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CAP journal

Communicating Astronomy with the Public

Aesthetics & Astronomy
The Public's perception of astronomical images

Big Bang
How well is it communicated to the public?

Disney's Phineas & Ferb
Explore the Moon with Galileo

THE UNIVERSE YOURS TO DISCOVER
BEYOND INTERNATIONAL YEAR OF ASTRONOMY

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Colophon

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Cover: Detailed view into the Compact Muon Solenoid (CMS) experiment, one of two large particle physics detectors built at the Large Hadron Collider (LHC) at CERN in Switzerland and France. The three concentric cylinders, each comprised of many silicon strip detectors (the bronze-coloured rectangular devices, similar to the CCDs used in digital cameras), surround the region where the protons collide. The experiment is looking for evidence of physics not described by the Standard Model, essential to understanding the Big Bang. More information: http://cms.web.cern.ch/ Credit: CMS/CERN

Editorial

At the end of 2010, the International Year of Astronomy 2009 (IYA2009) Secretariat will finish its activities. It was back in 2007 that the International Astronomical Union (IAU) established the IYA2009 Secretariat at the European Southern Observatory's (ESO) Headquarters in Garching, Germany. The Secretariat's role was to act as a hub for IYA2009 activities. It coordinated projects from the planning stages through to evaluation, and was a central contact for the hundreds of national nodes, international organisations, global projects, the media and the general public.

The Secretariat was embedded in ESO's education and Public Outreach Department (ePOD), which provided invaluable support and expertise for IYA2009. Its position within ePOD, with a ready-made editorial team already in place, was integral to the launch of the CAPjournal.

While the IYA2009 Secretariat closure marks the end of the largest initiative that the International Astronomical Union (IAU) has ever embarked upon, the organisation remains committed to promoting education and public outreach throughout the world. As part of the legacy of IYA2009, the IAU is supporting the continued production of CAPjournal. I will remain editor-in-chief, and Lars Lindberg Christensen will continue his vital role as executive editor.

On a personal note, in early 2011 I will be starting a new position at Leiden University in the Netherlands, where I will be the International Project Manager of the educational project Universe Awareness, an IYA2009 Cornerstone project. I have enjoyed my tenure as IYA2009 Coordinator and I have appreciated the opportunity to work with the talented team at ESO ePOD.

Speaking for the last time as IYA2009 Coordinator, I would like to thank you all for your hard work, support and dedication in making IYA2009 an astronomical success!

Happy reading,

Pedro Russo
Editor-in-Chief

Explained in 60 Seconds: Pro-Am

Key Words

Written Communication
Case Study
Pro-Am

While professional astronomers are lucky enough to make a career out of their passion, amateur astronomers enjoy observing the night sky purely for the pleasure of seeing distant celestial objects. But there are amateur astronomers who want to take their hobby further — and professional astronomers are now recognising how amateurs can help them with their research. This kind of cooperation between professional and amateur astronomers is referred to as a Pro-Am collaboration.

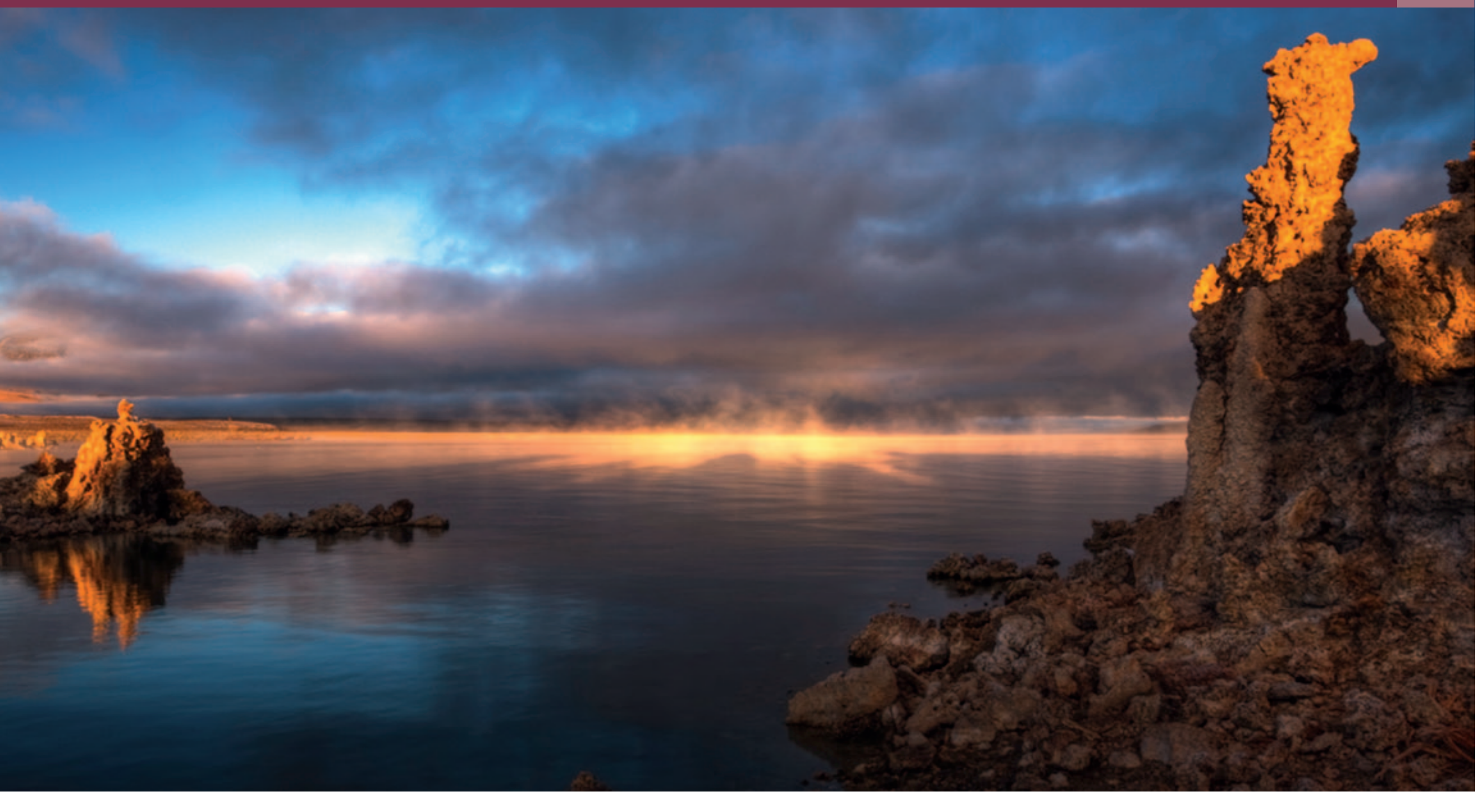
Good examples of Pro-Am projects are the long-term observational studies by amateurs that are too time-consuming for professional astronomers to even consider undertaking themselves. An alternative type of Pro-Am project involves amateurs working on their own initiative to make important observations and discoveries of, for example, supernovae, which are then followed up by professionals. For example, in 2009 and 2010, amateur astronomers were the first to spot impacts on Jupiter, with their observations then pursued using professional telescopes.

The sudden surge in Pro-Am collaborations is partly due to the affordability nowadays of cutting-edge equipment, like large (8-inch or more) telescopes and high-spec CCD cameras, which bring faint celestial objects firmly within the reach of amateurs.

Hopefully, in the future, the number of Pro-Am projects will continue to grow, as they are greatly beneficial to advancing our understanding of how the Universe works.

Text crowd-sourced with valuable inputs from Jean-Luc Dighaye (EurAstro) and Sarah Reed (ESO). A list of Pro-Am collaborative projects in astronomy can be found on line: http://goo.gl/WzKL2

The Mono Lake Research area in central California (USA) has a central role in the most controversial science media story of 2010: NASA-supported researchers have announced the discovery of the first known microorganism on Earth able to thrive and reproduce using the toxic chemical arsenic. The microorganism, which lives in California's Mono Lake, substitutes arsenic for phosphorus in the backbone of its DNA and other cellular components. However the scientific community, journalists and new media activists have been vocal in their opposition to the way NASA publicised the story and even the veracity of the findings. Maybe 2011 will shed some light on this controversial story. Credit: NASA



Taming the Watchdog

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Key Words

Media Relations
Pitching a Story
Media Requests

Summary

Talking to the media about a particular expertise or passion might seem easy, but not knowing certain details of the media interaction process often prevents science communicators from sharing their knowledge and expressing their enthusiasm to journalists and, through them, to their final audience, the public. Here is some advice on how to make the most of talking to the press.

One of the oldest roles of the mass media has been compared to that of a watchdog, guarding the public space by deciding which pieces of information are allowed through. In the process of communicating science to the public, science communicators will often resort to mass media channels as a way of reaching out to a greater target audience. Inevitably, this leads to contact with journalists who will then decide if or how the story is actually published.

Communication between science communicators and journalists is challenging because a misstep anywhere in the process can mean failure or success. So it is crucial for a communicator to develop media relations skills that can help to get a story across.

So how can the watchdog be tamed so that the communicator can cross the threshold into media territory and reach the interested audience at the other end? There is no specific recipe, but there are some basic steps that can help make the process not only less difficult, but also more pleasant.

There are two general cases when science communicators interact with the media: proactive communication, when the communicator pitches a story to journalists, and reactive communication when journalists request information from the communicator.

Case 1: Make the watchdog your friend

It is natural to think that media relations start when a dialogue begins between the two parties, communicators and journalists, and that the most important aspect in media relations is what one party says and sells. However, there is another step, before contact is even made, which is even of greater importance as it determines how the relationship kicks off — research!

According to standard communication strategies, the first step a communicator should take is to research the relevant media target, as well as the organisation and the sector where it is active. The primary objective of this research is to get to know the mass media channels and its journalists in as much detail as the journalists are supposed to know their own target audience.

Communicators should be familiar with the specifics of each targeted media channel in a depth that goes far beyond the obvious issues — for example, be aware of the difference between communications that target written publications versus television, or radio versus online. Other important details are a media outlet's editing policies, its planning of monthly topics for the current year, favoured topics, its area of coverage, whether it has a science journalism department (and its size), the names of the journalists covering science, deadlines, format and style of written/broadcast materials.

Most of this information is usually easily accessible, but gathering it is a time-consuming process. The first place to look is the website of the mass media channel, where editing policies, the mission statement, departments and the names of journalists working for the media channel are all available. Sometimes media channels will even upload presentations about their targets onto their websites, that is, information about their reach, distribution, audience or traffic — all fascinating numbers for any communicator. For future topics or thematic numbers/editions/shows contact the editor-in-chief/producer and simply ask for this information. In most cases, they will gladly share it with you. Make sure you also ask for any deadlines that they might have for submitting press releases or pitching a story that is in line with the topic.

Communicators should also carry out research at the personal level. Journalists in your database should be more than just the people you talk to when you have something to communicate on behalf of your organisation. They should be your professional friends, or, even better, simply your friends.

As in your personal life, you should get to know their likes and dislikes, hobbies, family and friends, professional background, where they spend their vacation etc.

Ideally, this knowledge would come naturally from contact with a journalist on a variety of occasions, and not just when you are pitching a story. However, for practical reasons you will not be able to make friends with each and every one of them. Make sure you research for sufficient information that will allow you to identify the best way and timing to contact a particular journalist, as well as the most interesting approach to take for a story that will make it appeal to the journalist. You can do this very easily today with the help of the social media that blur the boundaries between professional and personal lives and allow you to access parts of the private life of a journalist. You could search for a personal blog, for example. Take your time and read through posts, identify interests, likes and dislikes, opinions.

Once you have come to know your journalist, you are more likely to be able to present your story from the right angle, engage them in the topic and take a more friendly approach. With the right background information you can make your story more scientific, or give it a more human touch as appropriate. As a result, journalists will be more open to listen to you and, often, they will brainstorm with you on how the story could be given an even more interesting spin. Make sure you always try to offer at least one of the following extras, if not all: valuable information, interesting insights and spectacular imagery that makes your story, and ultimately their article, appealing and unique.

After you have provided all the information for the story, it is advisable not just to wait and see what happens. Try to get an impression of the final look or draft of the material before it is published. This will not always be possible, due either to editorial policies or simply to the journalist's own working practices. Asking to see a story prior to publication is a sensitive issue and if you do not know the journalist that well, or fear that you might upset or offend him, it is better to trust him and wait for the release of the story. As in any type of relationship, trust is built with time and sometimes by taking some risks.

Mark the day of release in your calendar and check the article as early in the day as possible. Read it carefully and if there are any factual errors in the material, point them out to the journalist in a friendly manner and they will normally be willing to correct them. Do not forget to thank the journalist for the collaboration and continue to keep in touch with him. Don't comment on anything other than factual errors as journalists have to have total freedom in how they present a story.

Case 2: The watchdog comes after you

Sometimes a journalist who wants to write a story featuring the organisation you represent will contact you. The first thing to do in such situations is to read the questions, make sure you fully understand the request and to answer instantly, not offering any direct answers, but simply acknowledging the request. If there are questions that you are not sure that you fully understand, now is the time to ask for details.

Before you are able to give any information addressing the story, research must be done. Focus on the topic of the story. Identify the organisational information that might be useful and how much can be made public, who are the most appropriate people to speak in the name of the organisation or who could give you more information. Always try to offer more than requested, but do not include organisational facts that are irrelevant to the topic. Depending on the subject, you could suggest an interview, indicate a scientific paper, or offer the possibility of a visit that could help the journalist gather more information. Finally, research what has been written on the topic and make sure you can bring added value to the table, whether it is new data in the field, other opinions and perspectives, predicted future developments etc.

Also, do some background research on the journalist. If you have not interacted with her before, the process described earlier should be followed, although not necessarily in so much depth, as time will likely not allow it. If you have done your homework and your database is up to date, it should contain detailed information about the journalist, and you will have an easier job in interacting with her, saving time that can be used for investigating the topic itself.

Once the research is done, you can prepare the answers. There is no question that cannot be addressed — even though you may have to say "no comment". Be as thorough as possible and never assume that something is known or obvious. Attach documents for further information if they are available. Finally, make sure you reply within the journalist's deadline. If you have set up an interview, do a short media training session with the person to be interviewed and be present at the meeting. If you have arranged a visit, plan ahead and make sure that everything is in place as journalists have sharp eyes and will spot the tiniest inconsistency.

On the due date of publication, read the article as soon as it comes out so as to be able to react instantly, regardless of the situation: either to send congratulations or to deal with issues arising. At this point, there are several possibilities, depending on the tone of the article and the accuracy of the information. An article can have positive, neutral or negative spin, and it can be entirely correct or contain some wrong information.

A positive or neutral article with correct information is obviously the preferred situation. If this is the case, make sure you contact the journalist on the same day of the release to congratulate him for the material and thank him for the collaboration.

If you find yourself in the less pleasant situation, with a negatively nuanced article, read through the arguments. If all the information is correct and the negative take is simply the opinion of the journalist, there is little to be done, and it is important not to let the journalist know how you feel, since he has the right to an opinion. Thank him for the article and try to understand what is the cause of the negative opinion. Is it something you need to improve inside the organisation or is it simply a matter of personal belief that could be improved? The most you can do, if the situation allows it, is to try to improve his opinion, for example, by inviting him to see how observations are done or how data is handled if he hasn't yet had that opportunity, and hope that this might impress him.

Finally, if the article is positive or neutral, but it contains some incorrect information, contact the journalist, thank him for the collaboration and point out any mistakes, asking if they can still be corrected. In most cases, journalists will appreciate a friendly indication of a mistake as delivering correct information is important for their reputation and the reputation of the mass media channel they are working for. Lastly, do not forget to keep in touch and update your database with all the useful information that you have found about the journalist from this collaboration and which can be used on future occasions.

Biography

Oana is a communicator with a passion for astronomy, as much as she is an amateur astronomer with a passion for communication. With a degree in Communication and Public Relations and a Masters Degree in Marketing, Oana is working as community coordinator for ESO's education and Public Outreach Department. She heads the public relations work for the Space Generation Advisory Council, as well as for other international organisations and projects. Previously she worked for one of the leading PR agencies in Romania and Eastern Europe. To get in touch with Oana visit her blog www.astronomycommunication.wordpress.com or connect on Twitter (www.twitter.com/oana.sandu).

The Big Bang —
A Hot Issue in Science Communication

Opinion

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Key Words

Communication
Cosmology
Big Bang
Public Understanding of Science

Abstract

The Big Bang theory is one of the cornerstones of modern cosmology, drawing on a wealth of observational, experimental and theoretical data to underpin one of the most successful theories science has constructed. Why then is it under attack in the public domain? This paper will examine the theory and look at the perceived public problems that arise when it is communicated by following the dominant model of communicating science. This paper then examines whether, in the public perception, replacing a more traditional faith-based worldview by the Big Bang theory results in a loss of purpose, philosophy and the replacement of ideals is responsible for the negative portrayals.

Introduction

The hot Big Bang theory has been extremely successful in correlating the observable properties of our Universe with the known underlying physical laws. However, there are some difficulties associated with the Big Bang theory. These difficulties are not so much errors as mathematical assumptions that are necessary to make some progress, but that do not have, as yet, a fundamental justification. Nevertheless, the Big Bang, taken as a whole, is the most complete and evidence-based explanation that astronomers currently have to account for the origin and evolution of the Universe.

However, the public understanding of this theory appears to be a somewhat hit-and-miss affair, a situation that is exacerbated not only by the public, but also by journalists and scientists. Most of the issues surrounding the Big Bang can only be understood and resolved with some training in the field. To the outside observer it would appear that the discipline is riven with dissent. Is this just a case of the public misunderstanding the issues and failing to grasp the connections between disciplines that are necessary to make sense of this theory, or is this misperception one that is due to confusing and contradictory statements issued by the press and scientists alike? This article will examine these issues.

The Big Bang as a scientific theory

The Big Bang was named by its strongest critic, Sir Fred Hoyle, during an interview for the programme, *The Nature of Things,* broadcast on BBC Radio in March 1949. As used by cosmologists, the term "Big

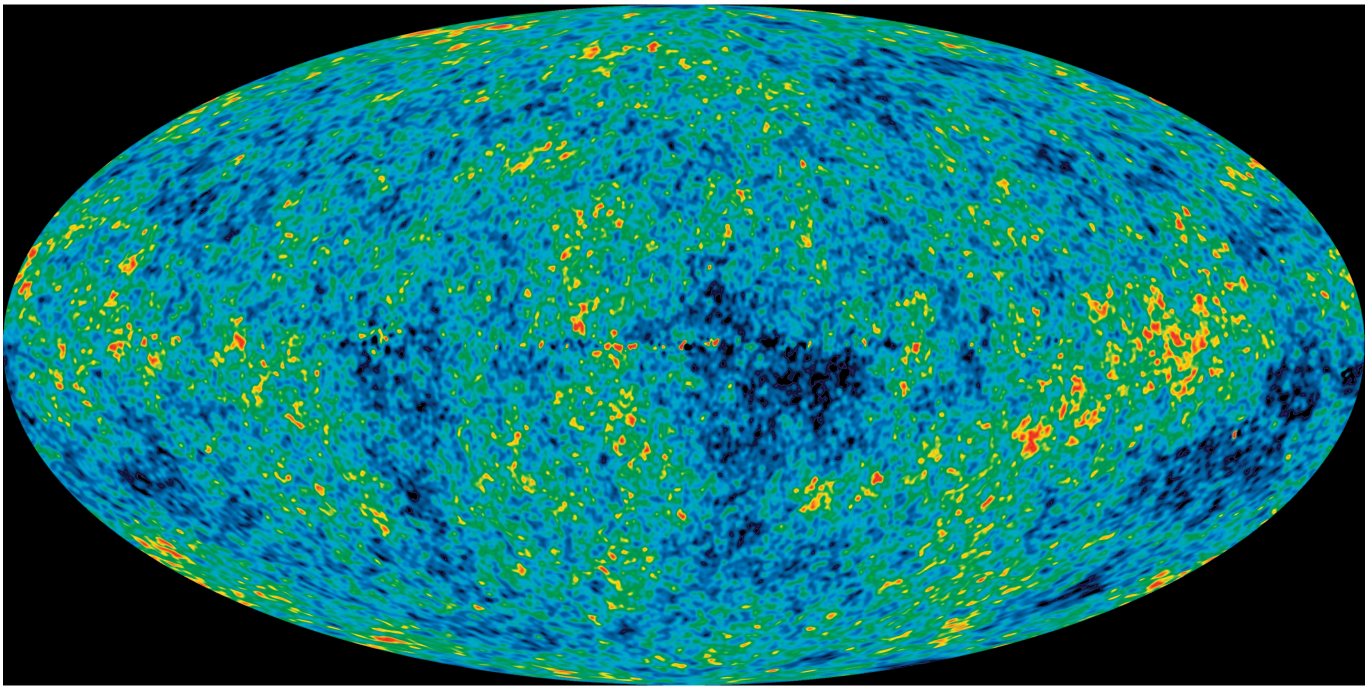

Figure 1. The Cosmic Microwave Background temperature fluctuations from the seven-year Wilkinson Microwave Anisotropy Probe data seen over the full sky. Credit: NASA / WMAP Science Team

Bang" generally refers to the idea that the Universe has expanded from a primordial hot and dense initial condition at some finite time in the past, and continues to expand to this day. It is a cosmological model describing the initial conditions and subsequent development of our Universe, and is supported by comprehensive and accurate explanations based on current scientific evidence and observation, engaging such fields as astronomy, cosmology, chemistry and quantum physics.

From the above, we can already pinpoint a few misconceptions. First of all, contrary to popular belief, a scientific theory is not limited to one area of science; the Big Bang theory is grounded in several scientific disciplines. In addition, a scientific theory continues to be tested repeatedly and the results create a body of evidence supporting the theory. Furthermore, part of the problem with scientific understanding is science education (formal and informal) itself. It usually presents "the facts", as if everything were already known. Science is taught as if it were something complete, a finished endeavour, but science can never be complete as it is constantly being modified and extended by new observations or measurements, which in turn lead to new insights and predictions; and it is this very flexibility that makes the "scientific method" so successful in explaining the world. It does not hold dogmatically to outdated or incorrect information or paradigms as if the "truth" had been found once and for all, an approach that separates it from religion.

Finally, any gaps in our understanding of a scientific theory do not always bring the overall theory into question — just because we don't fully understand gravity, it doesn't mean that we can't predict what will happen when we jump from the top of a building. *"Science is a work in progress; it is an ongoing human endeavour. It will never be fully complete, otherwise curiosity, and thus part of what it is to be human, would die. The communication of science needs to emphasise this point."* (Oliveira, 2008)

Communicating the Big Bang

Any science communication exercise has to recognise the cultural, educational and social setting of its audience and adjust to this. Communicators often make an assumption that their audience will be reasonably well-educated and aware of some of the fundamental science that will be touched on within the context of the work. These assumptions illustrate the problem of making an effective interdisciplinary communication. A general audience will be made up of people with different agendas, training, interests and professions. They will, according to Scanlon et al. (1999), probably reflect C. P. Snow's definition of the "two cultures" with the emphasis on the humanities rather than on the sciences. Inevitably something is going to be lost in translation, and few readers or listeners will be able to follow all the arguments or points covered.

These are valid points, but communicating the wonder of our understanding of the Big Bang need not be difficult. For instance, take Bill Bryson on cosmic background radiation:

Tune your television to any channel it doesn't receive, and about one percent of the dancing static you see is accounted for by this ancient remnant of the Big Bang. The next time you complain that there is nothing on, remember that you can always watch the birth of the Universe. (Bryson, 2004)

Science communication of this type is excellent: pithy, entertaining and pointed. Bryson is not a scientist, so his message had to be understood first by him, and then re-written for a public audience. Whilst most journalists follow this approach, they do sometimes fall short — as we shall see later. Occasionally of course, it is difficult to communicate an idea correctly and scientific simplifications may become oversimplifications and lead to public misconceptions, such as the "Solar System" model of the atom for example.

Sadly, even the most well-known science writers can fall into the negativity trap and cloud the waters of understanding. Take the following quotes from Terence Dickinson, recipient of the Royal Canadian Institute's Sandford Fleming Medal for Public Communication of Science:

- *The Big Bang theory is the best explanation we have for the origin and evolution of the Universe. It may be wrong. It may even seem childishly naïve a century from now.....*

- *One concept favoured by researchers in this field offers the fanciful hypothesis that our Universe was created from nothing. Even more outlandish is the corollary: our Universe may be one of countless universes that have materialised out of pure nothingness.* (Dickinson 1993)

These quotes may seem negative and confusing and, although Dickinson then goes on to attempt an explanation of the underlying theory, he starts two chapters on the intricacies of the Big Bang in this fashion. This form of communication may lead to confusion, as the general reader may get bogged down in the later explanations and so that the only part of the discussion that registers are these rather florid descriptions of a well-developed theory that is being questioned rather than explained! Here Dickinson is attempting an expression of scientific honesty about the nature and methods of theoretical science as it pertains to the Big Bang — he is portraying a "best-fit theory" model in his communication. However, such honesty can result in legions of doubters, some of whom then go on to portray the Big Bang theory as problematical, institutionalised and ignorant of factors or alternatives, leading to public confusion, with a resultant focus on pseudo-scientific explanations that are presented as fact.

This problem can be further illustrated by the writings of astronomer Tom van Flandern. Van Flandern is notorious for his unorthodox views (human face on Mars, the asteroid belt as an exploded planet) and has written several books on such themes, in addition to forming the Natural Philosophy Alliance and the *Meta Research Bulletin* to propound his unscientific viewpoints. With the rise of alternative explanations, be they religious or pseudo-scientific, what Gregory and Miller (1998) would later call the "anti-science" alliance arose as a form of public communication that supplied positive answers to the doubts of an interested public. In this vein, Van Flandern's views on the Big Bang theory have been received by a wider audience. In public broadcasts and in the pages of the *Meta Research Bulletin*, Van Flandern gives a short list of the leading problems faced by the Big Bang in its struggle for viability as a theory:

1. *Static Universe models fit the data better than expanding Universe models.*
2. *The microwave background makes more sense as the limiting temperature of space heated by starlight than as the remnant of a fireball.*
3. *Element abundance predictions using the Big Bang require too many adjustable parameters to make them work.*
4. *The Universe has too much large-scale structure (interspersed "walls" and voids) to form on a timescale as short as 10-20 billion years.*
5. *The average luminosity of quasars must decrease with time in just the right way so that their mean apparent brightness is the same at all redshifts, which is exceedingly unlikely.*
6. *The ages of globular clusters appear older than the Universe.*
7. *The local streaming motions of galaxies are too high for a finite Universe that is supposed to be everywhere uniform.*
8. *Invisible dark matter of an unknown but non-baryonic nature must be the dominant ingredient of the entire Universe.*
9. *The most distant galaxies in the Hubble Deep Field show insufficient evidence of evolution, with some of them apparently having higher redshifts ($z = 6$-7) than the faintest quasars.*
10. *If the open Universe we see today is extrapolated back to near the beginning, the ratio of the actual density of matter in the Universe to the critical density must differ from unity by just a part in 10^{59}. Any larger deviation would result in a Universe already collapsed on itself or already dissipated.* (Van Flandern, 1997)

It is not our intention to answer these points here — and they all have scientific counter-arguments; rather we quote this in full to illuminate the point that the Big Bang theory is in the public domain as a point of argument. It is also an argument that appears to be dressed in scientific clothing, thus compounding the public's problems of perception and choice, muddying the waters of public acceptance and understanding.

These arguments are increasingly being taken up by the pseudo-scientific and religious communities, who not only misunderstand, but misrepresent the Big Bang theory, and become points of debate in an intellectual miasma labelled by Helge Kragh (1999) as "*extra-scientific arguments with no role in cosmology*". They may have no role in cosmology, but they are certainly influential in the public domain. This can be seen by the religious criticism of some of the Big Bang's predictions in countries where Christian fundamentalist views prevail.

Is the Big Bang a truly scientific theory? Has "science" proven the age of the Universe? We will explore the Big Bang and see why many scientists are abandoning the theory. We will see why the Big Bang doesn't fit the Bible or science. (Lisle, 2009)

This follows a typical straw-man argument used by creationists; further, they neither name the scientists who "doubt" the Big Bang nor specify the institutions to which they belong, although a little further research reveals that these "scientists" all have PhD's from, or hold posts at, the Creationist Research Institute. And their evidence for refuting the Big Bang? After discussing various points that have been laid to rest by scientists many years ago:

- *Ultimately, the best reason to reject the Big Bang is that it goes against what the Creator of the Universe Himself has taught: "In the beginning, God created the heaven and the Earth." (Genesis 1:1;* from Lisle, 2009)

This sowing of doubt and uncertainty affects the public debate as it gives the false impression that the Big Bang is questionable as an explanation of the Universe's origins. Whilst any scientific theory can certainly be questioned, the methods used should be consistent with scientific methodology. Creationists lack the requisite scientific detachment. Such negative portrayals are having an effect, as faith schools and evangelical movements gain public acceptance and follow a largely American ecumenical lead. Again, this is not to say that the Big Bang is inviolate; the Big Bang is open to investigation, and is falsifiable according to Popper's definitions, but it must be pointed out to the public that the theory is *not* under threat within science; some of the interpretations of data are argued over, but the Big Bang as a theory is as solidly founded as Darwinian evolution. Furthermore, it's interesting that both theories deal with evolution: the evolution of life, in Darwin's case, and the evolution of the Universe, in the case of the Big Bang.

Evolution seems to be an anti-religious concept. Perhaps this is why the two are lumped together by the anti-science lobby and that this link is reflected in science reporting in some broadsheets:

- *Poll reveals public doubts over Charles Darwin's theory of evolution and the Big Bang. Belief in creationism is widespread in Britain, according to a new survey.* (The Telegraph, 6 February 2009)

- *Science can't explain the Big Bang — there is still scope for a creator. We should not dismiss the concept of intelligent-design lessons in school.* (Crowley, 2009)

What can be done to redress this public balance? Is it necessary to redress it at all? Will the public see to the heart of the matter and maintain a trust in science that will enable the controversy surrounding the Big Bang and its public perception to die a natural death? As a number of communicators have maintained:

- *The debate over the Big Bang theory* vs. *the story of Creation taken literally is a debate that cannot continue and be engaged unless society demands that a single standard of evidence be applied.* (Odenwald, 1996)

How and when this standard — the standard of science – will be acceptable to all is open to question; indeed it may never become acceptable to all, which leaves the scientist and communicator with an ongoing problem that merely continues the public debate:

- *It is the business of science to offer rational explanations for all the events in the real world, and any scientist who calls on God to explain something is falling down on his job. If the explanation is not forthcoming at once, the scientist must suspend judgment: but if he is worth his salt he will always maintain that a rational explanation will eventually be found. This is the one piece of dogmatism that a scientist can allow himself — and without it science would be in danger of giving way to superstition every time that a problem defied solution for a few years.* (Bonnor, 1964)

It is precisely because science does not have all the answers that the Big Bang becomes a bone of communications contention from the viewpoints of creationists, scientists and sceptics alike. From a communications viewpoint, the solid acceptance of the Big Bang model is unlikely to be a definitively resolved question in the near future. The Big Bang theory is a point of open debate and an excellent example of the ongoing nature of science communication in our modern society. How can science communicators face the difficulties of alternative contrasting ideologies?

What now for communication?

Perhaps recognising that the public communication of science is a field that is contentious and little understood would be a starting point for communicators. One view of the "dominant" model of science communication (Hilgartner, 1990) sees science as watered down for public consumption and losing some of the flavour and nuances of the rigorous science along the way. Hilgartner claims that the differences between genuine and popularised science must be caused by the distortion or degradation of original truths, a pollution of science by journalists and a public that misunderstands much of what it reads. There is some evidence in the foregoing and in popular science books about the Big Bang to justify this view.

This model was recently aired and criticised at high levels. In February 2000, the House of Lords Select Committee on Science and Technology reported: "*society's relationship with science is in a critical phase*" (Hansard, 2000). The report showed that public interest in science was high, yet there was a basic lack of trust in science. The problem was not the amount or quality of the science available for public consumption, but how it was communicated. The committee concluded that:

- *There is a condescending assumption that any difficulties in the relationship between science and society are entirely due to ignorance and misunderstanding on the part of the public: and that with enough public understanding activities, the public can be brought to greater knowledge, whereupon all will be well.* (Hansard, 2000)

It is this assumption of education, science activities and public involvement leading to a more science-oriented society that is at fault. It is obvious from the foregoing examples from our Big Bang case that society is not always attracted to, or even trusts, the answers science gives them. There is no doubt that the public do have more access to information, and thus can be better informed and more educated than ever before. There is no doubt that publications relating to popular science are at an all time high and the proliferation of Discovery-type TV channels and the plethora of podcasts and radio programmes dedicated to science communication are a testament to the literacy of the public. What is needed is not more public understanding activities, but more acceptance within society of one standard (Odenwald, 1996).

However, this is unlikely to be put into practice within society as much of the message from science lacks what Peter Broks (2006) calls "meaning in communication". Public understanding of science is mainly a passive activity, with the reader/listener receiving a "transmission" from the scientist to the public. This transmissive, or "dominant" model, does not actively construct meaning for the participant as they are given little opportunity to cogitate on the message and arrange it within their internal worldview. For public understanding of science to be a force for change, it has to be meaningful to the public and make a positive alteration to their views within the context of their own philosophies, politics, social grouping and outlook.

Science therefore must have ideological significance. Science doesn't take away the spiritual experience; philosophically it provides a more humbling experience, when we take into consideration how small we are in this immense Universe (Griffiths & Oliveira, 2010).

It can be argued that science does have a life-changing and ideologically altering perspective, but then the question can be posed, especially in regard to our example of the Big Bang — why has science communication failed? The failure of this dominant model is illuminated by Simon Locke who states that:

- *Citizenship through science comes at the price of expressing knowledge in ways acceptable to professional scientists — it is our way or not at all. Hence the presence of competing knowledge claims are rejected as simply 'anti-science'.* (Locke, 2002)

The public are not trained scientists and are open to competing claims of knowledge, as seen by the examples of Tom van Flandern and *Answers in Genesis* above. What the *Meta Research Bulletin* and creationist sources do well is to transmit certainties about the scientific alternatives which are more ideologically suited to a public audience than the necessary uncertainties of the world of science. The "meaning" in such transmissions already fits with a worldview that is part of the audience's culture and society in a way that the *"counterintuitive unnatural nature of science"* (Wolpert, 1992) does not.

How then can the communication of science answer, or, at least, successfully compete with alternative ideas from such philosophies, pseudo-science or religion? Broks (2006) outlines four main points that science communicators can and have utilised. He claims that popular science generates different meanings; these meanings are linked to social and political struggles; in these struggles, popular science is a form of mediation between public and experts; finally that those concerned with the popular understanding of science should be concerned with meaning and not message.

The Big Bang theory strikes at the heart of human philosophical and cultural meaning, uprooting a secure humanity from a known place in the Universe to one of unimaginable smallness, adrift in the unfathomable sea of space. This is the core of its contentious state for those who seek a more comforting and meaningful alternative. It is also a reflection of the place of science and its communication in our society — where does science fit in our culture? It is up to scientists to ensure that we replace one set of meaningful values with one of equal meaning that is deeply rooted in a new culture that addresses an understanding of our place in the cosmos. If science communication in respect of the Big Bang is at point three of Broks' claims above, then surely point four will naturally follow on?

This is not to say that any science communication is going to be perfect. Scientists understand the limitations of models in ways in which the public do not. Simply denying the theory merely because it cannot answer every question or seems impinge on the power of a creator does not mean that the theory is incorrect. Ultimately, the Big Bang model is about the origin and evolution of the Universe from the Planck time onward (10^{-43} seconds) and can say little about events prior to this. In a broad way then the theory is not "anti-creationist" and does not negate a spiritual comprehension. It does not remove "meaning" at all; in fact, a greater understanding of the event leads to a more profound respect for the many facets of our Universe both physical and spiritual.

Conclusion

The battleground of public understanding of science is then the open house of a democratic culture. It has taken centuries of cultural, social, economic and political struggle to build and is a continual work in progress. All that scientists can do is to continue to build bridges between experts and the public in such a way that these democratic and scientific ideologies become encapsulated in society. This should not be done within Hilgartner's "dominant" paradigm, but should be an inclusive, open-minded and honest appraisal of the state of science and its uses within politics and society. Science does not stand outside human society; it is an integral part of it.Science therefore should recognise the changes in philosophies and ideologies that it has wrought and should address the idea that science removes "meaning" from life, from philosophies and from cultural institutions. Science not only answers "how and when", but also supplies the "why". If science communication can adequately meet these challenges within the framework of Broks' ideology of meaning and cultural inclusion, it will achieve much.

This will be a slow process that will have its share of losses and triumphs along the way, but is an ideological war that is worth the fight. The price of failure is a return to a dark age that may become all the longer and more protracted if the superstitious and anti-science alternatives gain the upper hand. As Carl Sagan (1997) once emphasised, *"it is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring"*.

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Biographies

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Surveying Aesthetics & Astronomy: A Project Exploring the Public's Perception of Astronomical Images and the Science Within

Research & Applications

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Summary

Every year hundreds of astronomical images are released to the general public from the many telescopes both on the ground and in space that observe the Universe. These images cover both data gathered at visible wavelengths and other phenomena at wavelengths that cannot be detected by the human eye, so that the entire electromagnetic spectrum is represented. The release of astronomical images raises major questions about the dissemination and communication of that knowledge, including: how do non-experts (i.e., the public) perceive these images? In 2008, the Smithsonian Astrophysical Observatory began a unique research study — dubbed the Aesthetics & Astronomy (A&A) project — to examine the perception of multi-wavelength astronomical imagery and the effects of the various scientific and artistic choices in processing astronomical data. This article provides a brief synopsis of the results of the initial A&A study and its possible implications for astronomy outreach professionals. This article concludes with an overview of the latest study (in progress, 2010).

Introduction

Aesthetics is the study of how human beings react in a sensory and emotional fashion to the things we encounter in life, especially as being appealing or not appealing. (Smith & Smith, 2010)

Aesthetics — from a psychological perspective — is the study of all things beautiful, whether art or not, and all things art, whether beautiful or not.

Astronomy is one of the most visual of the sciences. Modern astronomy images capture the Universe not only with the narrow range of wavelengths that humans can detect with their eyes, but also with radio, infrared, X-ray electromagnetic radiation and more. From small telescopes wielded by amateurs to multi-billion dollar observatories controlled by professionals, astronomy has the capacity to lure us in by the sheer aesthetics of its data.


Figure 1. Beautiful art or not? Left: Untitled, serigraph on paper by Gene Davis, 1974. Credit: Smithsonian American Art Museum, Bequest of Florence Coulson Davis; Right: Multi-wavelength NGC4696 in X-ray, Radio and Infrared, Credit: X-ray: NASA/CXC/KIPAC/S. Allen et al; Radio: NRAO/VLA/G. Taylor; Infrared: NASA/ESA/McMaster Univ./W. Harris (used in 2008 online survey).

Every year, hundreds of astronomical images are released to the public by telescopes of all kinds both on the ground and in space. This represents a considerable investment — in both human and monetary terms — by the astronomical community. A small cottage industry, so to speak, straddling the worlds of astronomy and science communication has grown to produce and disseminate these images. Today, more than ever, these images are shared via traditional media (like newspapers, magazines, books, prints, etc.), planetariums and science museums, but also through websites, Twitter and the blogosphere, directly with the public.

But the question is: how good are we at what we are intending to do?

To our knowledge, there has never been a rigorous academic study to answer how well our choices in our image pipelines — from processing to dissemination — do in reaching the widest possible audience. We conceived the A&A to begin to tackle this void. The original A&A study was designed to probe how effective these choices (or compromises) are when it comes to science versus aesthetics in astronomical images.

The A&A team consists of a unique combination of professional astronomy communicators, astrophysicists and aesthetics experts from the discipline of psychology. In late 2008, the A&A team conducted both online studies (see Figure 2) and a series of in-person focus groups. The research questions were designed to test:

- How much do variations in terms of presentation of colour, explanation and scale affect comprehension of astronomical images?
- What are the differences between various populations (experts, novices, students) in terms of what they learn from the images?
- What misconceptions do the non-experts have about astronomy and the images they are exposed to?

Highlights from the 2008 study

It was a pleasant surprise, when over 8000 usable responses were collected in just over a week in the online survey. The full results from the project were accepted by the *SAGE Journal of Science Communication* in August 2010 (see Smith at al., 2010, for more detail on the methodology, data limitations, descriptive statistics of the study and a full reference list).

The online participants ranked themselves along a scale from “novice” to “expert”. There were some predictable differences among the groups. For example, the novices indicated that variations in terms of presentation of colour, explanation and scale affected their comprehension of the imagery. Those who identified themselves as expert, on the other hand, wanted shorter, more technical explanations (with scale information). Other less obvious results also emerged, including that the novices said that their aesthetic enjoyment increased solely based on their ability to access the information in the accompanying caption.

Some additional outcomes include:

- Providing a context for the image is critical to comprehension, particularly for novices.
- Experts prefer text that is shorter and to the point; novices prefer a more narrative expository style for the text that accompanies images.
- Providing a sense of scale to go with objects is helpful for comprehension at all levels of expertise.
- Experts and novices view space images very differently. Novices begin with more of a sense of awe and wonder, and focus first more on the aesthetic qualities of the image. Experts wonder how the image was produced, what information is being presented in the image, and what the creators of the image wanted to convey.
- Experts are much more likely to see blue as hot than are novices; about 80% of novices see red as hot compared to 60% of experts.

Putting the preliminary results into practice

Since this A&A group is led by members of the Chandra X-ray Observatory’s Education and Public Outreach (EPO) group we could implement the study's results almost immediately. As two of us (Arcand & Watzke) are responsible for a major observatory's public website and other outreach materials, the A&A outcomes could go quickly from preliminary academic research to field-tested practices on a website that receives 250–300 thousand visits per month.

What changes did we make? First, we added bulleted text for each new image, interactive labelling and put "Wikipedia-style" links in the body of the text. Each of these changes came out of the feedback we received during the online survey and focus groups.

The next, more involved implementation of the A&A results was to develop an interactive multi-wavelength image feature that allows the user to move from one energy band to another, and ultimately "build" the composite themselves. A sample of this can be found online .

The feedback on these relatively simple changes to the website from the public through our comment and rating sections has been overwhelmingly positive. Our next step is to implement a questionnaire on the Chandra website to ask users specifically how these new features affect their enjoyment and comprehension of an image and the science behind it.

We have also built an interactive, question-based text script into the Chandra photo pages with click-tracking methods to count the user clicks per question and per image, and to compare totals. We have also created a similar implementation for a series of print products that includes posters featuring multi-wavelength astronomical images (see Figure 3). Here, we use the tried and true series of questions: who, what, when, where, why and how to engage the viewer in an approachable manner. The text addresses some of the questions that were commonly asked during the focus groups, including how the images were made, the historical importance of the object, the location in the night sky, etc. Data collection and a brief summative evaluation of these six posters are being conducted to analyse the impact of the improved features on the public's understanding.

Other recommendations from the original A&A findings showed that it is useful (and not overwhelming for the reader) to provide colour code keys and physical scales in images intended for the public. Another useful finding has been that many novices want to understand how the experts — the astrophysicists — view the images. This type of information could be provided with images in the future by having a "rollover" on the image that annotates, "Here is what astronomers see…", or by including video or audio commentary from astronomers, available as supplementary digital material.

Current & future plans

We are currently conducting a series of studies, funded in part by a grant from the Smithsonian Institution, that ask viewers to evaluate astronomical images with their corresponding descriptions across different media platforms: web, mobile,

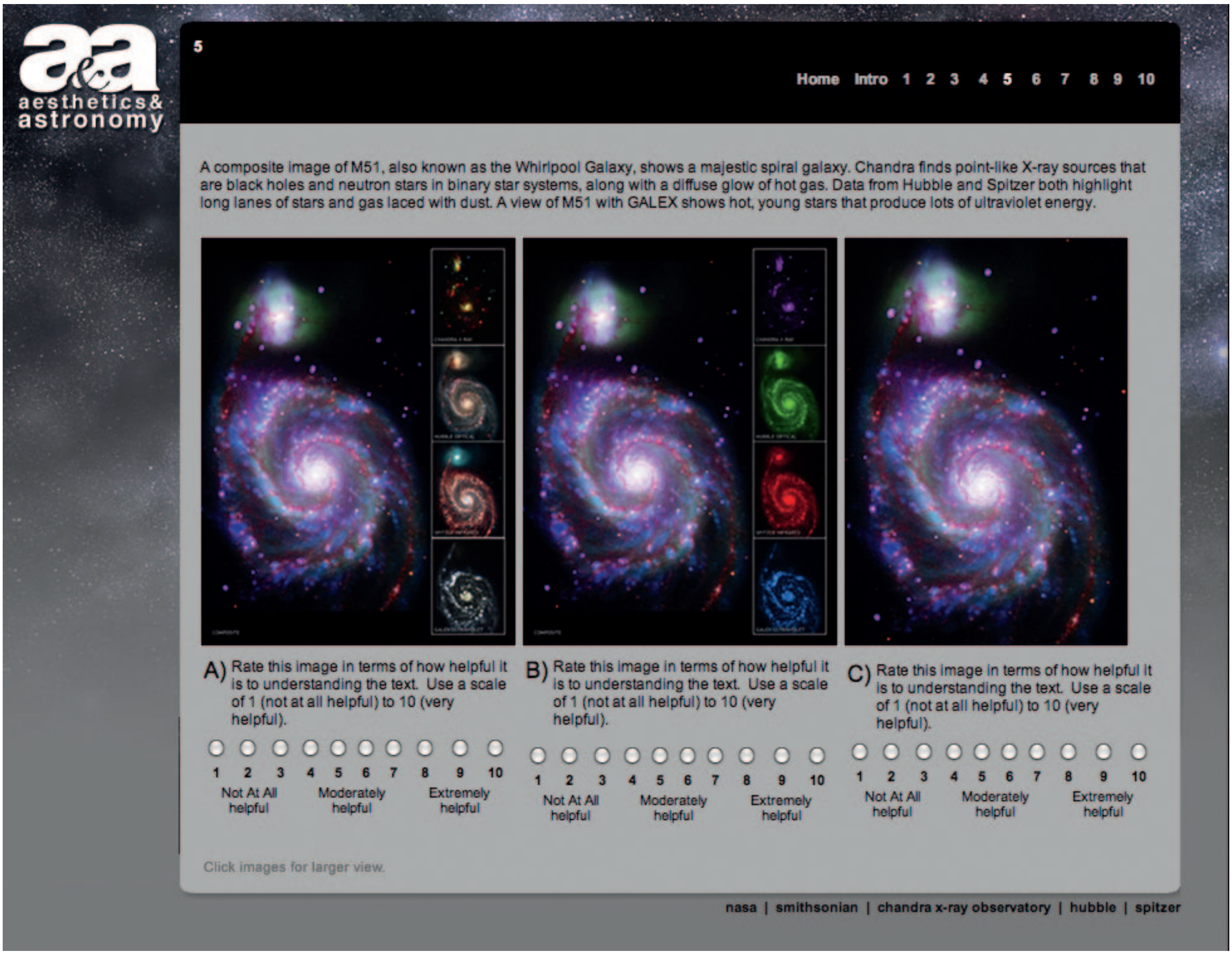

Figure 2. A sample page from the online survey at http://astroart.cfa.harvard.edu/ showing M51. Credit: NASA/Chandra/Hubble/Spitzer/GALEX

Figure 3. Sample of poster created using who, what, when, where, why and how questions (left) and a close-up of colour coding and supporting informational graphics from that poster (right).

traditional print and large format print. The images being used include some from the Chandra X-ray Observatory, Hubble Space Telescope, Spitzer Space Telescope, Solar Dynamics Observatory and others. Working with museum professionals and science centre partners we have produced a travelling exhibit of the material. Touring through six locations in 2010, this exhibit allows participants to access the astronomical imagery and text through traditionally sized and large-scale prints. The schedule of locations is available online.

An online study of the same material tests the user's perceptions on mobile devices in comparison with traditional online platforms. We will also be employing in-person focus groups this autumn to explore the aesthetics-context correlation further, across all four of the platforms. Questions on the interpretation of scientific principles (perception of temperature, for example), aesthetic appeal, and the interpretation of unfamiliar (meaning non-terrestrial) objects are being included in all forms of the study.

Conclusion

We believe that we, the professional astronomical community, are operating in an unusual age. At the moment, we are the beneficiaries of a multitude of fantastic telescopes and observatories. It is our goal to communicate these exciting discoveries to the public, and, quite often, the images are our greatest asset in doing this. At the same time, however, there is much discussion about "false colour" and what is "real" in this age of Photoshop and other digital manipulation. With so much data and so many tools at our disposal, not to mention the potential wide reach of the internet, are we employing all of the possible best practices? Can studies such as A&A uncover ways to help dispel some of the misinformation that exists about the veracity and legitimacy of what we distribute to the public? There are many lines of research we can follow and many unknowns to explore. We invite anyone who is interested in these issues to contact us.

Acknowledgements

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Links

[1] http://chandra.si.edu/photo/2009/galactic/
[2] http://astroart.cfa.harvard.edu/
[3] http://chandra.si.edu/mobile/aa.html

Biographies

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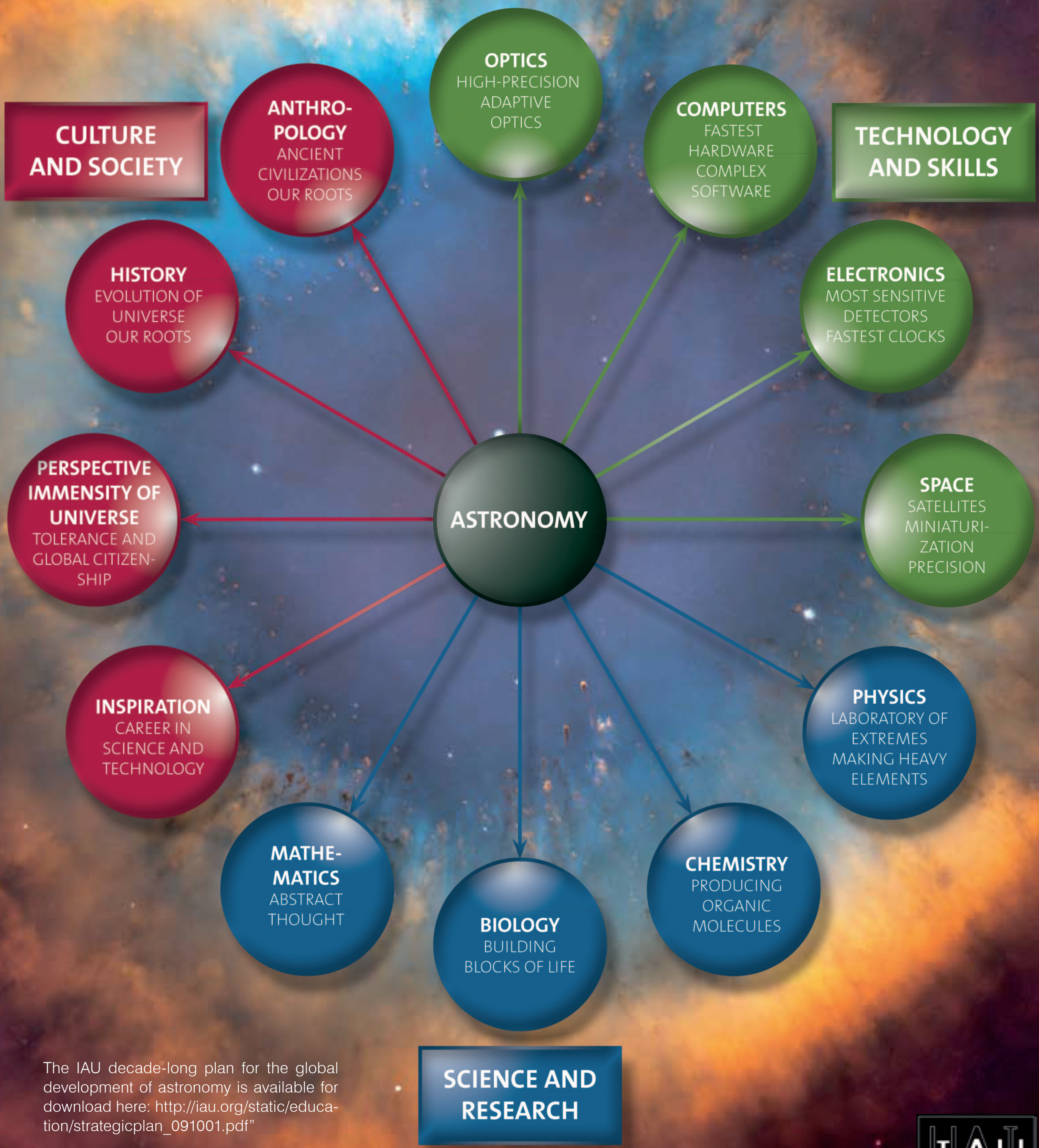
International Astronomical Union

Astronomy for the Developing World

Building from the IYA2009

Strategic Plan 2010–2020



The IAU decade-long plan for the global development of astronomy is available for download here: http://iau.org/static/education/strategicplan_091001.pdf"

IAU

The Sky is for Everyone — Outreach and Education with the Virtual Observatory

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Key Words

Virtual Observatory
Education
Data Mining
Databases

Summary

The Virtual Observatory (VO) is an international project to collect astronomical data (images, spectra, simulations, mission-logs, etc.), organise them and develop tools that let astronomers access this huge amount of information. The VO not only simplifies the work of professional astronomers, it is also a valuable tool for education and public outreach. For teachers and astronomers who actively promote astronomy to the public, the VO is a great opportunity to access and use real astronomical data, and have a taste of the daily life of astronomers.

Introduction

Astronomy is a very attractive science for teachers, students and the public, allowing them to carry out experiments and observations with relatively simple and inexpensive tools. Of course, having access to a telescope dramatically increases interest in astronomy, both for the public and for schools. However, even if the internet has made many resources available online, public access to remotely controlled telescopes (e.g, the Faulkes telescope and others) remains limited. This is mainly because time slots are in short supply and, moreover, are not easily scheduled during classroom hours.

In this paper we present the Virtual Observatory for Schools and Public (the result of Work Package 5 of the Astronomical Infrastructure for Data Access project — AIDA-WP5). AIDA-WP5 is a free resource developed within the (European) Virtual Observatory project. The aim of AIDA-WP5 is to give access to VO data using professional-level software tools that have been specially modified to make them appealing and easily usable. This gives students, teachers and members of the public access to tools which share the look and feel of those used by professional astronomers.

AIDA-WP5 is not simply a door to VO resources: it is a self-contained resource offering a set of activities that includes interesting astronomical problems to be solved using free software tools and data. Activities are presented in documents that both set out the astronomical problem and give instructions for how to solve it using VO tools and data. AIDA-WP5 complements, or even substitutes for, access to real telescopes with the obvious advantage of being flexible.

In the following we briefly describe the Virtual Observatory and, in particular the EuroVO–AIDA project; we then describe in detail the tools and activities that we have developed for the EPO work package of the AIDA project. Finally, in the last section we give a short account of our direct experiences of using AIDA-WP5 tools in schools.

The formation of the Virtual Observatory

In ancient times, astronomers looked at the sky with their naked eyes and noted their observations on clay tablets, parchment, papyrus and paper. When Galileo Galilei introduced the telescope to astronomy, this process did not change: astronomical observations and scientific results were published and stored in books and papers. When photographic plates came into common use, observatories had to

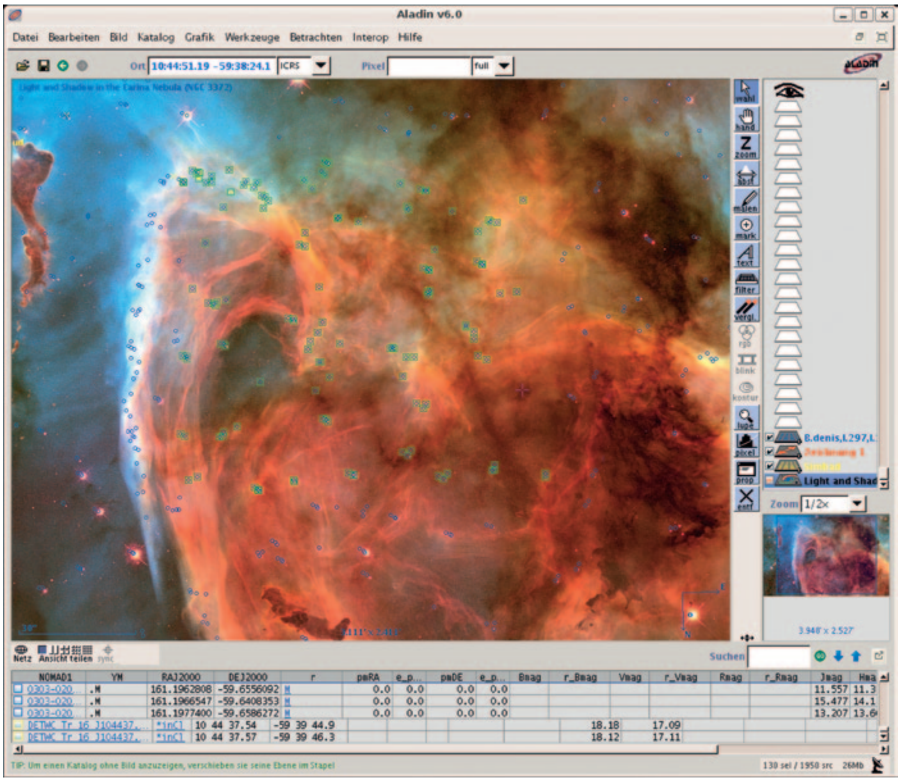

Figure 1. The VO-software Aladin; depicting an image of the Carina Nebula taken by the Hubble Space Telescope with an overlay of catalogue data from the Vizier Database. Credit: Authors, NASA, ESA, CDS.

store them too because they constituted the raw data and formed a valuable scientific archive. Nowadays we image the sky directly to a file on a computer and store our data digitally. Observatories all over the world, together with astronomical satellites, probes and telescopes in space, produce vast amounts of digital data every day and night.
In the past, accessing the collection of photographic plates of a certain observatory was difficult. Inspecting the plates either involved travelling to the observatory itself, or requesting plates to be shipped — which took a long time and ran the risk of damaging or destroying them. Today, however, exchanging digital data is very easy and can be done via the internet rapidly and without complications.

Thus, thanks to the internet, every astronomer can, in principle, easily access and profit from the observations made by all other astronomers worldwide. In practice however, a complex infrastructure is needed to collect and distribute the multitude of astronomical data. Since data are stored in different formats and according to different standards, internet communications and exchanges have to obey protocols of communication and pass several processes of verification. This infrastructure is provided by the Virtual Observatory (VO).

The International Virtual Observatory Alliance (IVOA) was established in 2002. The IVOA now comprises 17 VO projects from Armenia, Australia, Brazil, Canada, China, Europe, France, Germany, Hungary, India, Italy, Japan, Korea, Russia, Spain, the United Kingdom and the United States. Its mission is to:

"facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory."[1]

In order to explain some of the reasons for setting up a VO, consider the following: often, images taken by one observer are also of great value for another astronomer who is researching a totally different topic in the same part of the sky. Typically, the two astronomers would not be aware of one another and the second scientist would perform his own observations — producing a duplicate of the same data already archived by the first. But thanks to the VO, the observations made by the first astronomer can be easily found and used by the second, bringing a significant increase in efficiency and reduction of costs.

Ultimately, the goal of the VO project is to provide a skin beneath which the complexities of varied data coming from different instruments, telescopes and data centres can be concealed: as seen by an astronomer, the VO should look like a normal telescope.

Scientists are not the only group that can profit from the Virtual Observatory. Amateur astronomers can access professional data through the VO and use it for their work. And they are also able to submit their own observations, thus contributing directly to scientific research.

In addition, the VO is a great opportunity for teachers, students and in general for the public. Most data in the VO are available to everybody, whether or not they are astronomers — and in principle everyone should be able to access the same scientific data and tools as professional astronomers. However, without proper explanations, professional data and specialised tools are of little use for laypersons and non-professional astronomers.

Euro-VO AIDA for education and public outreach

In the framework of the European Euro-VO AIDA project[2], which is funded by the

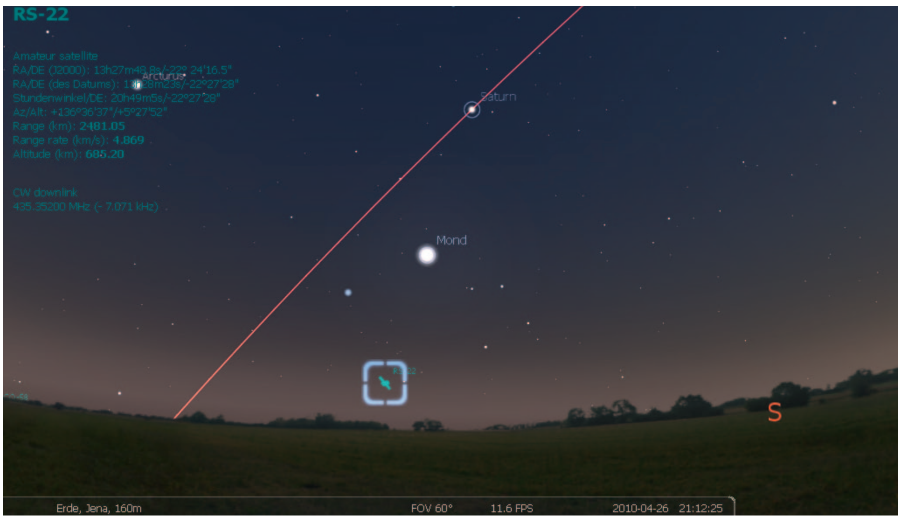

Figure 2. Stellarium shows how the sky looks. The Moon, a satellite and the orbit of Saturn are visible. Credit: ESO & the authors.

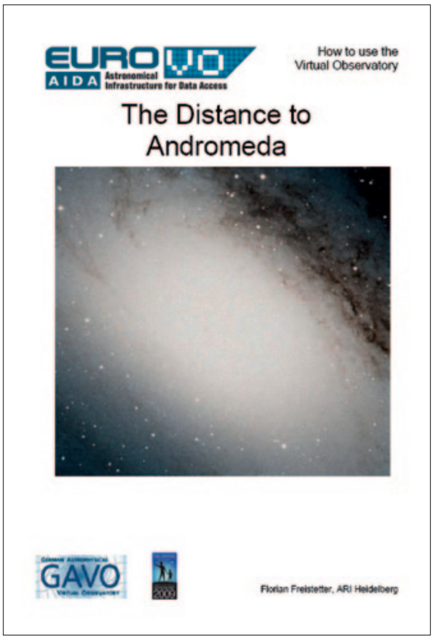

Figure 3. Example of an activity: measuring the distance to the Andromeda Galaxy with Aladin. Credit: Authors.

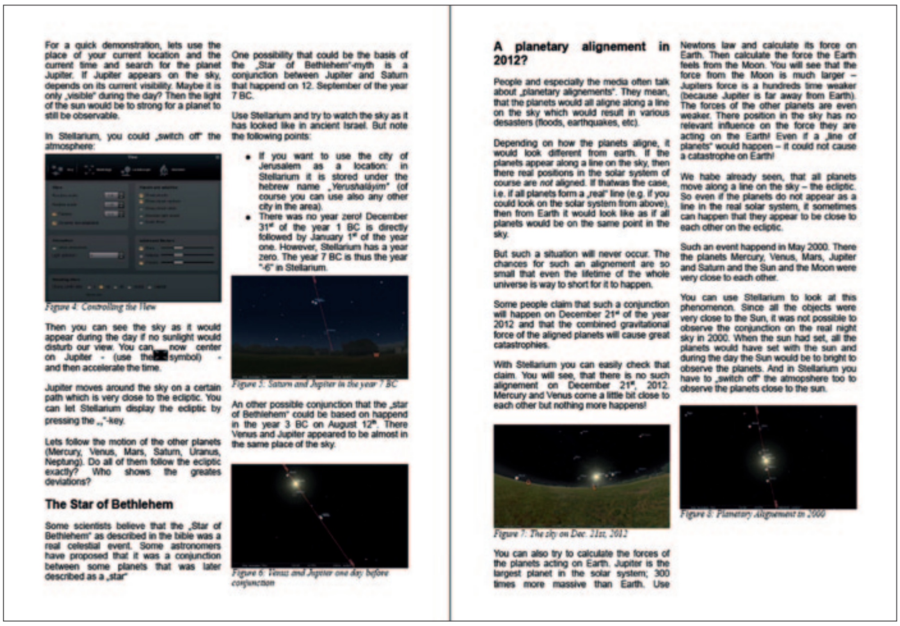

Figure 4. Example of an activity: learning about planetary conjunctions in Stellarium. Credit: Authors.

European Commission under the Research Infrastructure FP7, a special effort is being made towards education and public outreach. The fifth of AIDA's eight work packages is dedicated to developing tools and methods to let students, teachers and the public in general benefit from the European investment in the VO.

As a first step, we chose existing professional software tools for the retrieval, visualisation and analysis of VO data in order to adapt them for educational and outreach purposes. One of the most popular tools to access the VO is the Aladin program, developed by the Centre de Données Astronomiques de Strasbourg. In its professional version, Aladin is too complicated and contains too many specialised functions to be of any interest for non-professional users. We therefore created a simpler, more accessible version of Aladin.

A second valuable tool used and modified by AIDA is the sky browser Stellarium, developed by the European Southern Observatory. It simulates the night sky, including the motion of stars and planets, at any given location around the world and for any given date.

Using and adapting Aladin and Stellarium, it was our goal to develop tools that enable everyone — and not only professional astronomers — to (virtually) observe the sky and access all relevant data. For this purpose, it was not only necessary to provide the software; there was also a need for examples and use-cases that demonstrate how to use Aladin and Stellarium in an easy and comprehensible way. As a result, besides the development of the software, it was also our task to collect and create examples that show how the data in the VO can be accessed and used.

We chose the use-cases in order to apply them in schools, universities and public outreach. The VO is a great opportunity for teachers to introduce students to real astronomical data and the methods to work with it. We have developed a series of such activities of different complexities that are adequate for students of different ages and deal with different astronomical topics ranging from the distribution of asteroids to the distance of the galaxies.

A typical use-case that can be employed in a school or a beginners' astronomy lecture at a university deals with a concrete topic, like the determination of the distance of the Andromeda Galaxy. Every activity starts with a general introduction.

For example, in the case of the Andromeda Galaxy, it gives a short background briefing on the history and importance of distance measurements in astronomy. Less than 100 years ago, we did not even know if our Milky Way was all there was in the Universe or if the faint nebulae observed in the sky might be distant islands of stars similar to our own galaxy. To resolve that dispute, astronomers had to measure the correct distances to these nebulae. This was done by Edwin Hubble in 1924 by using the relation between the brightness and the period of variable stars known as Cepheids. The discovery by Edwin Hubble that the Andromeda Nebula was in fact an extremely distant galaxy full of stars and that our Universe consisted of myriads of such galaxies, which apparently move away from us ever faster the further they are away, was revolutionary and changed astronomy and the way we view the world. Making use of the tools and data from the VO, it is easy for students to retrace Edwin Hubble's steps using real astronomical data.

In our activity we show that with Aladin, one can not only access many astronomical images, but also a vast number of stellar measurements and catalogues. It is easy to retrieve observational data of all the Cepheid stars in the Andromeda Galaxy and use Aladin's built-in spreadsheet tools to process these measurements in the same way as Edwin Hubble did when he was calculating the distance to Andromeda.

Other Aladin educational activities developed by the AIDA-team include scenarios on the motion of stars, the confirmation of supernovae or the properties of stars in the Pleiades[3]. For younger students or the general public who are not willing or able to carry out astronomical calculations, we have developed other activities that make use of the Stellarium sky browser.

One such example deals with the widespread myth of a world-ending catastrophe on 12 December 2012; popularised all over the world as the main theme of Roland Emmerich's blockbuster movie *2012*. A major claim of the 2012-doomsayers is that exactly on 21 December 2012 the planets of the Solar System will align perfectly to form a straight line and the resulting gravitational perturbations will disrupt the Earth or at least cause major catastrophes (floods, earthquakes, etc). This claim can easily be refuted by using a desktop planetarium, like the VO-compatible Stellarium.

In our activity we again start with a general introduction that explains how the planets

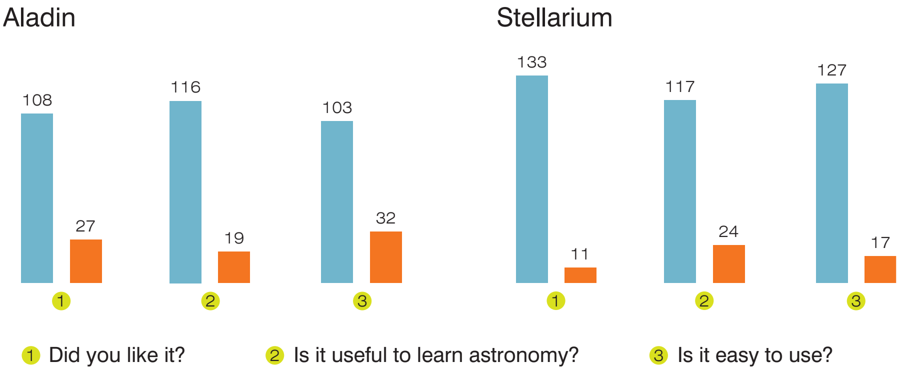

Figure 5. Evaluation of Aladin and Stellarium. Blue bars give the number of students who answered "Yes"; orange is the number of people who answered "No". Credit: Authors.

in the Solar System move and how this results in the astronomical phenomenon of conjunctions. We then show how one can depict the position of the planets for any given time and place and give examples of interesting conjunctions in the past (e.g., the conjunction of May 2000 or the conjunction of Jupiter and Saturn in the year 7 BCE that may be the basis for the story of the Star of Bethlehem). We also show that it is easy to confirm that there will be no special alignment in the year 2012 and give instructions on how to calculate the (negligible) gravitational effect on Earth if there ever were to be such a conjunction.

Classroom experiences with AIDA-WP5

Led by the Astronomical Observatory of Trieste (OATS), the AIDA/WP5 activities were applied and tested in many Italian schools with students aged 14 and 18. Four hours of teaching were dedicated to each activity: one hour each to introduce the astronomical background and the concept of the VO and two hours were reserved for the students to actually work on the problems.

More than more than 1500 students and 200 teachers know and have used AIDA-WP5 and helped us improve our tools and use-cases. Figure 5 shows some results of the evaluation.

Additional input came from various groups of amateur astronomers. Currently, a campaign is running to see if teachers can work with the activities without help and supervision by professional astronomers.

Conclusions

Astronomy is a science that fascinates not only professional astronomers, but also the general public. The AIDA-WP5 project is an attempt to make the large collection of astronomical data that is freely available both accessible and understandable for everyone who is interested in the sky. The goal is to obtain a set of dedicated tools and examples that can be used by teachers at schools and universities, by amateur astronomers and people working in public outreach in order to understand the concept of the VO and deploy it autonomously. The Virtual Observatory should become a standard tool not only for professional astronomers, simplifying their work, but also for anyone who wants to introduce people to the vast amount of knowledge and beauty that is uncovered by astronomical research.

Figure 6. Massimo Ramella (OATS) introducing the Virtual Observatory to students at an Italian school. Credit: Authors.

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Notes

[1] For details see http://ivoa.net/
[2] For details on EURO-VO AIDA see http://www.euro-vo.org/
[3] All use-cases and software can be downloaded from: http://wwwas.oats.inaf.it/aidawp5/eng_download.html?fsize=medium

Biographies

Florian Freistetter is an astronomer, working for the European Virtual Observatory EURO-VO at the Astronomisches Recheninstitut of the University Heidelberg (Germany). Previously he has investigated the dynamics of asteroids and extrasolar planets at the observatories of the universities of Vienna and Jena. He is the author of the ScienceBlog Astrodicticum Simplex (http://www.scienceblogs.de/astrodicticum-simplex/)

Giulia Iafrate works on astronomy outreach and education at the Astronomical Observatory of Trieste (Italy). She also collaborates with the Italian National Institute for Nuclear Physics in the analysis of the data of the Fermi-LAT satellite.

Massimo Ramella is associate astronomer at the INAF-Osservatorio Astronomico di Trieste. He coordinates the outreach and education activities of OATS. He is the team leader of Work Package 5 of the Euro-VO AIDA project. His field of research includes the large-scale structure of the Universe and systems of galaxies.

Celestial-themed Cartoons Captivate Children

Best Practices

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Key Words

Education
Entertainment
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Cartoons
Children
Informal Education
Moon

Summary

Attivamente: Big discoveries with Galileo and Phineas & Ferb, an educational entertainment project for children, was a collaboration between Disney Television Italy and the Education and Public Outreach office of the INAF Astronomical Observatory of Padua, Italy. The project started during the International Year of Astronomy 2009 and came to an end in June 2010. It consisted of a cartoon series, several articles in a Disney magazine and an educational kit focused on Galileo Galilei and the Moon. The kit, called the First Astronomical Kit, was distributed to 30 000 children in Italy, and included a board game about the Moon, an observation diary and a lunar fact card. The aim of the kit was to give children some basic astronomical knowledge and to demonstrate the essential role that observation plays in understanding the heavens. This article discusses how a research institute and a major entertainment company — each with very different working practices — were able to work together to form a successful partnership.

What can happen when astronomers have the opportunity to work with a top entertainment company like Disney? The creation of a brand new cartoon series that follows the adventures of Galileo Galilei as he meets two Disney characters called Phineas & Ferb.

The project began in 2009, during the International Year of Astronomy 2009 (IYA2009), when Disney Television Italy wanted to celebrate the 400th anniversary of Galileo's first glimpses through a telescope and to introduce children to astronomy. They decided to use their existing education and entertainment project, aimed at children 8–13 years old and called *Attivamente*, which has a different theme each year. To get some expert input into the project, which had the working title *Big Discoveries with Galileo and Phineas & Ferb*, Disney approached the INAF Astronomical Observatory of Padua, Italy.

The project had three parts: a cartoon series, a series of articles published in a weekly Disney magazine for children (with a circulation of one million copies per week in Italy), and the First Astronomical Kit. The Education and Public Outreach (EPO)

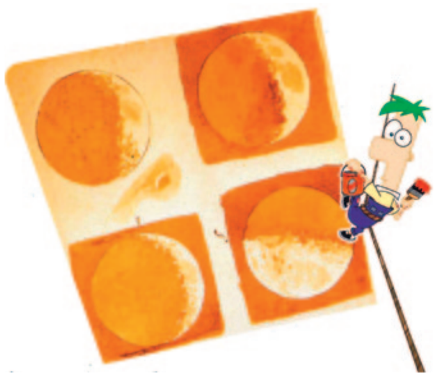

Figure 1. Phineas and Galileo's Moon drawings. Credit: Disney Italy

Figure 2. The Disney characters: Phineas & Ferb. Credit: Disney Italy

office at the INAF Astronomical Observatory of Padua worked on the latter part of the project, drawing on their experience to identify the most appropriate astronomical concepts for children in the target age range. Most importantly, we had to propose the most effective ways of conveying these concepts to children and to define an appropriate language and style.

Attivamente: Big discoveries with Galileo and Phineas & Ferb started in May 2009 and came to an end in June 2010. During that time, 30 000 First Astronomical Kits were distributed to children during visits to 25 INAF observatories and institutes, as well as to Italian science museums.

The stars: Phineas & Ferb, Galileo and the Moon

In order to engage children in this astronomical adventure we needed to find the right characters to explain the concepts. We chose the well-known faces of Disney's Phineas & Ferb — two curious and funny inventors with a love for science and technology — and a new Galileo Galilei cartoon character.

The Moon is the last character, and perhaps the most important. The Moon is the most prominent astronomical object in the sky after the Sun and is the perfect tool for introducing children to observational astronomy. Anyone can easily observe the changes in the Moon's appearance in the sky and realise that they are a periodic celestial phenomenon. Also, the Moon is strongly linked to Galileo, because it was the first object that he observed with his telescope, back in 1609.

With the characters in place, we were able to start writing and editing the texts to be integrated into the Disney layout and graphics. The result of this work is the First Astronomical Kit, which includes a board game about the Moon called Conquer the Moon, an observation diary called Mooncatcher, and a fact card about the Moon called the Moon Identity Card.

The board game: Conquer the Moon

The board game follows a traditional format: to move along the board and reach the Moon, players have to correctly answer "true" or "false" to questions from a deck of cards. The winner is the first player to reach the Moon. The playing cards were organised into four different categories: science, history, "oddball" and "chance" cards, all with questions related to the Moon. In addition to giving the correct answer, a brief explanation of the topic was also included on the card.

On the back of the board game, there is a short biography of Galileo Galilei and a description of the history of observational astronomy from naked-eye observing to the revolution ushered in by Galileo's first telescope and leading eventually to today's advanced astronomical instruments.

The fact card: Moon Identity Card

The Moon Identity Card gives essential facts and figures about the Moon, such as its diameter, temperature and distance from the Earth. Further information is included on the card, including an explanation of what Galileo saw with his early telescope (accompanied by his famous drawings of the Moon) and what is achievable nowadays. We decided to include this information so as to focus on the importance of observation for astronomy.

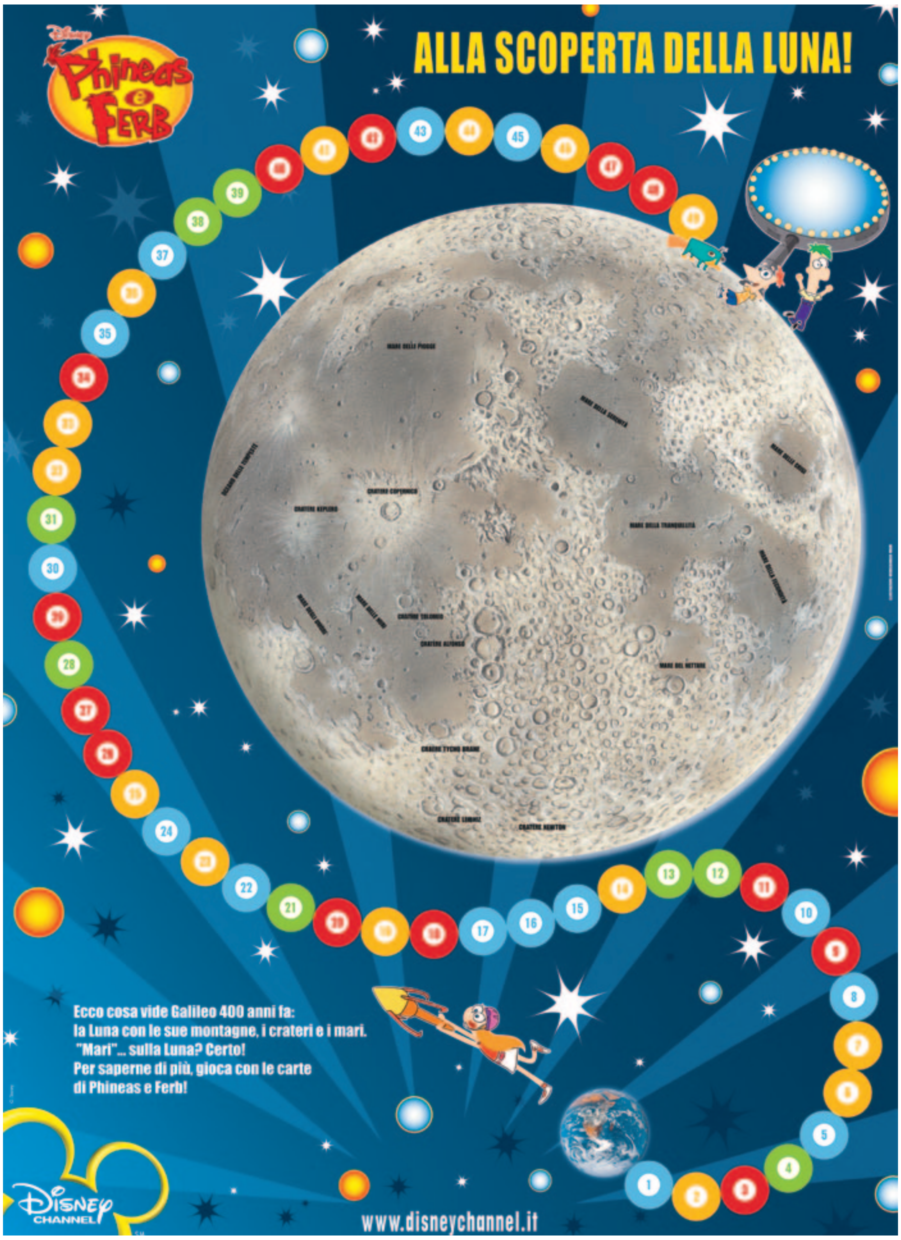

Figure 3. The board game: Conquer the Moon. Credit: Disney Television Italy

Figure 4. The Identity Card. Credit: Disney Italy

The observation diary: Mooncatcher

To inspire children to start looking at the sky, we included an observation diary in the kit, called the Mooncatcher. This diary adds a practical element to the kit, and is a natural follow-on from the informative board game and Moon Identity Card.

The children were asked to look up at the sky every day and night, to observe the Moon, its presence (or not) over the horizon, and its appearance. By drawing what they saw each day in their diaries, they could witness the periodic cycle of the Moon for themselves. And by flipping through the pages of their diaries, they

Figure 6. The cards. Credit: Disney Italy

Figure 7. Part of the game. Credit: Disney Italy

were able to observe the lunar cycle as an animated cartoon.

Communicating with children

We decided to simplify the language, wherever possible, but never when this made the science incorrect. For example, to explain the concept of lunar eclipses, the Italian text says, *"La luce del Sole non riesce ad arrivare fino alla Luna perché la Terra le fa ombra."*, which translates as: *"Sunlight doesn't manage to reach the Moon because the Earth casts its shadow on it."* The expression "*fare ombra*" ("cast its shadow on it") has a definite meaning, which is easily understood by children.

We also avoided unnecessary technical words, but we kept those that could not be accurately replaced with everyday language, such as gamma rays, black holes, orbit, galaxy and satellite. When technical words were used, we paid particular attention to simplifying the sentence structure. Often, technical words can be easily understood if the context is made clear.

We had to keep the texts short and to the point to fit them onto the small cards, so we only introduced one concept on each card.

Figure 5. The booklet. Credit: Disney Italy

However, it should be noted that the brevity of text does not mean that it is clear and easy to understand. Sometimes it is better to give a more detailed explanation in order to clarify a concept.

Last but not least, we needed to incorporate the language style of the cartoon characters Phineas & Ferb, and where possible, we used jokes and quotations appropriate for the cartoon characters. For example:

"Phineas celebrates the anniversary of the landing on the Moon ... and the party lasts too long! Step back two boxes!"

The main issue we had to face was connected with the language: we had to make sure that the smart and young linguistic style of Phineas & Ferb was the best to communicate astronomical topics. We had to attract the children but be clear and accurate: this was the hardest task to solve.

Lessons learned

Just as in a Disney story, our tale is coming to its happy-ever-after ending. Following our collaboration with Disney, we strongly believe that a balance between education and entertainment is possible. But to achieve success, the various stakeholders need to work together and be willing to understand the differences in the ways that they approach a project.

We put a lot of effort into finding a balance between the needs of our research institute and those of Disney. We had different ways of working, points of view and goals, and we had to respect both. Going by the responses of the children who visited our observatories and laboratories, we think we have succeeded in this challenge and created a positive synergy between Disney and INAF Astronomical Observatory of Padua.

Finally, we found that using different media — a board game, observing diary, magazine features, cartoon series — was beneficial, with each different part of the project helping to reinforce the astronomy concepts.

Credits

The *Attivamente* First Astronomical Kit project was developed by Leopoldo Benacchio, Valeria Cappelli and Chiara Di Benedetto, INAF — EPO Office & Astronomical Observatory of Padua, and Elena Baldini and Francesca Visini from Disney Television Italy.

Biographies

Valeria Cappelli studied communication at the University of Padua (Italy) and has a master's degree in publishing. She was involved with the IYA2009 — Italian National Node and managed the official communications and coordination of the IYA2009 in Italy. She is interested in science education for children and writing.

Chiara Di Benedetto studied communication at the University of Padua (Italy) and has a PhD in linguistics. She teaches writing courses at the University of Padua and collaborates with the research centre Observa — Science in Society. Since 2007 she has worked at the Astronomical Observatory of Padua and is engaged with science communication, and in particular events and activities for children and social research.

Valeria and Chiara are freelance workers in science communication. During IYA2009 they collaborated with the INAF — Italian National Institute for Astrophysics — to manage communication for the IYA2009 in Italy and they developed outreach projects like the activity for Disney Channel; as members of the local secretariat, they organised the IYA2009 closing ceremony in Padua.

A Journey Through the Universe at the Deutsches Museum

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Key Words
Exhibitions
IYA2009
Collaboration
Museums

Summary

Five research institutions in Munich and Garching bei München joined forces in the International Year of Astronomy 2009 to realise a unique exhibition project at the Deutsches Museum. The exhibition is called *Evolution of the Universe* and invites visitors to take a tour through time, beginning 13.7 billion years ago with the Big Bang and finishing with a glimpse into the future of the Universe. En route visitors learn how space, time, matter and the large structures in space have formed. The exhibition combines findings from astronomy, astrophysics, nuclear and particle physics in order to present the history of cosmos from different perspectives.

Introduction

In the orchestra of the natural sciences, astronomy plays the part of the first violin; it is a fascinating and diverse science, which impacts on neighbouring disciplines, like physics, mathematics, chemistry, engineering, and in the future, possibly biology too. In ancient times, observing and studying the sky was the only way to find one's bearings, and when mankind started to settle, the celestial constellations led our ancestors through the seasons of the year, telling them when to plant and harvest. Astronomy also touches on deep philosophical questions, such as: where do we come from?

Recognising the importance of astronomy, nearly 150 countries took part in dedicated projects and events that took place throughout the International Year of Astronomy (IYA2009). Here I will describe the planning and execution of one such IYA2009 project — an exhibition at a science museum in Munich, Germany.

The Deutsches Museum in Munich, Germany, is one of the biggest and most visited science and technology museums in the world. It was founded in 1925 and became world-famous in the post-war era. Today it attracts close to 1.5 million visitors per year, with the museum being a "must" for both school classes and visiting tourists.

The permanent astronomy exhibition at the Deutsches Museum is extensive and stretches over 1100 square metres. It focuses on classical astronomy and astrophysics, displaying a large number of instruments, both old and modern, and supplemented with demonstrations and small experiments. However, apart from small cosmetic touch-ups, the exhibition was last restored in 1992, and thus does not include the important findings of the past two decades. Also, the museum had reached a point where it needed to modernise its presentations to meet the expectations of today's more technically and visually demanding audience.

This is where the IYA2009 exhibition, *Evolution of the Universe*, stepped in to help — to fill this knowledge gap with a modern exhibition that covers recent discoveries in cosmology and astrophysics. Five research institutions co-produced the exhibition: the European Southern Observatory (ESO), the Max-Planck Institutes for Physics, Astrophysics and Extraterrestrial Physics and the Excellence Cluster Universe. The project planning began early in 2009 and the exhibition was opened to the public on 9 December 2009 and will remain open for at least two years.

From planning to execution

The five institutions behind the exhibition agreed to be equal partners with regards to financing and most of the project management, but with the Excellence Cluster taking the project lead. The main aim of the exhibition was to interest and educate the general public, taking them on a journey through the 13.7 billion years of the Universe's history, and the methods and tools astronomers use to investigate its different stages of evolution. As all the institutions involved have a strong commitment to education and public outreach, the exhibition offered a fantastic opportunity for them to continue this important work.

Since the exhibition room was small (about 100 square metres), it was important to limit the number of topics covered. The 13.7 billion years of the history of the Universe was subdivided into five major epochs or stages: Big Bang, The Early Universe, Structure Formation, The Local Universe (The Universe on Your Doorstep) and The Future of the Universe. Staying with the usual format at the Deutsches Museum, the timeline was complemented with a hands-on demonstration area, plus a movie on the ceiling.

After the institutes had approved the finance plan for the exhibition, the start of the project was marked with a kick-off meeting in February 2009. At this meeting the partners set the milestones and decided on the structure of the team. The opening of the exhibition was scheduled for the autumn of 2009, but this was quickly postponed to a more realistic date of December 2009. The project team consisted of only five scientists (Werner Collmar, Olivier Hainaut, Hans-Thomas Janka, Georg Raffelt and Jochen Weller), who were each responsible for the material for a specific epoch in the timeline, four consulting scientists (Andreas Müller, Herbert Scheingraber, Achim Weiss and Florian Zaussinger), three public outreach experts (Ed Janssen, Barbara Wankerl and Silke Zollinger) and a science journalist. A professional team of interior architects — a company called Die Werft, which specialises in designing and building exhibitions — was also brought on board the project.

As mentioned earlier, due to the size constraints of the room, the exhibition could only focus on a few crucial stages in the Universe's history. But after the first round of collecting ideas, we had far too many proposals for themes, exhibits and movies. Also, not all of the artwork and film material were of sufficient quality. It took the team two workshops in April and May, in collaboration with the architectural partner Die Werft, to sift through the collected material to find the best resources for the exhibition. With five large institutions involved, this was a slow process, involving long discussions before decisions could be reached on the proposals. Fortunately, the hard work paid off: the first exhibition layout presentation by Die Werft in May 2009 was accepted unanimously.

Figure 1. Exhbition poster.

Figure 3. View of the exhibition. Credit: KB Media/Die Werft

Amazing Universe

On entering the exhibition room, visitors can choose whether to walk along the History of the Universe wall, or to sit or lie on the central circular sofa and watch the movie on the ceiling. The exhibition presents a unique combination of exhibits and demonstrations. For example, a football is used to explain how the Universe quickly inflated from an unimaginably small "dot" to the size of ball, while two boxes of differently coloured sand are used to represent matter and antimatter. A demonstration about the cosmic microwave background (CMB) shows how the CMB would look with different ratios of dark energy, ordinary and dark matter. A very simple and effective presentation was achieved in the Future section: three different-sized mirrored boxes with LEDs (each light representing a galaxy) give a stunning impression of how dark energy is influencing the Universe.

The exhibition also benefits from excellent contributions from the Deutsches Museum, such as a life-size model of the inner tube of the Large Hadron Collider and the Differential Radio-wave Micrometer used in the COBE mission. ESO contributed a new model of the European Extremely Large Telescope, and the Max-Planck Institute for Extraterrestrial Physics provided a beautiful model of a black hole at the centre of the Milky Way.

Conclusions and future plans

The exhibition has been immensely successful, with very positive feedback from both the visitors and the Deutsches Museum management team. At the opening of the exhibition on 8 December 2009, Professor Wolfgang Heckl, director of the Deutsches Museum, said that this "extraordinary exhibition" should hopefully become a permanent part of his institution.

It is impossible to count the number of visitors who come to see this exhibition, but if only one percent of all visitors visit the exhibition, that would mean 30 000 visitors over a two-year period. Assuming this low estimate for the number of visitors, with the total costs for the exhibition amounting to 200 000 euros, the institutions have spent less than 7 euros per visitor, which is an excellent return on their investment.

The best way to guarantee the future of the exhibition is to integrate it permanently into the portfolio of the Deutsches Museum. In 2011, important discussions will be held to agree on the terms and conditions for making the exhibition an integral part of the museum. We are optimistic the story will be considered good enough "to be continued".

Biography

Barbara Wankerl has been the PR manager of the Excellence Cluster Universe since July 2007. Barbara holds a university diploma in biology from the Ludwig-Maximilians-Universität (LMU) in Munich. After her degree she completed a professional training to become a PR specialist and technical writer. She worked for several years as a senior consultant with the Munich-based PR firm Dr. Haffa & Partner, where she was in charge of several accounts for international IT companies. In 2007 she joined the Technische Universität München to work in the field of science communication, first for the faculty of electrical engineering and later for the Universe Cluster.

Best Practices

Tweeting Spacecraft: Communicating Space Science in the Age of Web 2.0

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Key Words

Twitter
Web 2.0
Microblogging

Summary

Since 2008 NASA spacecraft have been using the microblogging service, Twitter, to communicate science topics and results to a long list of public followers. In its ability to reach hundreds of thousands of individual users, Twitter offers many benefits for the public communication of astronomy. But to use social media services responsibly requires several competing tensions outlined here to be balanced: specifically, with respect to agency[1] and intimacy, and scientific expertise.

The *Phoenix* phenomenon

In November 2008, NASA's *Phoenix* lander watched the Sun set over the arctic horizon on Mars for the last time. With the Martian winter in full swing, solar power and temperatures reached their expected low, freezing the robot's circuits. As the communications stream from Mars fell silent, a room full of the scientists and engineers who had commanded the robot for the duration of its brief mission mourned its loss at their headquarters at the University of Arizona, USA.

But once word went out to the Twitterverse on *@MarsPhoenix*, over 40 000 Twitter users around the world mourned *Phoenix's* passing, posting tributes, poems and heartfelt condolences online to commemorate the spacecraft, as if it were a dear, distant friend. When *Wired* magazine held an online competition for a suitable epitaph for the robot, they were "officially impressed" to receive almost a thousand entries. "*Either you people really love NASA swag [free gear],*" the magazine exclaimed, "*or the little lander that could captured some hearts and minds.*" (Madrigal, 2008)

In this article, I will discuss how the use of microblogging services like Twitter and other Web 2.0 communities do not just communicate science ideas with the public. They also have implications for how the public sees and interacts with the spacecraft; and potentially for how science is done on the missions. First I will explore what it means to tweet from a spacecraft account, and how Twitter constructs agency and affective relationships with distant robots. Second, I will examine the tensions that Web 2.0 technologies can bring to our understanding of publishing and discovery in scientific communities. These issues must be well understood by any communications office when they engage in Twitter activities.

The findings that I present here are based not on quantitative or computational analysis, but on my qualitative studies of spacecraft organisations based at NASA's Jet Propulsion Laboratory (JPL). As a sociologist of science, I have conducted in-depth, on-site studies of the Mars Rover mission and the *Cassini* mission, as well as historical research on missions such as *Viking*, *Voyager* and *Galileo*. Lessons learned from these missions can be helpful to other organisations interested in the public communication of science to local and international audiences.

Robotic relationships

Usually, we think of single Twitter accounts as managed by a single user, who may use their profile and connections to establish their online persona or interact with other single users through the system (Boyd et al., 2010; Honeycutt & Herring, 2009). Twitter can be used by these individuals for a variety of purposes, from general chatter about everyday activities and making online connections (Java et al., 2007), to informal lightweight communications that sustain a collegial work environment (Zhao & Rosson, 2009) to rapidly distributing critical information among communities in distress (Starbird et al., 2010). But corporate microblogging is also expanding in popularity. An increasing number of companies, product lines, politicians and celebrities possess and use Twitter accounts to interact with a wider public (Böhringer & Richter, 2009; Gilpin, in press). Such Twitter accounts may masquerade as individual users with individual accounts, but in reality they are highly controlled by press offices, product managers or agents. Their interactions with their followers are usually one-way, relying on the retweet function to spread information from a single point to a wider audience.

Tweeting spacecraft fall into this category: a single user account carefully managed by an organisation. Although *@MarsPhoenix* appeared informal and even casual, it was a carefully orchestrated presentation of "self" managed by a single member of the JPL Press Office. This staff member attended the daily *Phoenix* science meetings, and used her knowledge of NASA communication policies to craft appropriate Tweets. As the number of followers quickly grew to over 40 000 users, the NASA Press Offices, from Headquarters in Washington to individual centres across the United States, took notice. By the end of the mission, all active and forthcoming NASA spacecraft possessed active Twitter accounts, some with thousands of followers. These robots are "tweeted for" by members of various NASA Press Offices located at different NASA centres or affiliated research institutions, much in the way that other corporate entities tweet to their various publics.

What is Twitter?

Twitter (www.twitter.com) is a microblogging service. Users who sign up for accounts can post short statements of only 140 characters or less, called *Tweets*. Users may also collect *followers* with whom they share these short statements. When a user logs in to the service, the first thing they see are recent Tweets posted by the people they follow in their Home Timelines. Other Web 2.0 systems, like Facebook, have similar features in that they allow users to post status updates to their Friends list, but these often include other methods of interacting within the system than the exchange of shortened Tweets. On Twitter, users' posts are publicly available and may be traced across the system through the use of some Twitter-specific tools. For example, tagging posts with the "#" symbol can identify and then collate popular or "trending" topics; users may get their followers' attention by placing the "@" symbol in front of their follower's user name in their status message; users may also type "RT" to "retweet" or re-post someone else's message as their own.

When spacecraft tweet, what do they say?

Like celebrity Twitter feeds, spacecraft Tweets are carefully managed to give the impression of the robots speaking directly to their fans. While in actual fact, each Tweet is subject to the same regulations as NASA press releases and vetted by the Press Office, the use of colloquialisms, first person pronouns, and idiomatic expressions makes the result appear informal and direct. For example, on 23 July 2010, *@MarsCuriosity* (the Twitter account for the new Mars Science Laboratory mission) tweeted: *"Very busy in the clean room as I get ready to roll for the 1st time in about 15 mins (2pmPDT/21UTC) Join us: http://bit.ly/92t5HI."* The click-through link allowed *Curiosity's* followers to access an internet webcam in a backstage area of the NASA laboratory where the robot was being assembled. Note that the use of the first person makes it seem as though the robot is speaking directly to its friends in cyberspace, despite being an inanimate object on that could be on a planet millions of kilometres away. This sense of robotic personality is augmented when other JPL spacecraft like *@MarsRovers* retweeted *@MarsCuriosity's* call for webcam watchers, saying, *"Aw, they grow up too fast!"* Such a comment establishes a relationship between the two robots, using a familiar phrase often exchanged between parents or siblings. This relationship is then visible over the Twitter network to thousands of followers who feel that they are privy to this intimate relationship between their robotic friends.

Corporate accounts on Twitter are widespread, but bring up issues of online identity management and patterns of interaction in a social network setting that are still being explored by social media researchers. When commercial companies Tweet about sales or coupons, it seems that most human users do not reply, although they may retweet to pass information along to their followers. However, the fans of the spacecraft maintained their suspension of disbelief and would often address the robots as individual agents. During the Mars Phoenix mission, several users tweeted to *@MarsPhoenix*, asking questions for their science projects or to clarify news reports and received individual replies. For example, when Lucas Zallio *(@LucasZ)*, a web administrator in Argentina, tweeted, *"@MarsPhoenix Do you get oven power from the Sun or is it fuel powered?"*, the spacecraft appeared to reply directly, saying, "*@lucasZ* … I'm solar powered, saved to lithium ion batteries. At this latitude, panels are 28% efficient turning sunlight to power." The Press Officer behind the Twitter account recalls being astonished at the overwhelming volume of replies to the spacecraft's Tweets, each one of which she answered as *@MarsPhoenix.*

Only when the robot finally went silent did the users behind the account let up on the illusion. But even then, they carefully maintained the robot's identity as the source of most of the Tweets. Thus a Tweet from 1:42PM on 10 November 2008 uses brackets to designate the status of "Phoenix Ops" as interlopers on *Phoenix's* account, saying: "[*Phoenix Ops*: *We promised* Phoenix *to continue to update here its discoveries and future news. Another goodbye from Mars*…]"

Getting friendly

Because users outside NASA follow the spacecraft's Tweets, the robots' staged interactions give the impression of their acting as autonomous agents on the frontiers of space. An implication of this activity is the anthropomorphisation of the spacecraft, a transformation of the robot into something — almost someone — that can be known intimately by a diverse and dispersed group of people around the world. The spacecraft invites this sense of agency as it speaks of its experiences in colloquial terms familiar to internet users the world over, even using terms like "*yesss!*", or "*lol*". Further, because the spacecraft seems to reveal aspects of its personal experience, this invites its followers to experience a sense of intimacy with it. A spacecraft follower can expect to see regular updates from her robot on a regular basis, posted alongside Tweets from friends, co-workers or organisations. This produces a sense of the spacecraft as both singular and agential, with an evolving history. It also invokes a sense of intimacy in the constant process of revealing and following everyday events in a spacecraft's life. This affection was especially evident in the online response to *@MarsPhoenix's* death, when tributes, haikus and farewell messages were tweeted by followers around the world upon hearing of *Phoenix's* demise.

This sense of intimacy developed through online interactions has implications for Twitter users and followers alike. First, cases like these prove that the robot can develop and maintain a sense of agency and personality despite being millions of miles away (Suchman, 2007; Vertesi, 2009). That is, we do not have to be face-to-face with a robot, nor does the robot have to appear anthropomorphic, in order for us to develop a meaningful relationship with it. Second, studies of communication and psychology have shown that revealing details about one's private life builds a perceived sense of intimacy between two individuals, often as strongly felt on the revealer's side as that of the confidant (Collins & Miller, 1994; Levinger & Huesmann, 1980). Such perceived intimacy may contribute to the sense of success on behalf of NASA outreach personnel. That a low-budget, short-term, and largely immobile mission such as *Phoenix* could be seen to touch the lives (and Twitter Timelines) of thousands presented a public relations breakthrough. It also suggested that public outreach was being successfully accomplished on an unprecedented scale.

But because the press offices were controlling the information that the public received directly, Twitter seemed to eliminate the need for longstanding media practices. In the past, press offices had to rely on press releases sent to news media outlets, and could not necessarily control which stories were printed. As the press officer in charge of the Twitter feeds explained, "*Mainstream media are more likely to cover a bad news story than a good story. Twice we had bad days on* Phoenix*… and that would have been all [the information] they [i.e. the public] were getting. Being able to put out information daily changed the way people thought about the mission.*" Increasing control over the mission story as a whole, instead of being subject only to intermittent negative reports, can be a tremendous success for mission press offices, but the new approach also changes the relationship between these offices, the public and science reporters.

Web 2.0 and expertise

Over the course of *Phoenix's* short life, microblogging became increasingly central to the daily work of the mission. Twitter and other Web 2.0 technologies such as Facebook and blogs have since then been harnessed across NASA's offices to release their spacecraft's images in near-real time to the public. To date, *@CassiniSaturn* has 75 000 followers; *@MarsRovers* has 80 000. Their Tweets often include single-line descriptions about a discovery, and may include short links to blog posts, images or published papers. As Tweets are retweeted, URLs clicked and blog RSS feeds generated, word of a spacecraft's activities spreads quickly. But while this may seem like a dream come true for press offices, it is important to note that Web 2.0 technologies such as wikis and blogs have in the past exacerbated a tension between the mission press office and the participating scientists. In the drive to generate context for Twitter feeds, these tensions should be considered very carefully so that a strong working relationship can be established between those who operate the spacecraft and those who tweet on its behalf.

Where does data come from?

Taking a picture on *Cassini*, *Phoenix* or the Mars Rovers takes considerable social and scientific work. First, a scientist must be selected to join the mission via a lengthy application and review process. Then they must come up with a hypothesis, and observations that might prove or disprove that hypothesis. Next, they must make a case for that observation such that their team members support it, which means negotiating with other instruments for spacecraft time, bytes and power to take the observation. Finally, they may work with technical assistants to craft and code the observation request for upload to the spacecraft. The images, spectral readings and other measurements that return from the spacecraft are embedded within this delicate process. But when the spacecraft speaks with a single voice and appears to have an agency all its own, the people who make the spacecraft work seem to disappear and become invisible.

This invisibility masks three related issues with respect to spacecraft data. First, the data that spacecraft collect are neither neutral nor always inherently shared. Because scientists must compete against each other for the privilege of building an instrument, the data that their instrument returns belongs to them and to their team, and often cannot be easily or intuitively understood by outsiders. Second, scientists are cautious about stating anything about their data publicly until it has been sufficiently confirmed, calibrated and subject to peer review. They therefore negotiate for proprietary or validation periods with their data so that they can be sure to fully understand it and stand behind it when their findings are released to the public and to their colleagues. Third, many scientists on missions are anxious that when their data is released, others will see for themselves what the scientists had hoped to see in the first place: that which inspired them to convince their colleagues that it was worth dedicating spacecraft time, bytes, and power to take the observation. Scientists who express reservations about releasing their data too early are usually not being obstinate or selfish, but acting in the best interest of their own and their team's scientific process.

Who are the experts?

With the coming of Web 2.0 technologies like blogs, wikis and amateur web forums, a new expectation of visibility to the public has inspired some changes in how scientists plan and craft their scientific observations, discoveries and announcements. Behind the scenes, I have often observed planetary scientists exchanging concerns about what the public will think of the Tweets and blog posts about their data. There is much anxiety that images from another planet will be misinterpreted, leading to public misunderstandings, or that amateur interpretations of these images will be misinterpreted as professional ones. Twitter also brings up complex questions about the process of science. Can significant science content really be conveyed in 140 characters or less? Does a Tweet count as a "publication" when it comes to a discovery priority dispute? What is the role of the expert in this new environment? How can scientists preserve and support the public's respect for scientific expertise, work and the status of peer-reviewed publications in the era of Tweeting and retweeting?

These anxieties are not unfounded. In January 2008, there were reports of an image of a woman or a Sasquatch on Mars, which many people claimed to see in an image taken by the Mars Rover, *Spirit*. Although quickly discredited by scientists on the mission, the story was already out of their control. It gathered considerable speed on the internet as it was blogged and shared by users the world over, and was even reported by traditional media outlets such as national television networks and newspapers (CNN.com, 2008). Similarly, in April 2010, a popular blogger in the planetary science community used Photoshop to put together her own composite of images taken by the *Cassini* spacecraft, and posted the result with a discussion on her blog. This image was picked up and posted as the Astronomy Image of the Day on a website hosted on a NASA server, no doubt to the blogger's excitement. But conspiracy theorists on the internet jumped on the image, claiming that it was doctored to the point of being unbelievable, proving that NASA was manipulating the public. Both the image site and the blogger were independent of NASA, but the space agency was held accountable for this interpretation. (see Lakdawalla, 2010).

Such examples do not come from Twitter, but do speak to some tensions that Web 2.0 technologies have generated with respect to scientific work. Releases of data used to be reserved for scientific publications and major press conferences, wherein a discovery would be appropriately announced — and credited. With Web 2.0, however, the expectation of immediacy and visibility means that more space agencies are asking scientists to release their data to the public sooner: sometimes even before their colleagues on the same mission have seen the data. To some scientists, such requests violate their scientific process, bypassing requirements such as peer review, analysis and even calibration. To be fair, not all scientists work this way: some missions believe it is important to release all their image data to the public as soon as it is acquired. However, in my research on the subject, missions launched before 2000 and the majority of European space projects are more likely to include independent teams that shepherd their results. And while one team member on an interplanetary mission may delight in the opportunity to have their data instantly streamed to thousands of people over morning coffee, another may express serious reservations about releasing such information to the public. Whether one believes that open data is the way forward or not, both perspectives need to be treated with respect and understanding when generating content for Twitter feeds.

Why, where and when to tweet?

There are clearly many benefits to starting a Twitter stream for one's spacecraft or scientific experiment. With a few short keystrokes, a single message can be relayed directly to followers around the world, by passing media relations, and allowing the public to build an intimate relationship with their spacecraft. For some, this is a dream come true, ensuring their mission's success and continued public support; for others, it suggests a public relations nightmare. But as for any new technology, reaping a cascade of benefits from Web 2.0 mission communications requires careful, local consideration of how press offices will work with scientists to release mission information responsibly and thoughtfully. This requires thinking about why, when, and where to tweet, and doing so in collaboration with each unique mission to hear scientists' concerns and excitement about the new process. Science press offices would be wise to meet with the scientists they represent to come up with internal policies for the use of Web 2.0 technologies or "new media". Such policies should aim to balance the enthusiasm of Tweeting spacecraft on the one hand, with a respect for local scientific and operational processes on the other. Without such initial communication, a rush to embrace Twitter runs the risk of generating more bad press than positive public experiences. As with any technology, Twitter cannot *change* the process of science, and would be unwise to try to do so. Instead, to be truly valuable both to the scientists and to the public, we must bring it mindfully into existing relationships, restrictions and ways of working within the scientific community. After all, these are crucial to getting the work of science done in the first place.

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Notes

[1] Agency: Here, specifically referring to the received impression that the robots and spacecraft are able to act autonomously.

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Biography

Janet Vertesi is a PhD graduate from Cornell University in Science & Technology Studies. Currently she is a Cotsen Fellow at the Society of Fellows in the Liberal Arts at Princeton University, where she also holds a Lecturer appointment in the Sociology Department. Her work focuses on the complex intersections between people, science and technology such as the social organisation of robotic spacecraft teams, and the role of images in scientific practice. She is currently conducting an ethnographic study of the *Cassini* mission to Saturn. More information: http://janet.vertesi.com/

Visualising Astronomy: "The Big Picture"

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Key Words

Visual Communication
Astronomy Visualisation

News flash! Planetariums have changed. With fulldome video technology[1] in nearly 700 planetariums worldwide[2], these "theatres of time and space"[3] have evolved into learning environments that truly deserve that moniker. How do we teach with these new tools, these new images? And what potential do planetariums now offer for changing the way people think about humanity and its place in the Universe? A few personal observations and speculations follow...

One can think of planetariums as offering two kinds of "big picture". First off, a domed theatre often projects an intrinsically large image: the Morrison Planetarium sports a 23-metre diameter dome, with a correspondingly enormous projection. But modern planetariums also allow for an opportunity to present nested spatial scales out to the Cosmic Microwave Background (CMB), scaffolding each hierarchical step in a fundamentally visual and visceral experience, a gateway to big-picture thinking. We in the biz usually refer to the latter under the umbrella term, the Digital Universe, a name coined by the Hayden Planetarium team at the American Museum of Natural History, USA.

As a couple of colleagues and I wrote more than six years ago, *"The Digital Universe atlas has grown out of a convergence of two great streams of technical achievement: celestial mapmaking, the product of centuries of observation and scientific breakthrough, combined with hardware and software engineering, which enables sophisticated data visualisation."* In closing, we speculated that, *"perhaps the Digital Universe can help stimulate a cosmic perspective toward our own species."*[4] With several more years of experience under the planetarium community's collective belts, we have gained significant experience working with the Digital Universe, but we still have a lot to learn.

A three-dimensional virtual model lends itself to talking about scale, and indeed, most teaching with the medium has centred on conveying the immensity of the Universe. Light travel time of course becomes the *lingua franca* of describing distance, and to maximise impact with an audience, one can link time to events in a person's life — or events in the history of life on Earth. The distance to the Moon? One and a half seconds corresponds to a brief pause in conversation. Between Earth and the Sun? Eight and a half minutes might afford enough time for a quick lunch. The diameter of Pluto's orbit? A good night's sleep. The nearest star? A high school or college education (in the United States, at least). Across the Milky Way? The history of our species on the planet.[5]

Sometimes, the temporal and physical scales mesh perfectly to reinforce conceptually important points. For example, the concept of the "radio sphere" has entered the vocabulary of many people who talk about the Digital Universe: a sphere 70-odd light-years in radius, which represents the distances out to which humanity's strongest radio signals have travelled. *"Before television carrier waves, the early-warning radar first used in World War II, and the detonation of atomic weapons, Earth was radio-quiet to the Universe. After the use of these and other radio emitters began, in the late 1930s and early 1940s, signals were able to escape the atmosphere and travel into space at the speed of light."*[6]

These examples speak to a critical point in helping audiences make sense of the size of the Universe. Connecting human experience to otherwise abstract data allows people to make the concepts more

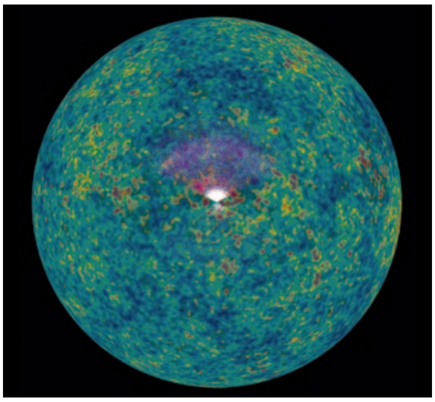

Figure 1. Earth's radio sphere (the small blue circle near the centre of the image) in context, with a two-dimensional spiral galaxy image scaled to the size of the Milky Way, rendered using Partiview freeware. Courtesy of AMNH/NCSA.

concrete — and more approachable. When one looks at an image of the radio sphere appropriately scaled relative to the size of (a stand-in for) the Milky Way, one sees humanity's electromagnetic footprint in space (Figure 1). It also represents a relative technological timeline: if the Milky Way's diameter corresponds to the age of *Homo sapiens*, then the radio sphere represents the duration of one of our species' technological attributes. The spatial and temporal scales overlap in a meaningful, visual way.

Of course, this only gets you so far. By the time you hit the Virgo Cluster, you're talking about the death of the dinosaurs, and the scale of light travel time becomes fairly abstract. And of course, the billions of light-years that separate us from distant quasars represent a period over which the Universe has changed dramatically. The ultimate punchline is the CMB placed in context with the galaxy and quasar distances measured by, for example, the Sloan Digital Sky Survey (Figure 2). Looking out in space means looking back in time, and the use of light travel time as a measure of distance eventually leads to a head-on confrontation with evolutionary changes in the Universe.

A written explanation of this journey does not communicate the impact of virtual travel afforded by a contemporary planetarium. Technological and aesthetic choices transform this intellectual journey into a visual experience. Indeed, in a modern planetarium, "flying" through a virtual model of the Universe, it becomes a truly visceral experience: you can feel exhilarated and perhaps even a little queasy making the trip out to the CMB.

What does this kind of cosmological thinking inspire?

For many, frankly, a certain amount of frustration. After taking people on a "tour of the Universe", I often get asked what things look like "right now": people grasp the idea that light travel time reveals objects as they existed in the past, but they find it difficult to divorce the three dimensions of the virtual model from the three dimensions of ordinary space. (Whereas the virtual model actually combines spatial and temporal dimensions, and of course, the finite speed of light allows us to reconstruct the history of the Universe, effectively embedded in the three-dimensional representation.) Overall, one can leave such an experience feeling very small...

But perhaps we can use the "big picture" to evoke other responses. Perhaps placing Earth in its spatial-temporal context can redefine how people think about their home planet. One could think of this as an extension of the "overview effect" reported by astronauts, in which the experience of seeing Earth from space invoked feelings of connectedness and euphoria.[7] Can such a response be elicited virtually?

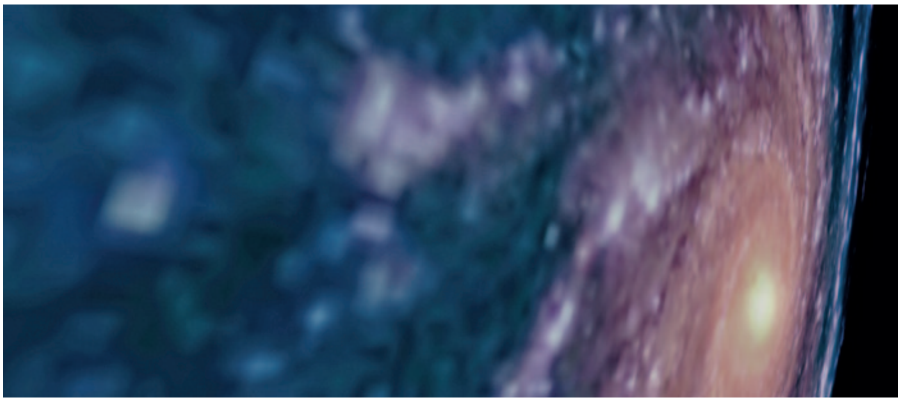

Figure 2. The Observable Universe seen from outside in both space and time: WMAP data depicted as a sphere cantered on Earth with SDSS galaxy (white and red) and quasar (purple) data scaled accordingly, rendered using the planetarium software Digital Sky. Courtesy of M. SubbaRao (Adler Planetarium) & D. Surendran.

My institution, the California Academy of Sciences, USA, does active research in the life sciences as well as outreach, and for a grand re-opening in a new, green building, astronomy played a supporting role in a planetarium show that knitted together the themes of the Academy's exhibits and research. *Fragile Planet* placed Earth in a cosmological context, with the intention of influencing audiences' ideas about environmentalism and sustainability. Our as-yet unpublished evaluation of the programme showed that audiences got that message, but not as loudly and clearly as intended.

Perhaps such connections require more specific emphasis. The Academy recently hosted a meeting for the NOAA-funded Worldviews Network team, and we spent an evening in our GeoDome[8] strategising. In the words of the proposal statement, *"the Worldviews Network will make explicit the interconnections of Earth's life support systems across time and space"* with the goal of *"engaging the American public in dialogues about human-induced global changes"*.[9] To paraphrase my colleague David McConville, a cosmological perspective might help open people's minds to the magnitude of the design challenges that face us in a rapidly changing world.

How might the Digital Universe transform people's views? The current generation of planetariums, equipped with appropriate technology and data, might just open people's minds to new attitudes and understanding.

Notes

[1] http://en.wikipedia.org/wiki/Fulldome (retrieved on 15 December 2010)

[2] Loch Ness Productions Fulldome Theater Compendium, retrieved on 15 December 2010 (available online at http://www.lochnessproductions.com/lfco/lfco.html)

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Biography

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