Science/Jayant Narlikar

What's India's role in the study of the cosmos?

THE Earth has been around for about 4,600 million years. The Sun has been there for a somewhat longer duration and will continue to be around and shining steadily for at least 5,000 million years more. Our Milky Way galaxy is at least twice as old as our solar system and the universe (if it was ever born!) has got to be older still.

But a century and a half is a long time for changes in human societies, much more so now that science and technology are bringing about rapid developments. In particular, the human perception of the cosmos has undergone revolutionary changes during this period.

A few examples will illustrate the point. All through the last century, astronomers believed that the Sun and its planets occupy the central position in our galaxy. Certain diffuse nebulae like the Magellanic clouds and the Andromeda Nebula were firmly regarded as belonging to our galaxy. It was assumed that the dark parts of the Milky Way are devoid of stars.

Today, we know better. We have discovered that we are not located at the galactic centre but are some 30,000 light years away from it. (A light year is the distance travelled by light in one year: In round figures, about 10 million million km). This puts us about two thirds of the way towards the outer suburbia of the galaxy. Andromeda Nebula is a galaxy as big as ours and located well outside it. In fact, the telescopes of the 20th century have revealed a gigantic universe full of billions of galaxies like ours out to distances of billions of light years. (1 billion equals a 1000 millions). And as regards the dark regions of the Milky Way, they are not voids but are full of stars obscured by the interstellar dust.

Thanks to the phenomenal growth of technologies, the astronomer's tools for studying the universe have proliferated especially in the post-world-war-II decades. He is no longer restricted to the visual window where only seeing is believing. He has gigantic radio telescopes on the one hand and ingeniously designed detectors in space for capturing cosmic X-rays, gamma rays, ultraviolet rays and the infrared waves.

When Isaac Newton wrote his famous 'Principia', he gave mathematical derivations of the three laws of planetary motion discovered by Johannes Kepler. This was the beginning of modern theoretical physics and astronomy may rightly claim the credit for providing evidence for verification of the laws of gravitation: The first of the four fundamental interactions known today. Incidentally, Newton's derivation demonstrated two important points.

First, the accurate computation of planetary orbits and the prediction by Edmund Halley of the arrival time and trajectory of the comet (that was subsequently named after him) showed that planets, satellites, comets etc. are inert bodies subject to the same law of gravitation as a ball tossed up in the air. In the early days when these motions were not understood, the belief had grown that planets and comets possess supernatural powers. Thus there is nothing mysterious now about these heavenly bodies. Certainly there is no reason to believe that these bodies possess any "extraordinary powers" that allow them to move at will. Although the very motivation for this belief was demolished by Newton's work, it is ironical that it persists today.

The second point to emerge from the 'Principia' was the fact that cosmic phenomena can be understood in terms of the basic laws of science. This tenet guides the theoretical astrophysicists of modern times. Why does the Sun shine? Why do stars come in different sizes and colours? What are cosmic rays? What is the nature of jets seen in cosmic radio sources? Why do pulsars pulsate so regularly? Questions like these ranging all the way up to the grandest of them all: "What is the nature of the large-scale behaviour of the universe?" are today brought and discussed within the strict discipline of science.

The measure of success achieved by this process is encouraging—to use an understatement. It would not be an exaggeration to say that we know today how and why the stars shine, we can relate changes occuring in them to internal physical processes, we know hy stars explode as supernovae and can connect their remnants with pulsars. IN 1917, Einstein made the first attempt to discuss the large-scale structure of the universe within the framework of his general theory of relativity. That attempt was to entirely successful but it paved the way for modern cosmology as a scientific discipline. Today, cosmology represents the largest system within the purview of science, viz. the universe that by definition contains everything.

It is against this background that one must speculate about the future. What new things will we learn about the universe in the coming decades?

In the immediate future, great expectations have been roused by the Hubble Space Telescope. The HST should normally have been orbiting the Earth and producing data by now. However, the challenger disaster in early 1986 delayed all subsequent space shuttle launches. The space telescope launch date has been postponed to 1989 and it will be the early 1990s before its impact is felt. The telescope will observe the universe from above the atmosphere and will gain thereby in its ability to resolve small scale images and to pick up very faint objects.

Faint and tiny objects are of interest in two diametrically opposite situations. By looking at very distant faint objects the astronomer can hope to know about the distant parts of the universe. Since light takes time to travel those distances, these images describe objects that existed long ago. Thus we may be able to know what the universe looked like five to 10 billion years ago and to decide whether it was markedly different from what it is now.

At the other end, astronomers are excited about knowing whether stars as a rule have planets like the Sun has. In particular, could some of the nearby stars, say within a 100 light years, have planets? Not being visually luminous, planets cannot be seen directly near other stars. However, the gravitational pull of a planet (if it is massive enough like Jupiter) can disturb the position of the star it revolves round, to an extent that the shift in the star's image can be charted by the telescope.

Knowing about planets around other stars opens up the exciting possibility of life elsewhere in the universe. Microwave and radio measurements have, since the 1960s, revealed the existence of complex organic molecules in giant clouds of gas and dust from which stars and planets form. These molecules are parts of the DNA molecule basic to life on the Earth. So the building blocks are there. Does a complete jigsaw picture exist? It may well be that the next century and a half will see the possible discovery of extraterrestrial life.

The long distances (by human standards) between stars make it improbable that a human expedition to a planet around a nearby star can be launched to find out the extraterrestrials. A more direct and simple way is to listen in to cosmic radio conversations between two advanced civilizations. The likely wavelength may be 21 centimetres, the characteristic wavelength of radiation by the atoms of neutral hydrogen. The wavelength is ideal for information transmission over long distances. And, it is a wavelength that will be familiar to any advanced civilization.

Enormous radio dishes need to be built covering a huge collecting area for such signals. Project Cyclops envisages about 1000 dishes of 100-metre diameters all pointing in conjunction in the same direction that can be changed from star to star. Modern technology can build the system but improved technology of tomorrow may bring in other even more efficient systems that are not so expensive in real terms.

What will be India's contributions to the worldwide spurt in astronomy and astrophysics? A and A have been recognized as thrust areas by the Government of India after consultations with the scientific community and as such they may expect to get better support now than they have in the past. A major national facility, the so-called Giant Meterwave Radio Telescope (GMRT)—a Rs 30 crore project—has been initiated at Narayangaon about 100 kms from Pune. It has been motivated by the desire to look for evidence for primordial galaxy formation. If the current speculations based on the big bang cosmology are along the right lines, the radiation emitted by clouds of neutral hydrogen as they clumped round to form galaxies should be received now at metre wavelengths.

The GMRT will be the biggest observing facility at these wavelengths. A facility of this kind is not normally feasible in the advanced countries because of the man-made (industrial) noise at these wavelengths. Thus the instrument at Narayangaon will hopefully fill a gap in our knowledge of the cosmos.

Other major facilities in optical and space astronomies will no doubt follow. But a related question needs to be answered. Will India produce the astronomers and astrophysicists needed to use these instruments?

Over the last decade the trend has been somewhat disappointing. Fewer and fewer bright students are being motivated towards fundamental research and among those who are, a large fraction emigrates. To reverse the trend, it is necessary to revitalise research in our universities. Over the years the universities have fallen behind in generating exciting frontier research that would attract and motivate students. By comparison, research institutes and R & D laboratories have enjoyed a better flexibility of operations, received more liberal funding. However, they have remained more or less isolated from the undergraduate population.

Almost all centres of excellence in advanced countries have flourished because those doing frontier research were also teaching and motivating students in their formative years. Fred Hoyle at Cambridge, John Wheeler at Princeton and Richard Feynman at Caltech shared their excitement of top class research with the students they lectured to. Excellent facilities of research in a teaching environment are essential to keep the tradition for science alive.

In this context the new experiment of inter-university centres is worth watching. Two such centres have been created by the University Grants Commission (UGC), one in accelerator sciences in Delhi and the other for astronomy and astrophysics at Pune. The Pune Centre (IUCAA) will conduct fundamental research, undertake pedagogical activities, have laboratories for astronomical instrumentation and will have close interaction with GMRT. It will be a central facility for universities whose faculty members are expected to visit the centre as associates and engage in reseach projects in A and A. It will be the centre's aim to see that the A and A research grows in universities and that good students are attracted there. IUCAA will therefore help nucleate and promote teaching, research and developmental activities in A and A in universities around motivated and competent persons.

On the international scene, the concept of a central facility shared by several universities or institutions is not new. The high cost of frontier research has forced even nations to club together in order to run a facility at the desired optimum level. The Hubble Space Telescope, for example, will be a venture sponsored by NASA and ESA, the space agencies of the US and Europe.

In the last analysis, the success of such an experiment depends on the individuals conducting it. The way to success lies in transcending parochial attitudes. So far as India is concerned, it has no alternative but to succeed. If we aspire to have a place in the top league of A and A.