Cosmological Constant

Flying Carpets Still to Take Off

By J V NARLIKAR

RECENTLY much publicity has been given to the 'discovery' that there is 'anti-gravity' in the universe. In 1917, two years after he proposed his remarkable general theory of relativity, Albert Einstein sought to apply it to the universe as a whole. That is, he wanted to construct a mathematical model that described the boundless distribution of stars and nebulae. As per the then prevalent belief, he assumed that this distribution is static.

To his disappointment, Einstein found that be could not find such a model. Did it indicate the inadequacy of his theory or was the prevalent belief wrong? Einstein assumed the former to be true and set about 'correcting' his 1915 equations. He found that he still had the freedom of adding an extra term to them, a term which corresponded to an extra force in nature. Acting between any pair of masses, this force increased in proportion to the distance between between them. The force could be either attractive or repulsive. But to get a static model of the universe, this force had to be repulsive. For, that way it balanced the gravitational force of attraction between the same two masses. The so-called cosmological constant that determined the strength of this force of repulsion is so tiny that the anti-gravity would not be felt at the terrestrial level or even on the scale of the solar system.

Big Blunder

The static model came to be known as the 'Einstein Universe' and for a short while it became the simplest model of the universe that everybody liked to adopt. A short while, because by 1929 enough evidence had accumulated to show that the universe is not static. Rather, it is expanding. The discovery pioneered by Edwin Hubble tells us that the vast framework of galaxies of which our Milky Way is one, is growing in size, so that seen from any one galaxy, the rest appear to recede. Hubble found a simple relation, now known as Hubble's law, viz., the speed of recession of any galaxy from ours is in proportion to its distance from us. The farther the galaxy, the faster does it recede.

By this time, thanks to the work of Alexander Friedmann and Abbe Lemaitre, it had also become clear that models of the expanding universe could be obtained from Einstein's original 1915 equations. In other words, the modification introduced by him in 1917 had been unnecessary.

Reflecting on this episode later, Einstein had called his introduction of the cosmological constant, the greatest blunder in his life. Little did he realise then that what he had discarded so summarily would prove the life-line for many cosmologists in the years to come.

The big bang model assumes that the universe came into existence with an enormous explosion which set it off on the road to expansion. The initial fury of the primeval event, of course, gave way to slower and slower expansion. It is the force of gravitation that applies brakes to the particles of matter and radiation flying away as the post-explosion debris. Their mutual attraction tends to pull in the particles and slow down their motion away from one another.

Age of Universe

The simplest models of Friedmann tell us, therefore, how long ago did the big bang occur. To express the answer in years, we need to know the rate at which the universe is expanding today and also the rate at which the expansion is slowing down today. The Hubble Space telescope and some of the leading ground-based telescopes are currently busy finding this information.

This answer, which we may call 'the age of the universe,' turns out to be broadly in the range of eight to 12 billion years. To us mortals this may seem a large number (a billion equals a hundred crore). For astronomical systems, it is not. For example, there are stars which are claimed to have ages in the range 12-18 billion years. How can the universe be younger than its minor constituents?

This age problem, as it is called, is resolved by reintroducing the cosmological constant. For, the force of repulsion accelerates the expansion rather than slow it down. So the theoretically calculated age of the universe increases. And by suitably choosing the value of this constant, the cosmologist can make the universe older than any star the astronomer cares to find.

In the eight decades that followed Einstein's 1917 paper, the big bang cosmologist's attitude towards this constant has been ambivalent. On the one hand, the theorist does not like the patchwork on the original Einstein equations and given the choice, would consign the constant to the dustbin, just as Einstein did. On the other hand, confronted with the observations and with the very survival of the theory at stake, the cosmologist is forced to resurrect it.

Marginal Effect

In the seventies, the community went through this latter phase when the age problem became severe. For a while, the cosmological constant was popular. Then the Hubble constant which measures the expansion rate of the universe, went down in measurement, thereby raising the age of the universe, while the stellar astronomers played down the long stellar ages. So the age problem disappeared and back went the cosmological constant into cold storage.

Recently the HST measurements raised the value of Hubble's constant and thereby lowered the age of the universe while stellar ages went up. So the age problem was back again and with it the cosmological constant! Rather than leave it to the whim of theoreticians, can we not measure this constant once for all?

It was against this background that the recent measurements assume significance. They do measure this constant directly, but try to estimate its effect on the rate of expansion of the universe. If we look far enough away we see the universe as it was in the past: because light from faraway galaxies takes that much time to travel to us. So if we are able to measure the rate of expansion of the universe in those past epochs, we can compare it with the present value and decide whether the expansion is accelerating or decelerating. The claims are that the measurements now require the existence of a cosmological constant.

Such measurements of the deceleration (or acceleration) of the universe have a long history dating back to the early 1960s. Observers have made claims this way or that way, always with a great deal of surety. Only to realise the significance of observational errors and uncertainties later, which negated the results. So one needs to be cautious towards the present claim especially since each new generation of observers thinks that their results are correct whereas their predecessors had got it wrong.

Even if the claim proved to be correct, the effect is extremely small. Far too small to make flying carpets a reality.

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