
Education through Astronomy

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*T*o the layman, astronomy is often mistaken for astrology and vice versa. He often brings all his superstitions to bear whenever the science of astronomy is being discussed or described. To the scientists in general, non-familiarity with astronomy makes the subject appear just a collection of speculative ideas.

The purpose of this paper is to highlight the vital contribution astronomy can make as a regular part of our educational curriculum and also towards the enlightenment of public at large. This is because astronomy possesses certain unique features that no other science can claim to have.

Let me illustrate this with an analogy. A person confined to his native village has a limited outlook and experience. If he moves on to the district town, he receives a quantum jump in his overall perception. Travel broadens the mind — so they say! If he travels to a metropolitan city, then through the state and the nation, then through the continent and eventually jets across different parts of the world, these quantum jumps

of knowledge continue in ascending order. So it is with astronomy *vis-a-vis* other sciences.

The typical laboratory scientist confines (and is constrained to confine) himself to experiments, observations and inferences here on the Earth. While he can claim to be in control of whatever experiment he performs, the terrestrial confinement necessarily limits his vision of nature. Astronomy takes him away from his native Earth out into space. The farther he moves, the wider is his perception of the universe. The quantum jumps of knowledge occur as he encounters the hierarchical structures in his journey through the universe: the planets, the stars, the galaxies, the clusters and superclusters of galaxies and so on.

The remarkable feature of astronomy is that even though man sits here and observes these celestial phenomena from afar, he is able to make some sense of what he sees on the basis of the science he knows. "The most incomprehensible thing about the universe is that it is comprehensible", said Albert Einstein reflecting his astonishment at the apparent universality of science.

This universality has two consequences. First, through a proper application of science, one begins to understand something that may have appeared mysterious, awe inspiring and even frightening to start with. Many superstitions arising from a lack of proper understanding of the cosmic events are thus washed away. Secondly, the scientist himself gains confidence in his laws of science which, after all, have been derived from empirical observations of nature in the first place. The cosmos provides him with a far bigger and far more versatile laboratory than the Earth could ever do. And so, through astronomy he gains a better understanding of science itself.

It is surprising therefore that these two benefits have not been properly assimilated in our educational system, either the formal one of schools and colleges or the extra-mural one relating to the general public. By integrating astronomy into other educational inputs we should be able to take advantage of what the subject has to offer. Indeed, I may go further and say, we must do so!

In the rest of this paper I will present illustrations of specific questions through which astronomy can generate important educational inputs. I will consider three different types of questions.

1

Motion through Space

- i. For us, the inhabitants of the Earth, the planetary surface appears fixed. However, it is not fixed within the cosmic stellar background. The Earth spins around its polar axis from west to east as a result of which we see the Sun rise in the east and set in the west. *But can we ever see the Sun rise in the west?* This question would immediately draw an answer 'NO'. The correct answer in fact is 'YES'. The trick lies in achieving motion around the Earth that would overcompensate for its spin. This is easily achieved at high altitudes by travelling in a jet plane from east to west. I had this experience while travelling from London to Chicago, when around dusk I noticed that the Sun, which had earlier set in the west, rose again and went up above the horizon for a few minutes.
- ii. *Why does the Moon appear to follow us as we move on the roads at night?* Any stationary object on the Earth in our neighbourhood changes its direction:

but not so the Moon, because it is very very far away compared to the terrestrial distances we travel in our journeys. This has a historic parallel that needs to be pointed out. The Greek thinker Aristarchus of Samos (around 310-230 B.C.) had the intuition to argue that the Earth is not fixed and that it moves through space against the stellar background. To verify his contention, Hipparchus (130 B.C.) had proposed observations of ~~directions~~ directions of stars. If the Earth moves round the Sun in a circular orbit (so assumed for simplification), then it is farthest from its contemporary position six months later. Thus, the star's direction would be changed when observed now and six months later. No such change was actually found. This was not because Aristarchus was wrong in principle. He had underestimated the stellar distances and overestimated the effect. The observing techniques of those times were incapable of measuring the very small changes of direction which could only be confirmed by the parallax measurements of the nineteenth century.

- iii. The shadow effect that leads to solar and lunar eclipses is described in the school texts. What need to be described also are the relative angular sizes of the Sun and the Moon and the fact of their being nearly equal. *What role does this fact play in producing a total solar eclipse?*

More interesting is to imagine the relative appearances of other planets and their satellites when viewing one another. *How large would the planet Jupiter look when viewed from its nearest satellite Io?* The angle subtended is 38 times that subtended by the Moon at the Earth. In other words,

Jupiter would look a disc of thirty eight times the size of the lunar disc.

The Moon rises and sets over the Earth. *How does the Earth appear from the Moon?* It looks as pretty as the Moon does from here. *But will it appear to rise or set?* The answer is not what you would normally expect.

- iv. Comets have inspired the astrologers to make dire predictions about disasters on the Earth. As Carl Sagan once put it, the only correct prediction about a comet was first made by an astronomer and not an astrologer! It was Edmund Halley who successfully calculated the passage of the comet close to the Earth, the comet that has now been named after him.

Indeed, Halley's calculation of the cometary trajectory was a direct application of a predictive scientific theory (Newton's laws of motion and gravitation) to observed data. The scientific nature of astronomy can thus be illustrated with this example.

2

Physics of the local environment

- i. By local environment, I mean the immediate surroundings of the Earth. A question which excited no less a person than Sir C.V. Raman to think about the answer is: *why is the sky blue?* The role of scattering and absorption of light by the particles of the atmosphere can be explained to the questioner in the course of giving the answer to this question.

A related question is: *how would the sky look from above the atmosphere?* If we consider light from the Sun, it would reach us straight, as there are hardly

any scatterers in space. Thus, the Sun would appear as a bright ball, while the rest of the sky is dark! This is why with a space telescope we can do astronomy twenty four hours a day.

It is the atmosphere again that leads to the twinkling of stars. *What is the visual difference between the appearance of a star and a nearby planet?*

- ii. Light is actually an electromagnetic wave and the appearance of light — its colour if it is visible — depends on wavelength. It is important to describe (even in a qualitative manner) the different types of astronomies at different wave bands. The radio astronomy, X-ray astronomy, the ultraviolet and infrared astronomies and gamma ray astronomy are all possible, thanks to the technological developments since World War II. *How have these astronomies added new dimensions to human understanding of the universe?*

A major input has, of course, been possible due to space technology. The atmosphere absorbs most electromagnetic waves, except those in the visible and radio bands. So to "do" all the other astronomies one needs to site their respective telescopes above the atmosphere, in satellites.

Once you are above the atmosphere, it pays to 'look down' on the Earth too. Why? Because, from a distance you can get a global perspective of the planet that no view from a short height can give. Here it is useful to give the analogy of how a view of a terrain from the top of a tall tower is more comprehensive than the information gained by walking on it. In short, we do not get a proper perspective from too short a distance : the remote sensing program has a valuable role to play.

The relevance of astronomy to our existence

- i. That astronomy is not a subject reserved for the starry eyed speculators only can be brought home through its applications to human life. To begin with, life on Earth would not be possible without the primary source of energy, the Sun. The Sun is at the 'right' distance from us for this purpose; neither too far, nor too near.

But how does the Sun generate energy? Here it is worth giving an account of how scientists solved the problem, first with some unsuccessful ideas. The final successful solution — nuclear fusion in a controlled form — was offered by astronomers and not laboratory physicists. Even today, it has not been possible to achieve nuclear energy generation through controlled fusion in a man-made laboratory. *Where and how does astronomy score in this game?*

- ii. Take a stainless steel spoon. *How was it created?* In a factory, out of steel, Where did the steel come from? From a steel plant. How did it get there? From raw ore in the mines of the Earth. *In what way did the Earth acquire it?* Probably it was present in the material from which the Solar System formed. *But how did it get into that material?* Probably dumped from the debris of nearby exploding star — the supernova.

This brings us to the question of nucleosynthesis in stars. The deep interior of a star serves as a fusion reactor. At temperatures of several million degrees, lighter nuclei can be fused to make bigger ones. The iron that forms part of your spoon was made in some

such star which has already exploded and dumped its inner core material out into the interstellar space. The story of how supernovae are observed itself is of interest, starting from the discovery of the Crab Supernova of 1054 A.D. to SN 1987A, the supernova seen only three years ago. How scientists could measure the neutrino fallout from a supernova with their newly set up detectors is a success story of astronomy as a scientific discipline. The neutrino emission is predicted by theory to happen before the star explodes. This is precisely what was found in the case of SN 1987A.

What would happen if another supernova explodes in our neighborhood, say within 30 light years? The fallout would also include high energy cosmic rays whose impact on our atmosphere can destroy the protective ozone layer. Thus, a supernova might one day destroy life on Earth just as another was probably responsible for the origin of the Solar System.

- iii. The physicists need to be reminded that one of their basic interactions was detected and tested through astronomical observations. The law of gravity was inspired and tested by the motions of planets and satellites, and not by any laboratory experiment. It is the law of gravity that forms the basis of all motions of the spacecrafts launched by man in the Solar System. The accurate trajectories of lunar crafts, the interplanetary projects like the Voyager and the geostationary satellites that play such a key role in modern communications are computed with full faith in the law of gravity.

Concluding remarks

These are some instances which demonstrate the need to integrate astronomy with education, either formal or extra-curricular. It is essential to provide astronomical inputs early in human life if only to give man a better understanding of the universe he lives in and a realistic perspective of his place in it.

The methods of bringing in astronomy need not be confined to books alone. Although there is great shortage of suitable introductory literature, Video programs can bring the rich visual material currently available in astronomy to the learner much more effectively than the written word can. Such programmes can succeed if they link astronomy with human existence and encourage the innate curiosity. It is through such educational experiments that we may successfully combat superstitions. For, in the last analysis, a superstition can be destroyed not just by demonstrating that it is based on false premises but also giving in its place the correctly reasoned scientific picture.