

I intend to tell you of some strange and fascinating things concerning our Universe. I am aware that as readers of 'BOBMAITRI' - the house journal of Bank of Baroda, you would not be exposed to the technicalities of Astronomy and Astrophysics. Therefore, I have tried to keep the content as simple as possible and accordingly, would confine myself to the most rudimentary level of the subject. Nevertheless, it is my belief that the simple facts or truths that I have described here would still appear to be quite intriguing. In fact, as is often said, "Truth is stranger than fiction". More so, in the case of the limitless expanse all around our planet called the Universe or 'Cosmos'.

But, before I proceed, I would like to make a point. Please do not blindly believe in whatever one tells you - make an effort to verify the truth on your own, even if the person telling you is an 'authority' on the subject. It is this quest for truth and the insatiable desire of man to uncover 'secrets' of nature that has brought mankind to its present status. Sending manned spacecrafts to the moon and artificial satellites equipped with cameras & super-sensitive equipments to far-off planets which were part of Science-Fiction in the last century have become "ordinary" events of today.

So, I request you now to bring your imagination with you on a tour with me as I take you away from 'terra-firma' - the firm surface of our familiar planet, on trip into space starting from a few tens of kilometers to light-years away, deep into the dark and mystifying recesses of the cosmos.

SUNRISE IN THE WEST!

"The Earth is fixed and the entire Cosmos revolves around it". This was the general belief till about the seventeenth century, and the term 'Geocentric' was coined to lay emphasis on a model where the planet Earth was considered fixed or stationary and other celestial bodies - Stars, Sun, Moon, and planets - were all considered as rotating and revolving around the earth. The belief was so strong that when Copernicus and Galileo dared to suggest that it is not the Earth but the Sun that is fixed, they invited the wrath of the then "authorities" in Rome. Galileo was severely admonished and in fact sentenced to life imprisonment at Florence! Today, we know that Copernicus and Galileo were right and that Sun, Moon, and stars all appear to rise in the East because of the Earth's spin on its axis from West to East.

The renowned Indian scientist of an early era in recorded history: 'Aryabhata' had drawn an analogy to explain this. He had said that if a person is going down a river in a boat he sees trees

The author and the article

An impossible task is being attempted, that of putting in a few lines what cannot be held between the covers of a bound book. Yes, Dr. J.V. Narlikar is a scientist whose eminence is second to none in the esoteric world of Astronomy & Astrophysics. As a mathematician, educationist, writer and a social reformer, his contribution has been phenomenal. A measure of his intellect can be had if you are told, that at the young age of 20 years, he was already a "Wrangler", a distinction conferred upon the most accomplished mathematicians.



After a meritorious career in Cambridge, spanning 15 years, Dr. Narlikar returned to India in 1972 as Professor in the Tata Institute of Fundamental Research.

Dr. Jayant V. Narlikar

Today as Director, he heads the prestigious Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune. Recipient of many prestigious awards for his valuable contribution in the field of cosmology and astrophysics, Dr. Narlikar continues his teaching, research and creative writing while shouldering the challenging task of making IUCAA an institution of International Standard.

The article is a transcript of the lecture he delivered to a massive gathering on the occasion of "Customer-Meet" organised by our Senapati Bapat Road Branch, Pune recently.

and hills and other objects on the river bank go in the opposite direction. Actually, these objects are stationary, but due to the motion of the boat - they 'appear' to be moving relative to the observer on the boat. In modern times - this experience can be had while traveling in the train. So, just because it is our perception of the movement of the Sun and the Moon from East to West - it is not the correct understanding of their motion.

Well, I will now give you a surprise. I have, myself, seen the sun rise in the West! How? Read on and find out! It so happened that for one of my scientific conferences I was travelling from London to Chicago and the flight I took was a typical jet aircraft. Going from London to Chicago is moving from East to West i.e. opposite to the earth's own spin around its axis. We also know that both the places London & Chicago are at high latitude in the Northern Hemisphere. The jet aircraft, therefore, was flying at a speed greater than the speed of earth's motion around its axis at such a latitude. These reasons in conjunction produced the most strange phenomenon. The Sun which had gradually set in the west, could be seen rising again from the west, as seen from the aircraft. It rose well above the horizon and it was daylight once again. But soon the aircraft approached the Chicago airport and had to slow down - eventually landing on the Chicago airstrip. This again brought us to the surface and the Sun set in the west, as usual.

Notice how drastically different an experience can be once we leave the Earth's surface.

SEEING THE SUN AND THE STARS IN THE SKY.....TOGETHER!!!

Now come with me still further from Earth. Let me take you to the space well over ten thousand kilometers from our Earth's surface. What does one see? It is our common experience on the Earth that when it is daylight i.e. when the Sun is somewhere in the sky - we cannot see the stars. It is also commonly observed that the sky during the day is coloured blue. But would you believe me, if I tell you that from space - from our imaginary spacecraft high above the Earth, we see the Sun, the stars and planets - all at once against a dark black "sky".

As for the colour of the sky - which changes to dark black in space, we all know from our school days that the white light of the Sun is scattered by particles of matter ever-present in our atmosphere and blue colour being a predominant constituent of the spectral hues gets scattered the most. Hence, the blue sky. Well, in the nothingness of interstellar space, there is no atmosphere and no particle to scatter the Sun's light. So there is a black sky and other stars can be seen along with Sun which still appears as a shining ball of gold in the dark sky.

VISIT ON THE MOON

Let's now land on the Moon itself. How does the Earth appear from the Moon? Well, it would surprise you to know that the Earth, looks just like the Moon does from the Earth the only difference being that it does not move from West to East or vice - versa. It is 'fixed' for all times. This happens because the rotation of the Moon around its own axis is so slow that by the time it completes a rotation around itself, it also completes a revolution around the Earth! As a result of this, it shows only one face to the Earth & the other side is always lost to us. Naturally, from wherever we land on the Moon - assuming we do so on the side which is seen from the Earth, we see the Earth always at the same place in the lunar 'sky'. Conditioned as we are to see the Sun and the Moon go past from the Eastern horizon to Western horizon every day and every night, it would seem rather strange to have the Earth continuously fixed at the same place for ever.

Just as it would be easier to study the Earth from the Moon due to its 'stationary' or 'fixed' place in the sky, so would the absence of atmosphere and the resulting ability to see the stars for as long as one wants, make it easier for astronomers to have their telescopes trained on stellar objects from orbiting space-crafts. One such telescope is the famous Hubble Space Telescope (please see picture on the front cover page) which is orbiting the Earth and continuously keeping an 'eye' on the object chosen by astronomers for study.

THE RISING OF JUPITER

Time has come now to go still further - to the faraway planet Jupiter itself. We know today that Jupiter is the largest planet in our solar system. I

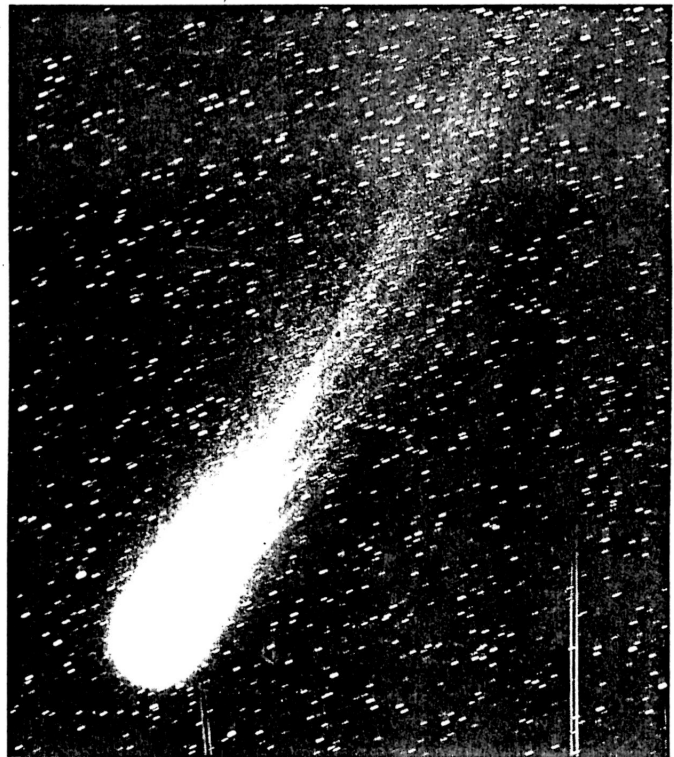
will not go into the technicalities of how many times the size of the Earth it is and so on. Suffice to say that compared to any other planet of our solar system, it is enormous. Jupiter has more than a dozen satellites - or 'moons' if I may so call them. Galileo was the first to observe four of its moons when he trained his telescope on the planet. How would Jupiter appear from its satellite - IO? Since the satellite is also spinning on its axis - it would be obvious that for us, on its surface, there would be a Jupiter - rise on the horizon at some time of its 'day' & 'night' cycle. But because of its enormous size, the Jupiter rise would be a spectacle to behold. It would rise as if a massive hill has suddenly come on the sky line and would soon cover an appreciable part of the 'sky'! Would it not be a spectacular sight for us? With our own Sun and Moon - as small discs - we would be stunned to see something so unusual and strange.

These results of travel to distant planets and their satellites are not imaginary. Given voluminous data on the distances, sizes and other relevant parameters and given computers which can simulate the scenario just described, it is possible to reconstruct fairly accurately what we have just 'seen'.

COSMIC COLLISIONS?

Going farther out we would cross the other planets in our solar system viz. Saturn, Uranus, Neptune, and Pluto. Many school children ask me whether there is a tenth planet in our solar system. They even tell me what it is named in their textbooks! but take it from me, there is no confirmed tenth planet beyond Pluto. It is not very easy to establish existence of such far-off objects because of the enormous distance and limited reach of our telescopic probings. To further compound the difficulty in observing or discovering a planet is the fact of its non-luminescence. That is, it does not shine on its own but reflects light falling on its surface from other stars - in our case, the Sun. Even Pluto - the ninth planet - was discovered in this century and not before!

Further out, but still within solar-system, we observe 'comets'. A heavenly body apparently moving very



Halley's Comet

fast and having a trajectory much more elliptic than the general planetary orbits.

Can a comet ever collide with the Earth? Well, this possibility is not entirely absurd. In fact due to the famed collision of comet 'Shoemaker Levy' with Jupiter, which was an event witnessed a year ago in all its splendour, the danger of one such wayward comet coming and hitting our planet has become more pertinent. Apart from the comets, there are massive chunks of matter moving in a belt between Mars and Jupiter. These chunks of matter called Asteroids are of varying sizes between a few kilometers to ten or even hundred kilometers in diameter. Some of them might be diverted towards our planet! Scientists have been strongly advocating the establishment of a dedicated programme to observe and chart-out trajectories of these asteroids. And with the help of super-computers now-a-days, it is possible to find out the probability of a collision - hundred, two hundred, or five hundred years hence.

What could happen if a big size meteorite or an asteroid were to hit the planet? Energy released on impact could be devastating spelling death and

destruction on an unprecedented scale. Suppose one such big-sized chunk is detected, and its course worked out on the basis of its speed, angle of flight and other data, and it is predicted to hit Town A exactly after a year or so. What are the options available to inhabitants of Town A? Large scale evacuation to safer places? Would that be enough? Well, as per scenario worked out with these assumptions, life on our planet would be endangered all over the Globe and not just at the site of actual impact. This is so because apart from the tremendous energy released due to its impact, the comet's entry into our atmosphere and its passage through it, would consume Oxygen gas on a large scale depleting its concentration drastically besides causing a tremendous rise in temperature. With that it would soon be a question of time for life on the Earth to flicker - out.

So, what can be done to avoid the predicted collision, if per chance we do have a real threat like the one described? Scientists working on this possibility have come up with various suggestions. One of these makes use of a nuclear warhead of sufficient energy and a long range spacecraft to take it towards the approaching object away to a distance which would be beyond the 'risk-limit', so to say. The on-board computer on the spaceship would be programmed to intercept the approaching comet or asteroid and explode the nuclear device very close to the object so as to deflect its course. The object would then miss the Earth. It is no use exploding the bomb at the object itself, for it would break up and its pieces would rain on the Earth, still causing grave damage.

When people ask - what is the point or use of peering at the sky and the stellar objects, when the very purpose of studying astronomy is questioned, I give the above example. The very survival of mankind hinges on its ability to spot a dangerous approaching projectile and to devise ways to deflect it. Some of these astronomical observations give us the information necessary to be prepared for an eventuality of the kind just told. I may mention in passing that about two decades ago, I wrote a Sci-Fi story called 'Dhoomaketu' envisaging exactly this scenario.

BINARY STARS:

Going further out to other 'stars', away from the solar system, its planets, comets and asteroids, we are faced with even more strange and fascinating things. For example, there are possibilities - which for the present do not seem to apply to our Sun, wherein a "Binary" star system is indicated. Here the perceived motion of a pair of stars and mathematical reconstruction of their relative position in space and time suggests that these stars are going around each other. An example where this relative motion is actually observed are the two near-by stars - the Alpha Centauri and the Proxima Centauri. Would it be rather far fetched to imagine the Sun as one of the stars in a similar "Binary - System"? In fact some scientists have speculated that our Sun is one such star and that the other star is quite far away. This other star has been named "Nemesis" - which, as you know, means death and destruction! Catastrophe of an unprecedented magnitude may ensue if two massive heavenly bodies come close to each other. This would happen due to their mutual gravitational and consequent redistribution of matter in the inter - stellar space.

In a close binary system containing one compact star and another big star observable from the Earth, it is commonly seen that due to the said gravitational pull between stars, matter from the larger partner is literally sucked in by the compact partner - resulting in the compact star growing bigger and bigger! It can also happen that a star becomes so big as to be called a Red-Giant, which our Sun will also eventually become. This will happen when during the course of stellar evolution, the Sun consumes all its hydrogen fuel. To keep its energy furnace going the Sun will then start burning helium. This also necessitates a re-adjustment in its size, and a bloated star with a reddish appearance emerges. The Sun will become so big that it will gobble up the inner planets including ours. But don't worry, this will not happen for some six billion years!

The Red Giant as such a star is called, has a very weak gravity on its surface. If per chance another star happens to come near a Red Giant, it would easily pull away a lot of matter from its surface. The

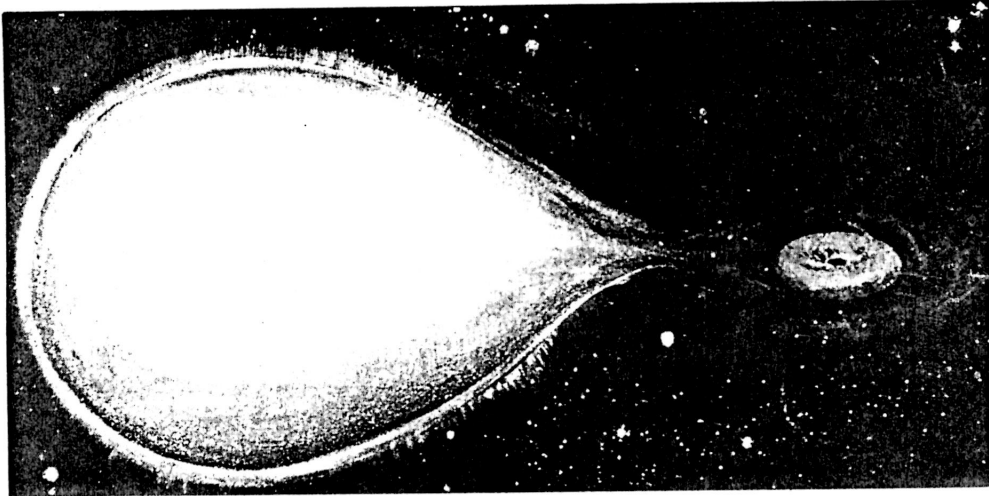
point that I am trying to make, is that a lot of such interactions are actually taking place in the Cosmos.

BLACK HOLES:

The reason why the binary - system, has assumed importance and renewed interest amongst the scientific community is that it helps in the discovery of a black hole. Astronomers look for this strange object in the following way. Suppose it is a member of a binary system, we only "see" its companion when its gravity

happen? Mass of the Earth would remain constant and its volume would decrease. As per Newton's inverse square law, the gravity of Earth would increase by four times, if I go on compressing the Earth to half its present size, further compression would like-wise increase its gravity till theoretically a stage would be reached when its gravity is increased so much that even light cannot escape from its hold. It then becomes a 'Black hole'! The mathematically worked out radius of the Earth at

that stage would measure 7 - 8 mm!



'Black Hole'

acts. We know from the laws of Dynamics that a body in motion would continue to move in a straight line provided it is not influenced by any other force. If star is observed to have a circular trajectory, it would mean that some other force is acting on it. In fact, the curvature of its trajectory would also indicate proximity or otherwise of the other invisible companion. Secondly, astronomers have detected X-rays from the vicinity of the unseen source. How are these X-rays generated? They arise when the compact unseen companion pulls matter from the visible star, and the infalling matter gets heated to high temperatures of millions of degrees.

A black hole, as its name implies is a highly compact object whose strong gravitational pull does not allow even its light to escape. How compact must an object be to reach this status? An idea of the compactness of such masses can be had by mathematically extrapolating the requisite parameters of our own Earth. If I were to gradually compress the Earth so as to increase its density - what would

Of course, it is not possible for the Earth to ever become a Black hole as it simply does not have the required mass and gravitational pull to go on shrinking. But some massive stars are so enormous that they cannot control themselves and literally collapse under their weight and soon become 'Black Holes'.

Professor Subrahmanyam Chandrasekhar, a Nobel Laureate astrophysicist, who passed away recently, had worked extensively on the subject of such compact objects, on the necessary pre-condition for the star to start collapsing under its weight. If the limit in mass is no more than the Sun's mass by a factor of 44%, it will spend the last stages of its life as a white dwarf star. For stars more massive than twice the Sun's mass, the ultimate fate seems to be to become a Black-hole.

In conclusion I would only say that what we know of the Cosmos even today with our latest telescopes, our sophisticated electronic equipments and our computers is a tiny fraction of the knowledge that still remains to be uncovered. Our efforts would have to continue with persistence and dedication to unravel the mysteries of the Cosmos and understand Nature in its unending glory.