

# Cosmic Puzzles and Speculations

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*"Clearly allusions to cosmic phenomena in the ancient Indian literature are in many respects similar to the present speculations about the cosmos. This in itself does not justify the claim that the ancients knew all about modern science. For testing such a claim one needs qualitative details about the cosmos in ancient literature, which are sadly lacking."*

I recall a sunny morning in Delhi. I was sitting across the desk from Dr Karan Singh in his office in the India International Centre.

"So, what is the current puzzle in cosmology?" asked Karan Singhji.

I was at a loss for a definitive answer; for there were (and still are) so many puzzles about the universe. Still I recall mentioning 'dark matter'. Matter, which is believed to exist because of the powerful gravitational attraction it exercises, but which cannot be seen. It cannot be seen no matter what type of telescope one uses, optical, radio, infra-red,

X-rays,... As I came to the end of my brief reply, pat came the comment from across the desk:

“*Asury ā n ā m te lok ā andhen tamas ā vṛta*”

The line means: “Those worlds are without any suns, being surrounded by blinding darkness.”

“Where did you get this quote from?” I asked. Dr Karan Singh replied quoting chapter and verse from the *Isavasyopanishad*. And to substantiate it he wrote it down for me. On going home I looked up the relevant Upanishad, and of course it was there.

I cite this example as an indicative one showing the scholarly character of Dr Karan Singh, combining knowledge about our ancient heritage with interest in modern science. No doubt others who have had the privilege of coming in contact with him, have noted this particular aspect. In this article, dedicated to his *Festschrift*, I try to answer the question he asked me that day, in a more comprehensive way.

I begin by elaborating on the answer I gave Dr Karan Singh that day in his office.

## Dark Matter

Till the early 1970s, most astronomers believed that aspects of the universe they saw through their telescopes contained most of what exists. And these telescopes, as I mentioned above, not only use the light our eyes respond to, but other wavelengths also, longer and shorter than the optical wavelengths. But these beliefs, however, began to receive blows as evidence began to pile up, of matter that cannot be seen, but which is believed to exist, if our understanding of the law of gravitation is correct.

Let us take an illustrative example. Our solar system has nine planets, ranging from Mercury to Pluto. Mercury, the nearest planet to the Sun takes about 88 days to make one round, while the farthest Pluto, takes about 248 years. If you calculate the speed with which these planets orbit the Sun, you will find that Pluto's speed is considerably less than Mercury's. This effect can be explained very well by Newton's law of gravitation. The force of attraction of the Sun on a distant planet being less than on a nearby planet, the former moves more slowly than the latter.

Now we can apply the same rule to clouds of neutral hydrogen gas which are known to circle our Galaxy and other similar spiral galaxies. The farther the cloud from the galaxy, the slower should it orbit round it. That was the expectation of astronomers as they

used radio astronomy to measure the speeds of these clouds. But they were in for a shock. The speeds did not drop down as one looked at farther and farther clouds! And, this feature was not seen just in one galaxy, but seemed to be common for all galaxies. What do these observations mean? Why should the rotation speed stay constant for clouds at three times the distance of the visible periphery of the galaxy?

There were two options before the scientists. The harder option was to conclude that Newton's laws of motion and the inverse square law of gravitation, which had worked so well for astronomy, had at last failed and that some new laws were needed to explain these phenomena. The other, softer option, was to presume that the galaxies extend well beyond their visible boundaries, and so their gravitational effect also goes farther. This second option is generally favoured by astronomers who like to think that the extended region beyond the visible boundary involves masses that are extremely difficult, or impossible to see.

This dark matter is believed to exist on a much larger scale in large clusters of galaxies also. This belief is based on the fact that random motions of galaxies in a cluster are much more energetic than warranted by their mutual gravitational pull. Normally the greater the pull, the greater is the motion generated. Judging by the motions of galaxies observed in clusters, astronomers argue that substantial amount of dark matter must be present in a typical cluster. How much? In some cases the dark matter may be as much as ten times the visible matter.

**And, most importantly, what is it made of ?**

This is being discussed and speculated on. Mundane explanations could be that the dark matter is in the form of planets which are mostly non-luminous, or very faint stars, or objects that do not have sufficient mass to become stars and which therefore remain cold balls of matter. More fancy version could be black holes, made from huge stars that having spent all their energy sources, finally shrink and collapse to become black holes. However, the cosmologists who believe that the universe originated with a big bang cannot accept these alternatives, as they turn out to be inconsistent with the overall cosmological picture. For them the alternative has to be what is called 'nonbaryonic matter'. Baryons are what we are made of, particles like neutrons and protons found in the nuclei of atoms. Planets,

stars, even black holes are made of baryons.

So what is this esoteric form of matter? Those who study the ultimate basic structure of matter believe that such matter may show up in interactions of extremely high energy particles. Unfortunately, these energies are a *thousand billion* times the energies that man-made accelerators could generate in their particles. The only way such particles could therefore have made their way into the universe was in the very early epoch, some billion-billion-billion-billionth part of a second after the big bang! Only at that stage was the universe able to accelerate particles to such energies.

So today astronomers do find such 'sunless regions surrounded by darkness' and would like to know what is their extent and what are they made of.

## Black Holes

I am sure readers would like this tale...of course they must be aware of it!

The Indian scripture *Bhagvatam* has the following story about Brahma, the first of the trinity of Gods, who creates the universe. A king called Kukudmi had a beautiful daughter called Revati, who attracted a large number of suitors. Anxious to make the right choice of son-in-law, Kukudmi decided to consult no less an authority than Brahma. So he went to Brahma's abode along with his daughter. As he was occupied with some important matter of the universe, Brahma sent word to Kukudmi to wait for a moment.

Presently Brahma came out, and having greeted the King asked the reason for his visit. Kukudmi explained his problem and sought advice from the Great One. Brahma laughed and said: 'Let me explain. All those suitors on your list are no more. They are dead and gone. Although you waited for a moment in my abode, during that period, thousands of years have passed on the Earth.' The King was naturally dismayed. However, Brahma offered a solution: 'Never mind. Go back to your kingdom', he said.

'There you will find a suitable boy called Balarama for your daughter.' And Brahma gave Kukudmi details of this suitor-to-be.

This is one of the oldest stories that I know of wherein the concept of time passing at different rates for different people or places plays a key role.

Black holes are objects that have intrigued astronomers over the last four decades. The notion behind them, that of a massive compact object which is able to attract and pull back even light, so that it is never seen, was much older. For astronomers, there are several examples where they witness a huge output of radiation and even particles of matter, coming from a compact region. Paradoxically, they associate such regions with the existence of a black hole.

Typically a black hole is believed to arise when huge masses collapse under their own gravitational pull which always acts inward. Einstein's general relativity theory tells us that once the object has crossed a certain limit of size there is nothing that can stop its contraction. I will return to this aspect again later in this article.

Once an object has shrunk to a stage close to that of a black hole, it acts as an attractor of matter in its neighbourhood. The infalling matter may circle round the black hole and some of it may fall in while some could be ejected with great energy. In this way black holes are considered as 'energy machines' of the cosmos. The techniques of astronomy are becoming increasingly more efficient in identifying such an active region, usually close to the centre of a galaxy and placing observational constraints on speculations about what is going on there.

The episode of Brahma has a strange connection with black holes and the concept of what is known as 'time dilatation' in relativity. Imagine a massive star on which we station an observer *B* who is to communicate with a distant observer *A*, via light signals. The arrangement may be for each observer to send to the other signals at hourly intervals. What happens? *A* discovers that he is receiving *B*'s signals not every hour, but with a slight delay, say after every hour and ten minutes. Likewise, *B* finds that *A*'s signals arrive ahead of the stipulated time.

Why does this happen? Because, the rate at which the passage of time is measured by the respective observers is influenced by the strength of the gravity field in their neighbourhood. The stronger the effect of gravity, the slower is the clock. Near *B* the field is stronger than near *A*, as the latter is far away from the gravitating mass; and so *B*'s clock runs slower compared to *A*'s. General relativity tells us how to estimate the magnitude of this effect

Using relativistic ideas, if we now imagine that the star has shrunk to a smaller size, then the gravity field near *B* will have become even stronger and correspondingly, the time dilatation of *B* relative to *A* longer than before. So at this stage *A* will have to wait even longer, say, for two hours between each of *B*'s signals. And the waiting period will progressively increase as the star further contracts. The black hole stage comes, when *no signal from B will ever reach A*. This happens when the star has shrunk to a size known as its gravitational radius, or its *Schwarzschild radius*. For the Sun this radius is only about 3 km., compared to its actual radius of 700,000 km. This illustrates the extent of compression an object of a few solar masses has to undergo in order to become a black hole.

Now let us identify *B* with Brahma. A few minutes in Brahma's neighbourhood may well have been equivalent to several thousands of mortal-years, if the time dilatation of the above kind were in operation! I am not suggesting this as an explanation; rather I wish to highlight the fact that our ancient literature quite comfortably accommodated ideas that are counter-intuitive, but are nevertheless justifiable by modern science.

## Creation Events

In Chapter 9 of the *Gita*, Lord Krishna says:

*Prakṛtim sāmāyāṣṭabhyā viśṛjāmi punah punah.*

("Laying hold of my nature I create again and again.")

The idea of repeated creation is not therefore uncommon to the Hindu mythology. Unlike the concept of creation as a single event, as found in several different cultures round the Western world, here we have creation taking place again and again.

A significant question to ask today is: Do we see instances of creation of matter in the cosmos today? The evidence for creation of matter comes, I believe, in explosive fashion, such as in quasars, active nuclei of galaxies, gamma ray bursts, etc. These diverse events share one feature generally...namely the outpouring of dynamical energy from a relatively compact region. If these are not instances of creation of new matter in *mini-bangs*, what else could they be?

The standard way of looking at these events is to assume the existence of a black hole and let it play the role of an energy machine as discussed earlier. However, the difficulty with this

explanation is that in a black hole scenario, we should be seeing matter from the surrounding region falling into the centre (where the black hole is presumed to be situated). *There is no evidence of this kind in any of the events observed to date.* It is conjectured that the infalling matter forms a disc which spins around the black hole and any infalling matter first gets into this disc and then falls into the black hole. While there are consistent arguments for such an assumption, there is no direct proof for it.

In recent years Fred Hoyle, Geoffrey Burbidge and I advanced a new theory of cosmology in which the expansion of the universe is driven by the explosive creation events, the *mini-bangs*. Such a universe shows a long term expansion superposed by oscillations (expansions and contractions), but has no beginning or no end. Known as the *quasi-steady state cosmology*, this model has been proposed as an alternative to the commonly accepted big bang model.

Did the universe originate in a single event, the *big bang*, or is it continually driven by mini-bangs? This is an interesting question for philosophers to speculate on. However, ultimately the observations will decide which picture, if any, conforms to reality.

## The Scientific Attitude

Cosmology, the subject dealing with the origin, structure and evolution of the universe is certainly the most basic of all sciences. I have touched upon the present speculations relating to the big bang vs the quasi-steady state cosmology. These are *current* speculations. How do they compare with the past speculations thousands of years ago?

Science is characterized by a questioning attitude. The 'whats', 'hows', and 'whys' are essential for the scientific culture to take root and prosper. Going back to the Vedic times we do find evidence of this questioning attitude. I give an example from the *Nāsadīya – sūkta* :

*Nasadashtno sadasht tadanlm nasldrajo no uyoma paro yat.  
Kimaavarivah kuha kasya sarmannambhah kimasld gahanam  
gabhlram. Na mrtyurasldamrtam na tarhi na ratrya ahna aslt  
praketah. Anldavatam svadhaya tadekam tasmadhanyanna  
parah kim canasa. Tama aslt tamasa gudhamagre praketam  
salilam sarvam a idam. Tucchynabhvapihitam yadaslt  
tapasatanmahina'-jayataikam. Kamastadagre samavartatadhi*

*manaso retah prathamain vadasit. Sato bandhumasati  
niravindan hr̥di pratisya kavayo manṣa. Tīraseno vitato  
rasmiresamadhaḥ svidas̥dupari svidas̥t. Retodha  
asannahimāna asant̥svadha avastat prayatīah parastat. Ko  
addha veda ka iha pravocat kuta ajata kuta iyaṁ visrstih.  
Ar̥vagdeva asya visarjanenatha ko veda yata ababhuva. Iyaṁ  
visrstir yata ababhuva yadi va dadhe yadi va na. Yo  
asyadhyakṣah parame vyomantso anga veda yadi va na veda*  
(Rg—Veda, X, 129).

Loosely translated into English, this reads thus :

‘At that time (when the universe was not born) there was no *sat* (being) nor was there *asat* (non-being). At that time there was no space nor was there the sky beyond it. Who (then) covered what, where and for whose welfare? Was the dense fathomless water there? Then there was no death nor was there the immortal to be distinguished from it. There were no means available to distinguish between night and day. (Whatever existed) was unique and alone surviving on its own. There was nothing else or beyond. There was darkness and living forms covered by it and free of any distinction. The Brahma was covered by Maya and appeared later (in a different form) because of penance. The seed from its mind was *kama* (desire), the inspiration for creation; The wise have thought over it and decided that this was the (first) contact between *asat* and *sat*. ‘This thread was spread between them below as well as above. (From these) some gave seeds that grew. Their power remained here and influence spread there. How did the spread of *sat* come about? Who can tell this in detail? Who knows definitely? Even gods came after the spread (of *sat*). So who can know where the creation came from? This spread (of *sat*), where it came from, whether created or not may or may not be known to him who presides over the great heavens ( who can tell?).’

We also find evidence of this attitude in *Upanishads* and some of the *Puranas*. Unfortunately this attitude seems to have fizzled out, perhaps largely through the tradition of orally transmitting knowledge from one generation to another, with no critical discussion between the teacher and the pupil. Even in the *Bhagavad-Gita*, we find Arjuna asking critical questions in the early stages:

Jy ā yas̥ cet karmaynaste mat ā buddhirjan ā rdana;  
Tat kim karmani ghore m ā m niyojayasi kesava.

Vy ā misreneva v ā kyena buddhim mohayasva me;  
'Tadekam vada niscitya yena sreya hamapnuyam. (III. 1, 2)  
(If you hold, 'O' Janardana, that knowledge is superior to action,  
why, then, 'O' Kesava, do you engage me in this terrible action?  
With these apparently contradictory words you seem to confuse  
my understanding. Therefore tell me definitely that one thing  
by which I shall reach the highest goal.)

But later this critical attitude does not remain, although Lord Krishna Himself at the end does not insist that Arjuna follow his dictates : he says, *Yatheccchasi tatha kuru* (Do as you please).

Our ancient tradition of accepting guru's sayings uncritically perhaps has not encouraged the scientific discipline. This may very well have been the reason why very few of our ancient manuscripts contain descriptions that would conform to the scientific discipline. I give an example.

As the late M.N. Saha pointed out, almost all the Hindu calendars are based on Vedic traditions, enunciated for example in the *Vedanga Jyotisa*. Various time scales are found in the *Puranas*, of which the time scale giving the day of Brahma as 4.32 billion years is intriguing. This duration is derived as made of 1,000 cycles of the four *yugas*, each cycle taking 12,000 divine years, with one divine year equal to 360 human years. The final answer of 4.32 billion years is amazingly close to the present geologically estimated age of the Earth, 4.6 billion years. Is this a coincidence? Or did the ancients know about dating the Earth and other astronomical objects whose ages are presently estimated in the 10-20 billion years range?

Unfortunately a scientific account is lacking and one must only conjecture. In this context an astronomical interpretation is given by S.R.N. Murthy in an article recently reproduced. Murthy points out that the above time scale and others, shorter and longer, were obtained in the *Suryasiddhanta* (one of the five *siddhantas* by Varahamihira) from the then available information on the rate of precession of the equinoxes. If so, the time scale of 4.32 billion years is related to celestial mechanics and not to the nuclear age determinations of the Earth and the Stars.

Clearly allusions to cosmic phenomena in the ancient Indian literature are in many respects similar to the present speculations about the cosmos. This in itself does not justify the claim that the ancients knew all about modern science. For testing such a claim

one needs quantitative details about the cosmos in ancient literature, which are sadly lacking. What we have, however, gives us glimpses into the profundity of ancient thinking, Like Dr Karan Singh, I too like to speculate on how far the ancient thinking on the cosmos went. I wish him a long, happy and intellectually satisfying life ahead, and many fruitful speculations about the cosmos!

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