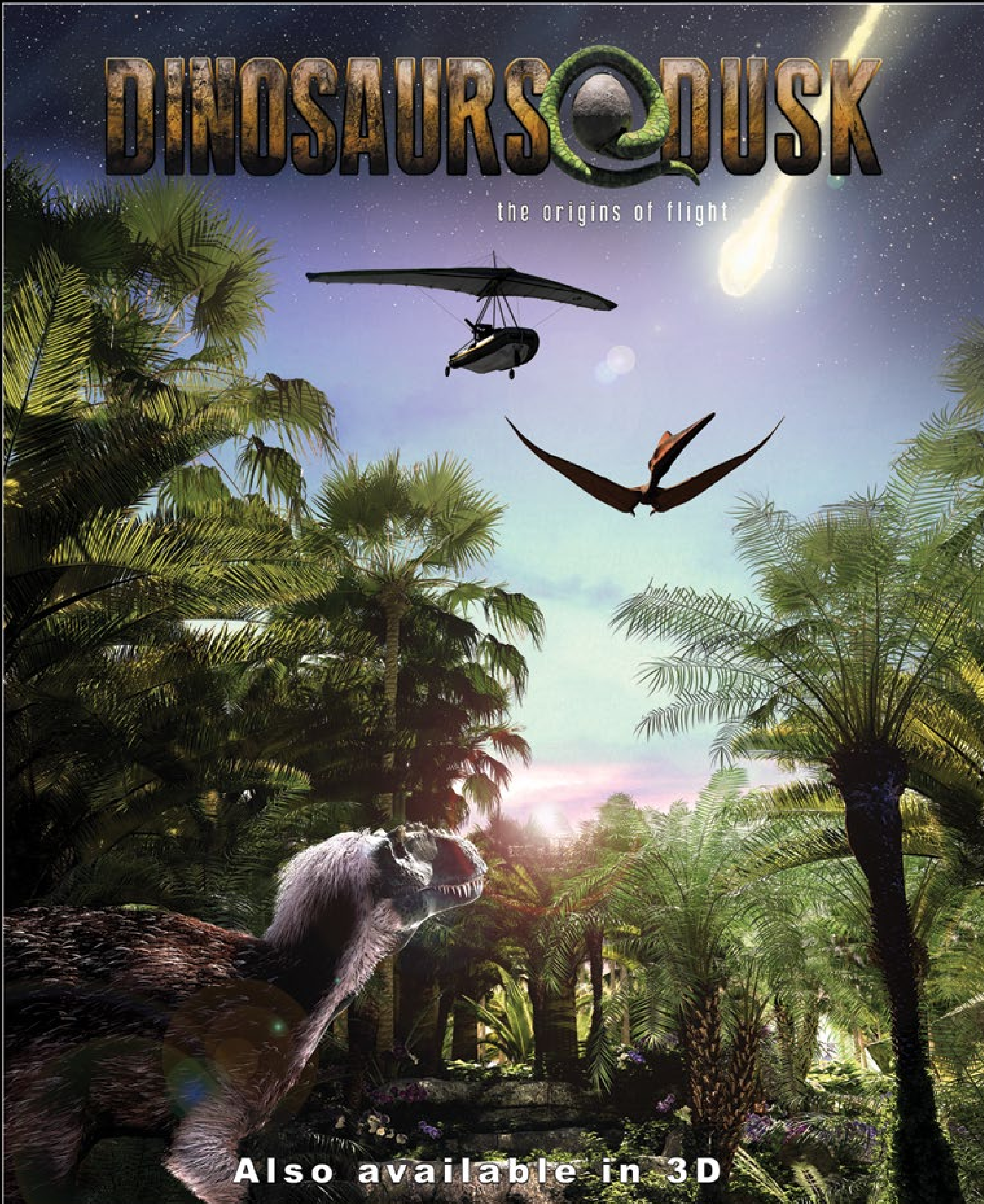
Philae's battery ran down three hours after landing, he reported, "and Twitter went into meltdown."

For a wonderful animation of the entire mission, see www.youtube.com/watch?v=Mz5j6pRRRtA.

Cheops? No! It's Tasmania

A commenter on the high-res photo's site: The shadow cast by the rock Cheops is almost an exact shape of Tasmnania's outline. I was showing the image for a presentation and the people immediately identified the shape. And being Tasmanian's we have a pretty good idea of the shapeof our state! Maybe the shadow will be given its own name when the sun casts the right shadow from Cheops... ☆

2 See en.wikipedia.org/wiki/Jeffrey_Archer to read about the exploits of The Right Honourable Lord Archer of Weston-super-Mare.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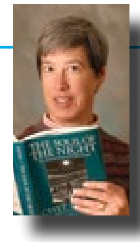
Book Reviews



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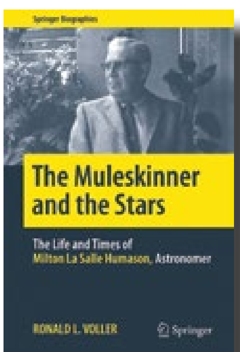
A biography, archaeoastronomy, and the Milky Way

The Muleskinner and the Stars: The Life and Times of Milton LaSalle Humason, Astronomer

Ronald L Voller, Springer, 2016

Reviewed by Francine Jackson, Providence, Rhode Island, USA.

What would be the odds today of a high school dropout who begins his work life as a laborer, becomes a favorite with the pack mules, and spends much of his time gambling with his buddies, becoming a world-famous scientist? In the words of the iconic 1978 movie National Lampoon's Animal House[1], "Zero point zero."



And, yet, that is the history of one of astronomy's most important figures of the 20th century. Milton La Salle Humason, along with Edwin Hubble, was a major player in changing our concept of the universe. Yet Humason left school in his early teens to work in a hotel on Mount Wilson, eventually becoming a mule driver.

As they say, "The rest is history."

While working on the mountain, he met the love of his life, whose father would not allow his daughter to wed someone with such qualifications. So Humason went from driving mules, to working on his family's ranch, to becoming a custodian/night assistant at the newly-built Mount Wilson Observatory.

His ability to work the controls of the telescope for the astronomers led to his becoming an integral part of the observing schedule. From there, Humason discovered his love of the science, and, surprisingly, his being color blind actually aided him in his resultant observations.

Oh, and yes, he did marry Virginia, and they lived happily ever after.

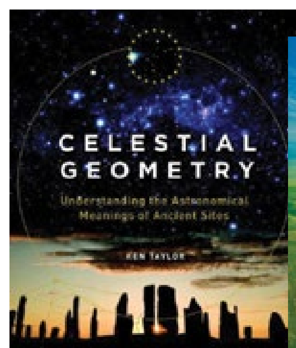
This book was very well researched. Not only is this the story of one of our most important astronomers, but Voller parallels Humason's life with the history occurring at that time, and, when applicable, its effects on Humason and his family. Also, there is a great deal written as to the creative genius of George Ellery Hale, the man behind the giant telescopes of the 19th and early 20th centuries.

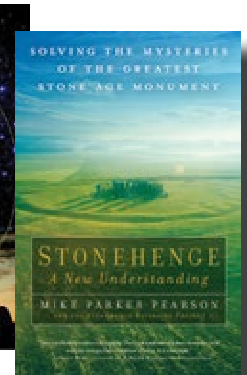
The author states it took him many years to gather all the information to put this biography together, and it shows in great detail. The book includes many pictures, giving the feel of life, and living, on Mount Wilson during that period.

There are, of course, a couple glitches that kept coming up in the reading: It appears when he wrote this book, Voller did so piecemeal. Very often, a fact in one chapter comes up as an apparent new concept in another. For example, George Patton is mentioned in the identical context in two separate chapters. Also, as a person for whom proofreading is a major part of life, I found many sentences not very well constructed—very often with words and phrases repeated, as if the author skimmed over a sentence without reading it carefully. In addition, although this book is just shy of 200 pages in length, the index is quite sparse. In attempting to look for certain references (for example, George Patton), I noted they weren't there, although normally index pages contain just about every person and object relevant to the volume.

Overall, though, as an introduction to a man who, though very important to our love of astronomy, didn't have much written about him previously, *The Muleskinner and the Stars* is sure to open your eyes to a person oftentimes forgotten, or overpowered by Hubble. Someone who, once you finish this book, you will realize was as necessary to our understanding of the universe as Edwin himself. He just didn't have the booming personality that Hubble was known for; instead, Humason was a quiet man who just loved his work and would always do his best. And, as you'll discover, his best was incredible.

1 See more in the Animal House wiki page: en.wikipedia.org/wiki/Animal_House





Celestial Geometry: Understanding the Astronomical Meanings of Ancient Sites

Ken Taylor, Watkins Publishing, London, 2012

Stonehenge: A New Understanding

Mike Parker Pearson and the Stonehenge Riverside Project, The Experiment LLC, New York, 2014

Reviewed by Dave Hostetter, Curator of the Planetarium, Lafayette Science Museum, Lafayette, Louisiana, USA.

I have an interest in archaeoastronomy and by coincidence found myself reading two books related to it, one at home and one at the planetarium.

Celestial Geometry is first and foremost a photographic tour of archaeoastronomy sites around the world. Not all of them are famous, which is part of the charm of the book—the author does a good job showing the worldwide presence of archaeoastronomy.

This is an attractive book. The photography is excellent and well printed, and the descriptions are generally well written, clear and concise. Pictures are sometimes accompanied by well designed maps and diagrams of individual sites (and more images can be found on web sites such as Google Maps). I think this is a book nearly anyone with an interest in archaeoastronomy would enjoy.

Unfortunately, there's a dark side. The author's description indicates that he has written about "earth energies," whatever that means, and several of his other books are about "crystal power" of various sorts. This really gave me pause when deciding whether to buy the book or not, but my concerns were not realized until the last chapter. Why dredge up the fantasies of von Däniken[2], the long debunked claims about the mysterious "knowledge" of the Dogon tribe about Sirius, or claims of alien rock art? It hurt the credibility of an otherwise very good book.

The book is loosely divided into groups of archaeoastronomy sites dedicated primarily to different astronomical themes: solsticial sunrises and sunsets, lunar standstills, planets, and so on. The basic astronomy is usually well explained at the start of each section, with more details added for individual sites.

The one exception is jaw-dropping: on page 124 the author explains lunar phases as happening when "...the shadow cast upon [the moon] by the curve of the Earth changes shape, to create the lunar phases from new to full moon and back again." This is accompanied by a decent diagram of moon phases that clearly shows this explanation cannot be right.

Despite all that, nearly everything about *Celestial Geometry* is quite good, and it's a pleasant read. I think anyone with some knowledge of archaeoastronomy would enjoy it, but I'm not sure I would recommend it to someone who doesn't already have that solid background knowledge.

Stonehenge: A New Understanding is very different from Celestial Geometry. In fact, it's actually somewhat limited in its discussion of archaeoastronomy. Its strength is that it does a truly excellent job of putting Stonehenge into the context of Neolithic Britain. If you want to appreciate and understand Stonehenge more fully, this is a good book to read.

The Stonehenge Riverside Project involved research by the author and several other archaeologists to determine if Stonehenge was a stand-alone monument or part of a larger complex of Neolithic sites. Their research suggests that it was indeed part of the larger complex, and that the region around Stonehenge was a much busier Neolithic place than most people probably realize. In fact, the book covers not only the Salisbury Plain, but also sites from Wales all the way north to the Orkney Islands. I truly had not realized how many Neolithic monuments Great Britain has!

Far more than a simple compendium of sites, though, Stonehenge also details the Stonehenge Riverside Project's archaeological digs, giving behind-the-scenes insight into the archaeological evidence and how it can be interpreted. The author does an interesting job of comparing different interpretations, indicating their strengths and weaknesses and being clear about places where more evidence is needed to gain clarity.

Stonehenge and other monuments were built so long ago that their real purposes were largely forgotten by the time the Romans occupied parts of Britain, and the author includes some amusing stories of how these ruins were interpreted through the millennia. I liked his description of Medieval legends about a site northwest of Stonehenge. He writes (p. 299) that it involves "...the apparition of a giant rabbit with eyes that blaze like fiery coals—what an unthreatening natural world Britain is, if the worst creature that the Medieval mind could conjure up was a big, scary bunny."

2 Erich Anton Paul von Däniken, the Swiss author of several books which make claims about extraterrestrial influences on early human culture. The ideas put forth in his books are rejected by a majority of scientists and academics, who categorize his work as pseudohistory, pseudoarchaeology and pseudoscience. See en.wikipedia.org/wiki/Erich_von_Däniken

What about the archaeoastronomy? It's there, but isn't the main point of the book. The author presents evidence for geological ridges pointing toward the summer solstice sunrise position that may have been the reason for Stonehenge's location. Holes for very early wooden posts aligned with lunar standstills have been found, but the author is skeptical of claims of astronomical uses for Aubrey holes. Several other Neolithic sites are examined for astronomical alignments, but it's all interpreted in the overall context of Neolithic Britain.

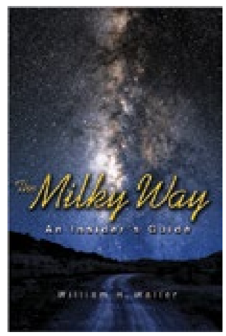
Like a lot of history books, the maps in Stonehenge could be better. I found, though, that reading it with access to Google maps and its street view really enhanced my enjoyment of the book. This really is one of the most interesting and enjoyable popular level archaeology books that I've read, well detailed and bringing Neolithic British culture and astronomy to life.

The Milky Way: An Insider's Guide

William H. Waller, Princeton Press, 2013

Reviewed by Stephen Case, Olivet Nazarene University, Bourbonnais, Illinois, USA.

As every astronomy educator knows, there's a difficult balance between scientific and popular writing. Many authors have a flare for prose, but either get the science wrong or present it in a shallow, distorted manner. On the other hand, there are brilliant scientists who can't write. I'm very pleased to report that William Waller avoids both these pitfalls in this excellent treatment of the Milky Way and our place within it.



Waller uses the galaxy as a thematic backbone on which to present a brief history of astronomy and a detailed introduction to astrophysics. Initially, there doesn't seem to be much new here, but as the book progresses Waller delves into the science and observational techniques that give us clues to the structure and evolution of our galaxy.

It's always a surprise for students to learn how difficult it is for us to actually understand our own galaxy, locked as we are to an observational perspective within it. Even having taught this for years, I learned a great deal through Waller's treatment about the uncertainties and controversies that persist regarding our own galactic home.

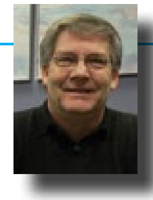
Waller doesn't spare the details, which is welcome in a popularization. Black and white diagrams with long expository captions allow the casual reader to skip and the questing reader to dig deeper. Helpful endnotes provide additional details, and a suggested reading section offers avenues for further discovery.

Throughout, Waller's explanation of stellar dynamics and multi-spectrum observation fill in details that many popular texts gloss over. Though the 2013 publication date means some of Waller's comments on particular space missions are now dated, he points readers to online resources to stay up to date.

But it's not enough to write a popularization that's technically rigorous. Waller succeeds by keeping the reader engaged through two primary techniques. First, the chapters of the book are organized topically in easily-digestible chunks. This makes it ideal to circle back to specific portions that were difficult to follow initially or skim over pieces of the galactic puzzle that a reader might find less interesting.

The second method Waller uses is the most important: he writes well. His prose is clear, compelling, and even playful.

If you want a thorough introductory treatment on how astronomers are answering lingering questions about our own galaxy, suitable for the general reader but also a good resource for the specialist, this book is highly recommended. Indeed, I'm going to give it the best commendation I know how to give: I'm going to pass my copy along to my dad to read. ☆



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Exhibits to foster STEM and STEAM

Modern exhibit design has certainly left behind the idea of only looking at stuff in glass cases when it comes to science subjects. We are in the electronic age and the visitor simply demands a more interactive experience. The current buzz words in education are STEM and STEAM.

Science, Technology, Engineering, and Math and/or Science, Technology, Engineering, Art, and Math. Many grants and funding mechanisms are in place for implementation of programs that support this track. Of course, the planetarium and the planetarium lobby/entry areas are a superb location for interactive exhibits that support such programs. The following are some ideas we have had the opportunity to implement in working with some of the best exhibit designers in the world. Some places where you can see these are listed as well.

The objective—The design—The story

Defining this part of the design is the most important. What do we want the exhibit to do? How do we determine this? Is the exhibit tactile or electronic? Interactive? Or linear? Visitor initiated or looping?

Maria Piacente from Lord Cultural, a professional practice dedicated to creating cultural capital based in Toronto, offers in a recent email, "If we understand that exhibitions are about meaning, communication, and affective transformation, it follows that any museum experience is not first and foremost a problem of design, but a challenge in planning for effective communication with intended groups of visitors. What meanings do we wish to communicate? To whom do we intend to communicate these meanings? What are the most appropriate means of communicating these meanings? How is this content relevant to lives of our visitor?"

She continues, "In order to answer these questions and to successfully connect objects and content found in museums to visitors emotionally and intellectually we need to be grounded in the story we want to tell. By creating a storyline or interpretive plan that addresses audience objectives and content requirements, we can ensure that interactive exhibits make sense and don't end up like a series of touchscreens individual exhibits that are disconnected and irrelevant to the lives of our visiting public."

Kirsten Tashev at the Computer History Museum in Mountain View, California, the heart of Silicon Valley, suggests in another email that "If you decide to create an interactive exhibit, make sure you understand your goals and audience, otherwise you risk spending a lot of time and money on a flop. Interactives are best for explaining concepts or giving visitors a chance to experience a phenomenon for themselves or role play and not necessarily cramming in more detailed content."

The content

Typically called the media or media content in the exhibit world, it is best to determine what the content will be and how it works before the technologies/electronics are selected.

Some good advice came from Tim Lay from Northern Light Productions in Boston, a documentary film production company. "In general, the technology should be subservient to the content of the exhibit, and not vice-versa. This is because an effective exhibit is all about telling a good story. You don't really want the technology to be the message, you want your story to be the message. In many exhibits, you want the technology used to tell the story to melt away in the visitors' minds, as you want them focused on the activity or story. In these cases, you want the visitor to be transported to another realm of learning, of inquiry, or of imagination. Good storytelling is all about captivating your audience, and you don't want the technology to stand in the way of this.

Right: Interacting with paleo at the new North Dakota Heritage Center. Photo courtesy Lord Cultural.

Below: Cybercrime scene interactives at the Tech Museum. Photo courtesy Northern Light Productions.

"At the same time, however, science museums and planetariums are constantly working to draw in visitors. In this world, science museums and planetariums are constantly looking to provide a unique experience for visitors that's unlike what they can get at home or elsewhere. All of this means that sometimes it's important to let the exhibit technology share the stage with the exhibit content. Visitors love fun and interesting ways of learning, especially when they are different than what they can experience at home. So, sometimes it makes sense to allow the medium to be become part of the message.

“One example of this is a project that we made for the Tech Museum of Innovation in Silicon Valley about cybersecurity called Cyber Detectives. One touchscreen interactive exhibit here focuses on password cracking. The program uses an open-source password cracking software that is used by actual hackers to provide a rigorous and authentic test of the visitor’s passwords. It is designed so that this software is an obvious and key component of the interactive experience. So, here the technology itself enhances the quality of the exhibit, and is in fact part of the message or story. All of this is part of the Tech Museum’s general philosophy that “science and technology should not be mysterious; therefore, the technological components which make exhibits work should be seen by the visitor.”

Above: Vistors interact with over 100 individual exhibits at the Computer History Museum in Silicon Vally. Photo by CHM.
Next: Visitors insert themselves into “virtual“ story backgrounds by using a green screen (see the monitor in the upper right hand corner). Photo by Bowen Technovation.

The technology-What the visitor experiences

There are four genre of technology to consider in the development of an exhibit:

Audio: Is there audio? No audio? Mono? Stereo? Surround? High impact? Low level for one visitor? Focused to prevent bleed into adjacent exhibits? User initiated by button, motion sensor or touchscreen? Looping?

Video: Is there video? Old archive footage? Photos? Live webcams from remote sites? New high-res HD or 4K material? How many visitors view at one time? Length of show?

Lighting: Is there specialty lighting to enhance the experience? Are there backlit photos/ transparencies/models or specimens that light when the visitor pushes a button?

Control: Is the exhibit a single self-contained “stand alone“ unit? Are the exhibits networked together from a central master control system? Does the visitor control interactives via buttons, motion sensors, touchscreens, or a Kinect-type gesture system?

The technology-Operational

OK. So now, we hope we know what the story is and that we can determine the technologies that best support the objective. Don’t forget you have to maintain and operate these nice toys. Some questions to consider are:

Do you want these to turn on/off at scheduled times and on certain days? Or do you want to walk around with remotes to manually turn these on and off? Even the simplest electronic exhibits can now have “schedulers“ built into their software to turn them on and off, to select what program runs on certain days and times, and can even allow for teacher/docent override (with button, wall switch, or even an app) so the technology can also be used for live presentations.

How will content be updated? Do you just swap a memory card with the new material? Do you update though network? Is there a sophisticated content management system such as with a database driven exhibit? Will you award an annual contract to the content developer to update? Or will you do so in house?

The structure

Well, we can’t just have bunch of touchscreens with wires dangling out of them. We need some structures for these electronics to fit into, typically called casework. One of the first considerations is to make sure all the structures are ADA and local code compliant.

In the USA, Americans with Disabilities Act info is available online, and other nations have their requirements for what is called “Universal Design.“ Here is link to some good information: accessible.si.edu/pdf/Smithsonian%20Guidelines%20for%20accessible%20design.pdf.

And don’t forget that they also must be kidproof ,while allowing for proper service access, cooling, and wireways.

Do want super clean look in the exhibit with minimal casework? Such as just a touchscreen on a rail? You might want to consider installing the head end computers, video players, audio gear, etc. in a nearby control room or data closet? Still want a lean look but in as impler format than providing a control room? Here is photo of a nice self-contained unit that Exhibit Concepts (Vandalia, Ohio) designed for the Computer History Museum.

Want more? Email me directly and I’ll send a detailed PowerPoint that drills down deep into this subject. We will look at “making it all work” in my next column.

Kudos to Mark Trotter

On another note, I would like to salute IPS for naming Mark Trotter a Fellow of IPS. He is one of the most dedicated planetarium professionals I have known and has worked daily with planetariums for 30+ years. Kudos to Mark and to IPS. (See page 13.)

Reader question for this Issue

Q: When I use my classoom projector I see a gray rectangle on the dome, even when I don’t send video to it. But I want to use it for short times in the dark when my stars are up. What can I do?

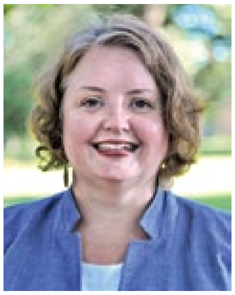
Typical projector shutter, controlled via DMX.

A: Some projectors have built-in dowsers (yes, that is the correct spelling) or shutters to block this LCD or DLP light bleed. If your projector does not have one, third part units are available that can “shutter“ the light as needed by control system control via DMX, 232, or switch closure.

Send your questions to me at jeffb@bowentechnovation.com. ☆

Waxing New

An eclectic collection about planetariums, products, and people
Compiled by Sharon Shanks



Amy Barraclough Denise Young

Amy Barraclough: Edelman

Rowan University, Glassboro, New Jersey, has appointed Amy Barraclough as the director of the Fredric and Jean Edelman Planetarium. She replaces founding director Keith Johnson, who retired after 12 years at Rowan.

Barraclough comes to Rowan from the University of Texas at Arlington, where she served as the planetarium program coordinator since 2008. At Rowan, Barraclough will work to continue to expand the planetarium programs that serve Rowan students and the community at large.

Barraclough earned her Bachelor of Science in physics at the University of Wisconsin-Stevens Point, where she served as a planetarium educator for four years.

Denise Young: Bell Museum

Denise Young, director of education and planning for the Morehead Planetarium and Science Center at the University of North Carolina at Chapel Hill, will assume her new role as executive director of the Bell Museum+Planetarium at the University of Minnesota on September 12.

She will oversee programs, research and facilities at a crucial time in the Bell Museum's 144-year history, as it prepares to move to a new, state-of-the-art facility with improved exhibits space, a versatile 120-seat planetarium/digital theater, and expanded educational areas on the university's St. Paul campus. The new building will open in 2018.

She holds an Ed.D. from the University of North Carolina at Chapel Hill in curriculum and instruction, M.S.A. in school administration/educational leadership and B.A. in early childhood education.

The Bell Museum of Natural History was established in 1872 as the official natural history museum for the state of Minnesota. In 2011, the Bell Museum was joined by the Minnesota Planetarium Society in a historic merger that expanded the capacity and range of educational experiences for youth and adults.

Robin Sip joins E&S

Evans & Sutherland (E&S) has welcomed Robin Sip of Mirage3D as director of show production and content. Robin will direct the E&S show and content production business, working closely with Terence Murtagh and Michael Daut. Sip is an award winning director and writer of the best-selling fulldome productions *Dawn of the Space Age*, *Natural Selection*, and *Dinosaurs at Dusk*.

MARS 1001: A Thousand Day Trip to Mars will be the first E&S production written and directed by Robin. Filming for this groundbreaking production will take place both at E&S Headquarters in Salt Lake City, Utah, and also at the Mirage3D Studio in The Hague, The Netherlands.

Two new free shows

Free is always good, and there are two new fulldome shows available at no charge to domes around the world.

The first is *The Dark Matter Mystery: Exploring a Cosmic Secret*, produced by the Planetarium in Laupheim, Germany. Written by Dr. Rafael Lang and funded by the National Science Foundation, the show is being released under a Creative Commons license and freely available for download at show.darkmatter.org. It includes fulldome footage from the LHC/CMS-detector and the Laboratori Nazionali del Gran Sasso in Italy.

Duration: 38 minutes; resolutions: 2k, 4k; languages: German, English, and French and Italian (audio only). Go to www.youtube.com/watch?v=qD4VN4s0EZU for a fulldome preview.

The second is *The Incredible Sun*, an 11-minute production of the Brno Observatory and Planetarium that was featured at the recent IPS Fulldome Festival Brno. It is geared for general audiences and comes in 4k.

There are several conditions, however. The show is a gift of the Brno Observatory and Planetarium to the fulldome world. It is free of charge and royalty free for both commercial and non-commercial use, and cannot be sold to a third party. The show cannot be altered or modified and must be used as a whole. Translation and recording the voiceover in your language is fine, but you must make your language track available free of charge to other planetarians.

You will receive a download link within 48 hours after the registration at www.brnoplanetarium.com, where you can find more information.

More music in the library

Loch Ness Productions has announced that four new discs with nearly five more hours of music have been added to its royalty-free production music resource specifically created for planetarium use. It was introduced in 1978, and continues to be updated. There are now 16 volumes and 19 hours of music in the library.

The new tracks can be auditioned at www.lochnessproductions.com/mb/mb.html.

Also new: every library track is now available a la carte. Through LNP's affiliation with CD Baby, producers can download individual tracks and pay online.

Good news from a former student

Thomas Wm. Hamilton of New York, sponsor of a scholarship to support students interested in entering the planetarium field, received some heartening news from one of his scholarship recipients.

Nick Juliano wrote recently saying: "I am eternally grateful for the opportunities you have given me through the Hamilton Planetarium Scholarship. You may be happy to hear that I have been hired as the planetarium program manager at the College of Southern Nevada in Las Vegas, Nevada. My start date is August 15, 2016.

"As a former recipient, I hope to foster further student interest in planetaria, and I intend to do so with the help of your scholarship. I will be referring capable CSN students to your scholarship. Hopefully, I will help find the first Pacific Planetarium Association scholarship recipient." ☆


Antonín Rükl

Antonín Rükl, 1932-2016

Antonín Rükl, 83, retired director of the Prague Planetarium, passed away on July 12, 2016.

He was born on September 22, 1932, in Čáslav, Czechoslovakia. As a student he developed what was to be a lifelong interest in astronomy. He graduated from the Czech Technical University in 1956, then became a staff member of the astronomical department at the Prague Institute of Geodesy.

Beginning in 1960 he joined the Prague Planetarium, eventually becoming deputy director and then head. He also became chairman of the Planetary Section of the Czechoslovak Astronomical Society and served as vice president of the International Planetarium Directors Conference from 1996 until 1999. He retired at the end of 1999.

During his career he was a popularizer of astronomy and authored many books on the subject. He was skilled in cartography as well as selenography, the skill of mapping the moon. He illustrated many of his own books, including the highly regarded Atlas of the Moon.

He was the recipient of many awards and in 2000 asteroid 15395 was Rükl in his honor. In 2004 he became the first non-German laureate of the Bruno H. Bürgel, which is awarded by the German Astronomical Society Astronomische Gesellschaft for popularizing astronomy in German. For lifetime achievement in the fields of astronomy and celestial and lunar cartography, he was awarded the highest astronomy award in the Czech Republic, the Price Francis Nusl, in 2012.

He is survived by his wife, Sonja, a daughter and a son. ☆

Source: Wikipedia, Prague Planetarium

Donald Lunetta Sr., 1940-2016

Donald Lunetta Sr., of Chappaqua, New York, passed away on July 15, 2016, at home after struggling with brain cancer.

He is survived by his wife of 56 years, Loretta-Jo; his brother, Dennis; children Roslyn, Matthew, Samuel, Celeste, and Donald Jr.; and four grandchildren.

Born in 1940 to Samuel and Esther Lunetta, Don was raised in Sacramento, California. After his marriage in 1960 he moved to Colorado, where he worked at the Denver Museum of Nature and Science as the curator of the planetarium. During his tenure at the museum, he designed several pioneering technologies for planetariums, including the first tilting dome and the first telescope/television projection system.


Donald Lunetta Sr.

Don's systems were used by NASA and national news media to show the progress of Apollo 10. In addition, Don was honored to be part of the discovery and first known documentation of nesting Goshawks in Colorado, with his photographs and story included in The Colorado Book of Birds. He remains known at the museum for his sense of humor, wonder, and aptitude for education and community outreach and was featured in DMNH's recent 50-year retrospective of the museum.

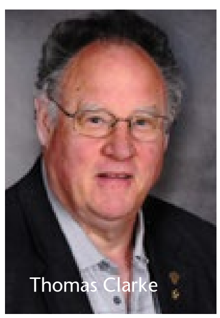
Hired by McGraw Hill in 1969, Don moved his family to New York, where he consulted on space and planetarium projects throughout the 1970's. He designed and directed the installation of planetarium domes and telescopes at Horace Greeley High School in Chappaqua and at Camp Kaybeyun in Alton Bay, New Hampshire.

Don owned and operated his own business, Small Moon Enterprises, an international multimedia production company. Responsible for all aspects of production, he created multimedia interpretive exhibits for museums and special projects, including work on the Intrepid Sea Air Space Museum, the Franklin Park Zoo in Boston, the Charlotte Science Museum, the Amarillo (Texas) Science Center, Roanoke Science Museum, West Virginia's Oglebay Park, the US Navy Band, Covenant House, and the Louisiana World Fair and Smithsonian Folk Life Festival.

He was a pioneer in multimedia production and interactive communications and marketing, starting with his creation of a panoramic five-camera system in 1975 and following through to water screens and interactive touch screens in the early 1990's. Don held multiple patents for his inventive technology related to multimedia production. ☆

Thomas Roy Clarke Jr., 1940–2016

Thomas Roy Clarke Jr., 76, of Toronto, Canada, passed away on July 30, 2016, after a short illness caused by recurring cancer. He was born in Montreal West on December 23, 1940, and settled with his family in Toronto in 1952.


Thomas Clarke

He received a PhD in radio astronomy from the University of Toronto, and served as the first (and only) director of the McLaughlin Planetarium from 1976 until it closed in 1995.

He very much enjoyed designing, assembling, and presenting the many planetarium programs over the years, and after the closure of the McLaughlin he continued to work on special projects at the Royal Ontario Museum until his retirement in 2003.

He was a life-long scout, moving through the ranks of Scout, Queen Scout, and Rover, and served as the leader of a Venturer company for a number of years. In all, he was involved as an adult in Scouts Canada for 56 years of service.

He leaves his wife of 38 years Kathy, children Christopher and Caroline, grandchildren, and brothers Allyn and Warner. ☆

> For my part I know nothing with any certainty but the sight of the stars makes me dream.
> — Vincent Van Gogh
> Spacequotations.com

> What beauty. I saw clouds and their light shadows on the distant dear earth.... The water looked like darkish, slightly gleaming spots.... When I watched the horizon, I saw the abrupt, contrasting transition from the earth's light-colored surface to the absolutely black sky. I enjoyed the rich color spectrum of the earth. It is surrounded by a light blue aureole that gradually darkens, becoming turquiose, dark blue, violet, and finally coal black.
> — Yuri Gagarin
> Spacequotations.com

Planetarians' Calendar of Events

www.astrofilibresciani.it/Planetari/Internationa_Calendar.htm
Compiled by Loris Ramponi - osservatorio@serafinozani.it

2016 International Year of Pulses

15 September. Deadline for the applicants of "A Week in Italy for an American Planetarium Operator," in collaboration with IPS Portable Planetarium Committee. www.astrofilibresciani.it/Planetari/Week_in_Italy/Week_Italy.htm

16-20 September. Association of Brazilian Planetariums (ABP), 21th Annual Meeting, CEU Foundation Planetarium, Brotas, São Paulo state, Brasil. www.planetarios.org.br

21-23 September. Digistar Users Group, conference, planetarium at University of Texas at Arlington, Texas. Contact: planetarium@uta.edu; 817-272-1183; www.uta.edu/planetarium; www.facebook.com/utaplanetarium

23-25 September. British Association of Planetaria (BAP), annual meeting, Bristol Science Center Planetarium, United Kingdom. Contact: BAP President Mark Watson, m.watson.bap@gmail.com; www.planetaria.org.uk; bapconference.org.uk

24-27 September. Association of Science-Technology Centers (ASTC) Annual Conference, MOSI, Museum of Science and Industry, Tampa, Florida, USA. www.astc.org

26-28 September 2016. IX Tecnoplanetario, the national meeting of Spanish planetarium professionals. Espacio 042-Planetario de Huesca, Parque Tecnológico Walqa, 22197 Cuarte, Huesca. www.espacio042.com

4-10 October, World Space Week, Contact: taganaba@worldspaceweek.org; www.worldspaceweek.org/calendar

19-22 October. Great Lakes Planetarium Association, GLPA Conference, Longway Planetarium, Flint, Michigan, USA. www.glpaweb.org; contact Todd Slisher and/or Jeff Stark at tslisher@sloanlongway.org; jstark@sloanlongway.org (A GLIPSA workshop will preceed on October 18)

21-23 October. Small digital planetarium workshop, Jardin des Sciences, Strasbourg, France. Contact lionel.ruiz@live.fr

8 December. Deadline of the Stratoscript Compendium Ring 2014, a scripting competition open to everybody by LSS-Planetarium. Contact: lionel.ruiz@live.fr; www.lss-planetariums.info/index.php?lang=en&menu=compendium&page=compendium2013

16-18 December. Small digital planetarium workshop, Marseille Planetarium, Marseille, France. Contact: lionel.ruiz@live.fr

31 December. Deadline for entries to "Page of Stars" organized by IPS Portable Planetarium Committee in collaboration with Serafino Zani Astronomical Observatory. Contact: Susan Reynolds Button, sbuttonq2c@gmail.com; www.ips-planetarium.org/?page=pagesofstars

31 December. Deadline for entries for A Week in the United States for an English-speaking planetarium operator. Contact: Susan Reynolds Button, sbuttonq2c@gmail.com; www.ips-planetarium.org/?page=share

2017

22-26 February. Annual IMERSA Summit, Denver Museum of Nature and Science. imersa.org

28 February. Deadline of PlanIt Prize for an original video production, organized each year by Italian Association of Planetaria (PlanIt), Italy. The prize is open to everyone. First prize 500 euro. www.planetari.org

12 March. International Day of Planetaria. www.dayofplanetaria.org

22-23 April. Italian Association of Planetaria (PlanIt), XXXII National Conference, Planetarium Südtirol/Alto Adige, San Valentino in Campo 5, 39053 Cornedo all'Isarco, Bozen, Italy. Contact: osservatorio@serafinozani.it; www.planetari.org

29 April–1 May. Gesellschaft Deutschsprachiger Planetarien e.V., GDP 2016, annual meeting of the German-Speaking Planetaria, Berlin. Three planetariums (Zeiss-Grossplanetarium; Wilhelm-Foerster-Sternwarte; Archenhold-Sternwarte)will host parts of the conference. www.gdp-planetarium.org

12-14 May 2017. Association of French Speaking Planetariums (APLF), Yearly Meeting, Cité des science et de l'industrie, Planétarium, La Villette, Paris, France. www.aplf-planetariums.org

17-20 May. 11 FullDome Festival in Jena, Zeiss-Planetarium, Germany. Contact: info@fulldome-festival.de or Volkmar Schorcht, schorcht@zeiss.de; www.fulldome-festival.de

18 May. International Museums Day, icom.museum

21 August, Total solar eclipse (USA).

1-3 September. Nordic Planetarium Association Meeting, Vattenhallen Science Center, Lund University, Sweden. Contact: Aase Roland Jacobsen, aase.jacobsen@sm.au.dk

October. US affiliates first-ever national meeting, James S. McDonnell Planetarium, St. Louis, Missouri.

21-24 October. Association of Science-Technology Centers (ASTC) Annual Conference, The Tech Museum of Innovation, San Jose, California, USA. www.astc.org

For corrections and new information for the Calendar of Events, please send a message to Loris Ramponi at osservatorio@serafinozani.it More details about several of these upcoming events is included in the International News column in this issue.

The most up-to-date information also is available online at the IPS Calendar of Events at www.ips-planetarium.org

How to organize an eco-friendly planetarium conference: www.scienzagiovanissimi.it/best-practices

To see more logos, go to www.astrofilibresciani.it/Planetari/Planetaria_Associations.htm

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Renovation fun and catching a comet with Rosetta

During a panel session at this year's Southeastern Planetarium Association conference in Montgomery, Alabama, Phil Groce stepped down from the podium, just as the computer glitched. A voice from the dark called, "Someone help Phil succeed!" (Phil's company is called Helping Planetariums Succeed.)

Several planetarium staff described their facilities' restorations or remodel projects during the conference. SEPA conference host Rick Evans noted, "We ran that hot race with Miami to see who could keep their STP (a Spitz star projector) running longest."

From the audience, Miami's Claudia Hernandez called out, "We won!" "You won," Rick replied, "because I quit. I'm not a proud man."

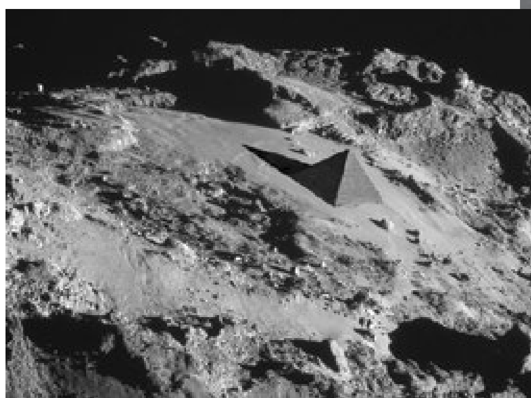
Rick described his planetarium's remodeling project. His administration, he said, is cheap. Showing images of the project, he pointed out the planetarium seats. They were not allowed to be replaced. Instead, years of student use, wear and chewing gum had to be scraped off by hand. When it was finished, he said, "We had the biggest ball of gum in the world. Some of it's not bad."

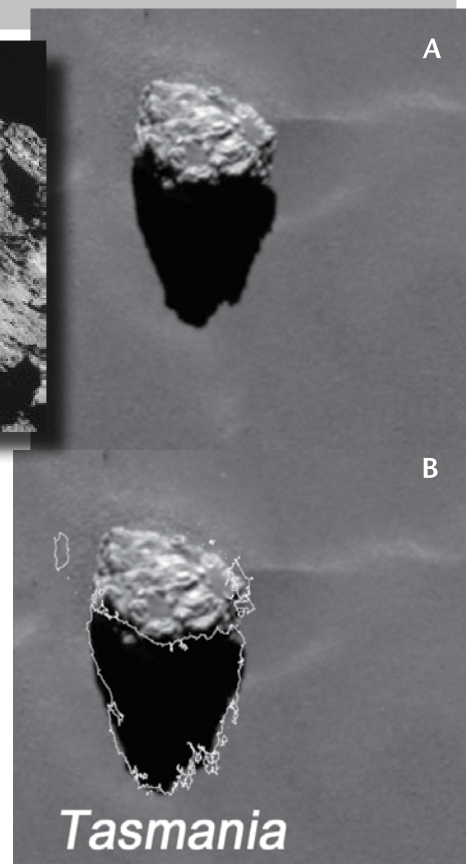
"We had the promise of help," Rick said. "See these guys in white? They're called prisoners. They're excited to be out of jail - even for a day." Exhibiting the tangled mess of wires at the console, "it always looked like this." The dialogue went something like: Q: "Is this wire hot?" A: "I'll let you know in a minute."

It was all done in 27 days, from February 1 to 28. "And three of those were snow days. In Alabama. I was the only one dumb enough to come to work. Hey—I was under deadline."

"Have I mentioned the administration is cheap?"

"The really amazing thing? Both of my employees are still there."





Above: This altered image of the Cheops boulder was sent to the BBC. It is sure to start conspiracy theories rolling. Above, image A: This image of the surface of Comet 67P/Churyumov-Gerasimenko was taken by Rosetta's OSIRIS narrow-angle camera on 19 September 2014, from a distance of 28.5 km. The boulder has a maximum dimension of about 45 metres. Because it reminded scientists of the famous pyramids at Giza near Cairo in Egypt, it was named Cheops. Credits: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/ID; go to sci.esa.int/rosetta/54756-boulder-cheops for more information. Or, if you look closely, the boulder's shadow in image B also could be the outline of Tasmania.

A phoenix rises in Memphis

Dave Maness (from the Memphis, Tennessee Pink Palace Planetarium) described his planetarium's rise from the ashes[1]. It wasn't supposed to burn down, but...

Cleaning the dome, Dave mentioned, made it less reflective. Think about it. All the holes were full of dust, and now they're not.

Dr. David King described the Wetumpka crater, located in Elmore County, Alabama. With the summer foliage mostly hiding it, a few hardy souls slogged their way to the crater after his lecture, and brought back some fascinating rock samples.

He enjoyed giving the presentation.

"One of the fun parts of my job," he said, "is I get to talk to people who actually listen to me, unlike my students."

In his work, Dr. King described finding the shock material discovered near the drill site. "We didn't know before we drilled (who knew?)" he said, "or I'd have just scraped some up from the side of the road."

Dr. King described a new class of meteorite as well, the "leaverite." As in, "Leave 'er right there." More of a "meteor-wrong."

The IPS meeting in Warsaw, Poland, was a huge success! Many thanks to our hard-working hosts and all their staff and volunteers. There was something for everyone, from the simplest of paper models to the newest software and imaging techniques.

Run with catching a comet

Prof. Mark McCaughrean was one of the excellent keynote speakers. His topic, "Rosetta: To Catch a Comet," was a hit. In 2014, the European Space Agency's Rosetta craft rendezvoused with comet 67P/Churyumov-Gerasimenko and sent the tiny Philae lander to the comet's surface.

The comet is tiny in astronomical terms, only four kilometers by one kilometer. Small mass, small gravity. Dr McCaughrean used an audience participation activity to demonstrate the difficulties in getting a lander to such a surface.

He instructed us to stand, and to jump vertically four centimeters.

(Continues on page 94)

1 Welders making repairs to air conditioning sparked the fire on March 18, 2015. The planetarium was undergoing renovation at the time.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