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The role of astronomy in society and culture

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Abstract. As an ancient and multidisciplinary field, astronomy is an ambassador for all sciences. Astronomy's broad appeal, whether from its cultural interest of our place in the universe, or its practical aims such as sea- or space navigation, is well recorded in history from ancient to modern times, and sky-awareness, more generally, began prehistorically. Astronomy's perceived role and purpose has continually developed over the ages. In all, astronomy is not to be viewed as a narrow subject operating in isolation but one that has contributed comprehensively to the advancement of society.

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The history of the development of science and its application through technology is as important as any other part of our heritage in understanding the nature of modern human existence. One might go further to say that the pursuit of science is the only truly universal culture, understood equally and subject to the same mental and practical engagement everywhere on the globe. Astronomy is perhaps the best example of this universality of science, which, as Thomas Jefferson put it, implies that "*The field of knowledge is the common property of all mankind, and any discoveries we can make in it will be for the benefit of yours and of every other nation, as we as our own.*"†

The very same sky, as observed by different cultures, while leading to different interpretations in space and time (see, e.g. Shlain 1991; Bertola 1995, 2003; Kemp 2006), nevertheless builds on astronomical knowledge which is valid across cultures just as arithmetic is, a fact that perhaps best illustrates the failure of the post-modernist and social constructivist accounts of scientific activities (see Bouveresse 1999; Boghossian 2006; Bensaude-Vincent 2003; Weinberg 2001; Sokal 2008).

In his anti-science (and anti-arts) diatribe, Rousseau (1751) wrote, quite rightly, that "*Astronomy was born of superstition.*". In contrast with the astrological superstition, astronomy has, however, evolved and made progress by applying the scientific method to objects which cannot be experimented with. Before this modern phase, the pre-Socratic philosopher Thales, and then Anaximander, of Miletus insisted that all observed events must have rational, discoverable causes (e.g. Cropsey 1995; Singer 2001). This truly revolutionary idea was not always easily accepted by political or spiritual authorities, which often based their power on presumed priviledged links to natural phenomena. The use, by politicians or religious authorities, of astronomical concepts to justify their ruling power has been a constant over time and space. This does not imply however that scientists should be held responsible for their discoveries of natural phenomena and their

† Letter to Henry Deaborn, June 22, 1807.

understanding. While it has been argued, since R. Oppenheimer, that the development of atomic bombs gave a thoroughly different meaning to the social responsibility of scientists, the practical uses of astronomy have not led – so far – to similar criticisms. Again, the fact that astronomy is not an experimental science per se, but rather an observational one, does also make a difference.

It can be argued that astronomy has, in fact, been the scientific discipline that, on the contrary, led the assault against the established authorities which based their rule on the *application* of astronomical discoveries to society. Likewise, astronomy has contributed to the process whereby "*the role of science in weakening religious certitude [is] one of its greatest contributions to civilization.*" (Weinberg 2009, p. 216). In his preface to the second edition (1787) of *Kritik der reinen Vernunft*, Kant described the process:

> "*It is only the principles of reason which can give to concordant phenomena the validity of laws, and it is only when experiment is directed by these rational principles that it can have any real utility. Reason must approach nature with the view, indeed, of receiving information from it, not, however, in the character of a pupil, who listens to all that his master chooses to tell him, but in that of a judge, who compels the witnesses to reply to those questions which he himself thinks fit to propose. To this single idea must the revolution be ascribed, by which, after groping in the dark for so many centuries, natural science was at length conducted into the path of certain progress.*"†

The history of astronomy is also the history of political interference with science that does not support some ideological beliefs, a long tradition rooted in the anti-Enlightenment movements (Sternhell 2006) and which unfortunately remains true to this day (e.g. Harwit 1996; Gross, Levitt & Lewis 1996). The implications for society are profound. As the Union of Concerned Scientists stated in the context of the so-called intelligent design attacks, non-scientific beliefs cannot be accepted as science, not only because the public understanding of science is eroded and the integrity of science diminished, but also becuse the decisions for our future could be based on unsubstantiated information.

In this context, media play a key role in transmitting scientific discoveries to the public, and all too often misunderstandings and misconceptions are amplified (e.g. Barrosa and Pullen 2008; Plait 2002), not to mention the pervasive image of the "mad scientist", from Faust to Dr Strangelove. It is one of the social responsibilities of astronomers to ensure that – besides emotions – the reasoning which led to the discovery is transmitted properly across society (e.g. Schatzman 1989). For example, *Universe Awareness* (UNAWE) is an international programme that aims to inspire young disadvantaged children with the size, scale and beauty of the universe, and their own placing on the globe, illustrating the multicultural origins of modern astronomy to broaden children's minds, awaken their curiosity in science and stimulate global citizenship and tolerance. The project is motivated by the premise that the formative ages of 4 to 10 years play an important role in the development of a human value system. UNAWE was one of the eleven Cornerstone Projects chosen to celebrate the International Year of Astronomy 2009.

In another approach, the relations that astronomy enjoys with the arts, across time and space, certainly help conveying part of the excitement, if not the rational process, to the public at large (e.g. Kemp 2006; Hockney 2001; Weinberg 2010; Lévy-Leblond 2010).

In modern times (Van Helden 2009), astrophysics – unique in encompassing the application of physics as a whole – has been extraordinarily successful in revealing a consistent picture of the development of the universe from an intensely hot and dense almost homogeneous beginning to its enormously expanded and widely complex present state.

† in J.M.D. Meiklejohn's (1855) classic translation.

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Largely this has been achieved by close conjunction of theoretical analysis and observational evidence in complementary, supportive ways. In recent decades the advent of new lines of thought, sophisticated computational advances and a wide range of powerful astronomical telescopes and instruments working from the ground and in space has led to fundamentally new understanding of the structural and chemical development of the universe over almost the whole of cosmic time. But, let us not forget, biological complexity is in another league altogether.

We are now at a startling juncture in recognising the existence – but not the nature – of the so-called dark matter and dark energy that the evidence shows together account for 95% of the mass-energy content of the universe and fundamentally influence its productive past developmentand its ultimate dissipation. And the advancing knowledge brings an appreciation that life forms and the macroscopic properties of the universe are logically inter-linked and that our universe may be just one in a limitless multiverse.

Today, astronomy is seen foremost as a scientific endeavour and the foundation of modern science. Explaining the structure and phenomena observed in the sky inspired Newton and Einstein to make their fundamental discoveries whose universality changed our understanding of nature. Our growing knowledge in science has come about from studies both in earthly laboratories and of physical phenomena observed in the sky. Within the universal expansion that began with the Big Bang about fourteen billion years ago it is now possible literally to see that the structural formation of the galaxies of stars has been evolving over most of cosmic time. To gain understanding of the universe in space and time astronomers need to apply the entirety of accumulated knowledge in the physical sciences. In turn, the discoveries continually push the borders of scientific knowledge. Alongside this are the engineering and technology challenges of producing ever more versatile and accurate instrumentation and detectors, building ever larger and more precise telescope structures both on the ground and orbiting in space to receive radiation from the furthest and faintest objects in the sky, and devising ever more sophisticated means of computational analysis and modelling.

The practice of astronomy thus is both at the cutting edge of knowledge and widely multidisciplinary, enabling it to boost the advance of science and technology together: astronomy is a tool for development. It is interesting and gratifying, therefore, to see already present or coming in Africa such major instruments as the Southern African Large Telescope (SALT), the High Energy Stereoscopic System (HESS) as the largest gamma ray detector in the world, the radio Karoo Array Telescope, and, possibly, the Square Kilometre Array as the largest radio telescope array in the world.

While science as a whole seems to have become less appealing at the university level, astronomy maintains wide public appeal and is a generator of public interest in science, and remains attractive to students. Consequently the introduction of astronomy-oriented courses has greatly increased student intake in physics. And again, astronomy – more than narrower scientific subjects – equips students with modern skills that are also widely applicable outside the academic *milieu*.

Astronomy is a subject that naturally promotes partnership and cooperation internationally: the same sky is studied by all; the same goals in understanding are sought; common data-bases are accumulated and accessed; telescope facilities commonly are open to international guest observers; and international cooperation in construction and operation of major new facilities is universal. The unique early formation of the IAU and the global activities of the IYA, are just two examples that testify to this. But there is a humanitarian side too. Astronomy, high among all scientific endeavours, in its practice transcends national borders and international constraints. A good example of bringing like-minded people in many post-conflict countries together is the project Enhancing as-

tronomical research and observation in South-East Europe and Ukraine of the UNESCO Regional Bureau for Science and Culture in Europe (UNESCO-BRESCE). This has the objective of strengthening astronomical cooperation in the sub-region, and between this and countries outside. It has been successful both in enhancing international cohesion and in raising the collective scientific productivity and international standing of the partner institutions.

The Astronomy and World Heritage initiative is a UNESCO World Heritage Centre thematic programme. The objective is to acknowledge the intertwined cultural and scientific values of properties connected with astronomy. The efforts of civilisations through the ages demonstrating sky

awareness and the will to understand or interpret what they see in the sky are often reflected in rock carvings, grand structures, architecture and other cultural representations. And the evidence of the more direct scientific activity in astronomy is borne through the existence of the many significant observational instruments and observatories that have been built over the centuries and which remain as beacons of humankind's search for fundamental knowledge about the universe. The identification, safeguarding and promotion of all these properties are the three lines of action for the implementation of this World Heritage programme.

But additionally, it is very important to recognise the natural dimension to the recognition of astronomical heritage – the preservation, from our vantage point, of the quality of the night sky itself through avoidance of overwhelming air pollution and extraneous light. While natural heritage sites are common in the World Heritage List, the local upper hemisphere of our heritage is all but forgotten. Most people now growing up in cities rarely experience the extraordinarily endowed night 'skyscape' still accessible to astronomers at the remote mountain sites where major observatories are now placed. While action on this fundamental loss has been widely urged for a long time, an important recent initiative `Starlight` – a Common Heritage has been launched through an international conference in 2007 on the island of La Palma in the Canaries (itself a UNESCO Man and the Biosphere reserve), home to the Spanish internationalised Observatorio de Roque de los Muchachos of the Instituto de Astrofísica de Canarias. This is a global campaign in defence of the values associated with the night sky and the general right to observe the stars, emphasising the value of this endangered heritage for science, education, culture, technological development, nature conservation, tourism and, not least, quality of life. It is open to the participation of all scientific, cultural, environmental, and citizens' organisations and associations, as well as other public and private bodies. At this ripe time in world awareness of the unsustainable environmental track we all are taking, this is a powerful move to drive home this all-enveloping heritage issue.

Astronomy has also become a "Big Science" in many respects, which has led to new relations with the five" Ms": money, manpower, machines, military and the media, the outcome of which remains to be seen. On the other hand, while astronomy is one of the few sciences where amateurs play an essential role, we are witnessing an evolution of the discipline whereby the public also becomes involved. The phenomenon of "*citizen science*" (see also Conner 2005, for earlier examples) started in astronomy with the wellknown `Seti@Home` programme which allows the public to let their computers analyse data gathered at radiotelescopes with the hope to detect interesting features possibly associated with extraterrestrial signals (see http://setiathome.ssl.berkeley.edu). More recent initiatives, which require some previous training, are Galaxy Zoo (galaxyzoo.org), Planet hunters (www.planethunters.org) and more generally the `ZOOUNIVERSE` (www.zoouniverse.org), which are leading to new generations of truly citizen scientists. Remarquably, this was already envisioned in the 19th century, when Camille Flammar-

ion famously stated "*Nous sommes tous des citoyens du Ciel*", or, as William Huggins described in 1891, "*Astronomy, the oldest of the sciences, has more than renewed her youth. At no time in the past has she been so bright with unbounded aspirations and hopes.*"

An increasingly wider fraction of the society in the 21st century participates to the quest for the understanding of a universe, which, as the British geneticist J.B.S. Haldane (1927) described, remains a never-ending puzzle: "*I have no doubt that in reality the future will be vastly more surprising than anything I can imagine. Now my own suspicion is that the Universe is not only queerer than we suppose, but queerer than we can suppose.*"

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