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 to 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 it 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).

Opinion

The Big Bang – A Hot Issue in Science Communication

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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 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.

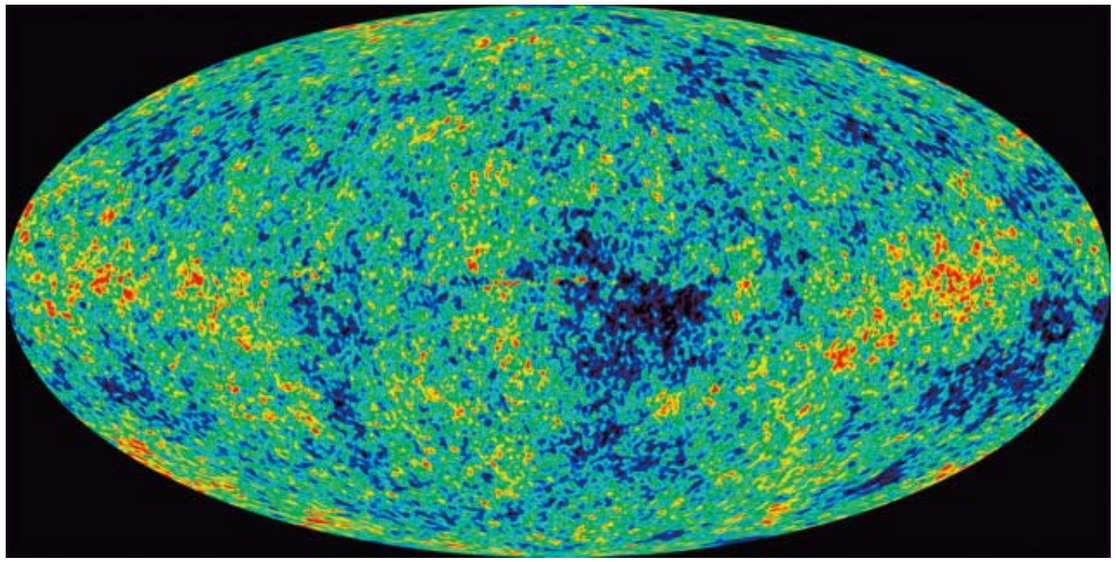
Introduction

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 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 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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