The Culture of Science

Jayant V. Narlikar

Introduction

While writing for the D.P. Chattopadhyaya *Festschrift*, I was in something of a dilemma, as I do not consider myself an expert in the area of history and philosophy of science, a field to which Professor Chattopadhyaya has contributed so profoundly, although I may claim to have an abiding interest in the field. After considerable trepidation, therefore, I have decided to write on a topic which keeps coming to my mind from time to time. My decision to write was inspired by some of Prof. Chattopadhyaya's (DPC in brief hereafter) own writings (Chattopadhyaya 1995; Chattopadhyaya, "Science , Technology and Human Roots," 1995; Chattopadhyaya 1996) and I humbly dedicate this article in his honour.

Some explanation is needed right at the beginning as to how science, which is considered neutral, may have a culture of its own. I am referring here to the practice of science, rather than science itself. How do the practitioners of science at any given epoch view their subject? How does the society itself perceive the impact of science? And finally, what

* A previous version of this paper appeared in the India International Centre Quarterly (Spring 2005). 156—169.

bearing does all of it have on the ethical values of the time? That such issues carry relevance to society at large, and to intellectuals in particular, even if they do not belong to the field of science, does not need to be justified and is amply demonstrated, for example by the writings of DPC.

Distinguishing between civilisation and culture, DPC has said: "...In a philosophical vein it has been said that civilisation is what we do possess or have, and culture is what we are" (Chattopadhyaya). One may adapt this to the present theme by saying that technological achievement is the content of civilisation while the spirit that drives science is part of culture.

As an example, one may point to issues currently debated hotly, for example should science be harnessed towards deadly weapons that will effectively eliminate the human race from the face of this planet? Is it ethical to tinker with nature's reproductive processes through cloning? To what extent is there a copyright on sponsored research if it can be harnessed for human welfare? I believe that such issues pertain to the scientific culture of the society.

Rather than confine the discussion to the present times, it is worth viewing it in a historical context. I will not follow any chronological sequence here, nor do I lay any claim to exhaustiveness. I begin with Europe of pre-Newtonian times, dating back to the eleventh century.

Europe ca AD 1050-1650

In the year AD 1054 a remarkable astronomical event occurred. The Chinese and the Japanese astronomers have recorded it and from their meticulous notes one may fix the date as 4 July 1054. On that day these observers saw what they described as a "Guest Star," which suddenly appeared in the sky. It was bright enough to be visible even during the daytime and gradually faded away. The Chinese had a custom of describing a

transient object in the sky as a "guest." In actuality, in hindsight of nine centuries one can say today that what they saw was the explosion of a star, the so-called supernova explosion in which the entire star is disrupted, ejecting its envelope and retaining a small compact core which is shot off in opposite direction like the recoil of a gun. The debris of the explosion may be seen today through astronomical photographs as a diffuse but highly energetic cloud called the Crab Nebula.[1]

This phenomenon was seen and documented by Ibn Buttan, a physician from the Middle East. There are also indications of it being sighted by the Native American tribes in North America who have left rock etchings and carvings illustrating what they saw..

It is interesting to see why these records were kept. The Chinese held the belief that their Emperor received signs from the sky as hints, advice or portents relating to his performance on the Earth. Lest he missed out these important signals, the Emperor had appointed court astrologers to monitor the sky and report to him any unusual happenings which is why the Crab Supernova was duly noted. In the case of Ibn Buttan, the heavenly signs were often related to epidemics on the Earth and he was interested in an epidemic in the Nile valley. So far as the Native Americans were concerned, the sight must have been unprecedented and unusual enough to be so recorded on rock. While the lunar eclipse, the solar eclipse and comets constitute unusual sights, they are far more frequent than a supernova explosion. So far only three supernovae have been sighted within our Galaxy in the last nine centuries, although more distant ones in far

[1] For a description of the Crab Nebula and its historical records see the book *Seven Wonders of the Cosmos* by J.V. Narlikar, Cambridge University Press, 1998.

away galaxies are seen regularly but only with telescopes.

What has all this to do with Europe, you may ask? Well the important thing is that searches in European manuscripts of those times do not show any records of the event. Like the episode of the dog in the Sherlock Holmes story, that did not bark at night, this non-event is significant. One may ask: Why are there no records?

Historian of science, George Sarton, and astrophysicist, Fred Hoyle, have independently argued that the reason why the event was not recorded was because it was inconsistent with the then current view on the origin of the universe. If the Biblical belief that God created the universe in seven days was to be rigidly adhered to, then how does one account for a new star suddenly appearing? Rather than getting embroiled in controversy or provoking reprimands from their superiors, the monks who kept all the records may have simply chosen to ignore the event! Lest it appears preposterous that an existing belief should dictate what you should observe and record, I will later describe an event of recent time which reminds us how strong the influence of a paradigm can be.

This example illustrates how science was perceived in medieval Europe. It related to the study and observations of Nature but strictly within the religious framework. Which is why, Copernicus and Galileo encountered such hostility in their times, when they sought to cast doubts on the geocentric theory.

Take the case of Galileo's telescope. Although tiny compared to its modern versions, this pioneering instrument led to such important findings as sunspots, lunar craters and Jupiter's four nearer satellites. Yet the intelligentsia of Galileo's time did not take kindly to the telescope, for its findings dealt blows to their deeply ingrained beliefs. If God created the universe in total perfection, how could they explain pockmarks on the beautiful face of the moon or the dark spots on the shining sun? And if the

whole universe is supposed to revolve around the Earth, how could they explain Jupiter's four moons going around it? No wonder, the telescope was dubbed as an instrument of magic and witchcraft.

The magnum opus of Copernicus was published when he was on his deathbed; he died shortly after receiving the published copy. It is now widely believed that the preface of the book is not what Copernicus himself would have written. It seeks to present the new heliocentric theory, which was the lifetime work of the author, mildly as an alternative hypothesis rather than a fact; as if the writer of the preface was anticipating violent criticism of the main text of the book. It is very likely that the editor or the publisher substituted this preface in place of a possibly more forthright one by the author himself.

While Galileo was a staunch supporter of the heliocentric theory, he had openly attacked the Aristotelian philosophy of nature. His book on a dialogue between two world systems heaped ridicule on the Aristotelian ideas of motion, force etc. While debates were not uncommon in those times, the normal practice was to confine them to philosophical arguments rather than to practical demonstrations. Galileo, perhaps the first scholar to rely on experiments to confirm theory, demonstrated through cleverly conceived experiments, how many of the long held beliefs were untenable.

Sensing a threat to its doctrines the Roman Church summoned Galileo before an Inquisition. Although he finally publicly recanted and accepted the views of the Church, it is said that privately he continued to believe in the heliocentric theory. In modern times, Pope John Paul II set up a study group to go over the historical papers relating to Galileo's persecution, with the result that the Church, some 350 years later acknowledged that Galileo had been right.

Reviewing the episode Pedersen has commented that Galileo

himself did not have a convincing argument as to why he thought that the Earth moves and the Sun is at rest. His best argument (which later turned out to be wrong) was that the splashing of the seas during tides must be because they are on a moving Earth. The real reason for tides lies in the law of gravitation, which had not been discovered in Galileo's time.

To summarise, the period AD 1050-1650 illustrates how science was perceived as part of the tenets of the Church. It began to have an existence independent of the Church only with the advent of the Newtonian laws of motion, gravitation, optics etc. We will return to this issue later.

India ca AD 450-1150

The above period may be considered the golden period of Indian astronomy, spanning as it does the times from Aryabhata to Bhaskara II. Aryabhata, in his book *Aryabhatiya*, makes the statement that essentially means that the Earth spins against a background of distant stars. This statement has been commented upon by subsequent astronomers of the above period (see, for example, the article by Bina Chatterjee). In none of the cases has any astronomer supported this statement. Rather the attempt is to "wish it away" as something of an embarrassment.

Unlike the cases of Copernicus and Galileo, biographical details on Aryabhata are sadly lacking. How was his above statement received in the contemporary circles? Was there any religious dogma that required geocentric theory to be right? So far as I know, the prevailing religions of the day in India had no such specific bias. It is possible, that the geocentric theory may have come from Greece, and may have gained a certain level of respectability. But this does not explain the cool reception accorded to Aryabhata. He was born in the present state of Bihar. Why did he go to Gujarat and then to Kerala as some versions of

his life story have it? Was that because of local ridicule for making a statement that did not agree with the wisdom of the day?

The difficulty of answering these questions is typical of the kind that historians of science in India face: i.e., the lack of reliable documentary material. I am currently encountering this difficulty while trying to answer a question relating to the Crab Supernova mentioned earlier—did people in India keep any records of its sighting? That they must have seen the event is certain, for the star would have been visible from the subcontinent, and monsoon or not, it was visible for a long enough period to be noticed from a large number of human habitations.

Assuming that there was no religious dogma against such a sighting as in the case of European scholars, and knowing that the event occurred during a phase when Indian astronomy was flourishing, one should come across records of its sighting. Attempts to look into old manuscripts in various libraries have so far proved futile. The main reason advanced is that our tradition did not encourage writing and recording; the transfer of knowledge was largely through oral/verbal means.

Another difficulty concerns reliability of the written material. Was it written at the time of the original manuscript or was it inserted later? There are instances where a later manuscript simply reproduces what was written in another manuscript several centuries earlier. Thus even if one found a reference to an event, one cannot be sure that it appears there for the first time or has been lifted from an earlier manuscript.

Compared to China, Europe and the Middle East, our historical records of scientific work done in this part of the world, are therefore scanty, notwithstanding the works of the astronomers and mathematicians of the above golden period. This probably tells us something about the status of these

subjects in our social perception. Did science as a means of understanding nature not enjoy a privileged status? Was recording data and interpreting its underlying pattern not part of scholastic studies? I may be open to correction, but I do sense apathy towards science as natural philosophy in our early traditions. This may well be the reason why science did not flourish in India in the next millennium until it was essentially imposed, in its by then well developed European form, by our colonial rulers. One may also raise here the frequently asked question as to why our rajas and maharajas who lavishly patronized the arts and humanities ignored science and technology altogether? Their European counterparts did appreciate and sponsor science as part of culture and knowledge, and this was one of the main reasons why science took off so well in the Renaissance and post-Renaissance period in Europe.

Hermann Bondi has thus commented on the success of a scientific theory: it is 100 per cent if it is tested and accepted, 50 per cent if it is violently resisted and rejected, and 0 per cent if it is ignored. Much as one may condemn the treatment meted out to Galileo, he at least achieved a 50 per cent success on Bondi's scale, whereas Aryabhata scored 0 per cent.

Post-Newtonian to Modern Times

With the success of the Newtonian framework in Europe, science broke away from the shackles of religion and a materialist and empirical approach came in its place. The hierarchical structure described by a set of diagrams by DPC illustrates very well the linkages between hard sciences and technology on the one hand, and cosmology and metaphysics on the other through a series of disciplines including branches of science, humanities, fine arts etc. The culture of science has changed as the subject has advanced in a dramatic fashion during the nineteenth and the

twentieth centuries. Indeed through its strong connections to high technology, defense and consumer world as well as to big budgets for frontier research, the culture of science has been radically transformed. In place of Isaac Newton who could afford to wait for two decades before fully satisfying himself with regard to the viability of the law of gravitation before publishing it, today's scientists guided by different priorities dictated by the above connections must rush to the press even before they have completed their lab-work. Or they may be forced to keep it suppressed for reasons marked "classified" or "under patent protection."

I will not dwell at length on the current issues relating to weapons research, cloning and genetic engineering and the question of intellectual property rights versus free exchange of information between scientists. I shall only stress the fact that these issues are inevitable and have to be faced whether we like it or not. It would be unfair to single out professional scientists as targets of criticism, for these issues deeply concern society at large. I will point out a rather disturbing feature that is assuming greater and greater significance even in the relatively calm waters of pure science.

Big budgets have brought about a change in the culture of pure research today. The scenario is as follows. Most frontier research costs a lot of money. The original apparatus used by Rutherford to split the nucleus cost no more than a hundred pounds. Today's high energy particle accelerators cost several billion dollars. In place of Galileo's one inch telescope made by him in his own workshop, today's space telescope is again a billion dollar project. Any scientific project using such an expensive facility necessarily costs big money too. To secure funds for this research one must approach a funding agency...usually the government of the country. The funding agency allocates funds on recommendations of peer review

committees. These committees guided no doubt by the need to allocate scarce funds in the "best" possible way, look for impeccable credentials of the proposal-maker and credibility of the proposal. As a result of this scrutiny only the "safe" that is, "no risk" proposals are selected. Safety is of course decided by the criterion that what is to be looked for should be consistent with what we already know. The committees discourage explorations of wild, untested ideas.

While all this seems commonsense, try to apply it to Galileo and Copernicus. If you were a member of a peer review committee set up by the Church of Rome, you would have no option but to reject their proposals! That we have turned a full circle from those days was illustrated by the recent episode of Chip Arp. I shall conclude with a brief account of that episode.

Arp is a distinguished observational astronomer who was trained by Edwin Hubble, the astronomer credited with the discovery of the expansion of the universe. Hubble's law forms the basis of modern cosmology. Arp himself has many discoveries to his credit and his atlas of peculiar galaxies is a standard for all modern observers. Yet, since the 1970s, Arp has been finding several cases of galaxies and quasars which do not fit into the Hubble expansion picture. These are known as anomalous observations. The establishment reaction to this evidence ranges from disbelief, anger, to plain apathy, for to face it squarely would involve questioning or seriously modifying the existing paradigm in cosmology. So a stage came in the early 1980s, when the leading observatories closed their doors to Arp, on the grounds that his discoveries did not make sense! Nor did research journals take kindly to publishing Arp's findings. Scientists refused to debate the issue in international conferences: they would sooner forget it altogether (recall the example of no records

being kept of the Crab Supernova by the medieval monks). The message therefore is, that in order to succeed in science you must learn to conform. In such an environment how can new ideas prosper in science?

Works Cited

Chattopadhyaya, D.P. "Rationality, Culture and Values." *Language, Logic and Science in India.* Ed. D.P. Chattopadhyaya and Ravinder Kumar. Delhi: PHISPC, 1995.

———. "Science, Technology and Their Human Roots." *Mathematics, Astronomy and Biology in Indian Tradition.* Ed. D.P. Chattopadhyaya and Ravinder Kumar. Delhi: PHISPC, 1995.

———. "On the Nature of the Interconnection between Science, Technology, Philosophy and Culture." *Science Philosophy and Culture Multidisciplinary Explorations.* Vol. 1. Ed. D.P. Chattopadhyaya and Ravinder Kumar . Delhi: PHISPC, 1996.

Olaf, Pedersen. *Galileo and the Council of Trent.* (*Specola Vaticana: Citta del Vaticano*, 1983.) Vatican Observatory Publications Special Series: STUDI GALILEIANI.

Chatterjee, Bina. "Aryabhata's Theory of Rotation of Earth." *Indian Journal of History of Science* 9 (1974): 51–55.