Secrets Of The Universe

Was There A Big Bang?

By JAYANT V. NARLIKAR

TWO years ago — on April 23, 1992 — the astronomical community and, indeed, the public at large were stirred out of the humdrum of daily existence by the startling announcement that at last the proof of "Creation" was at hand. Even practising scientists rushed to the media to share their excitement that the "face of God" had been spotted, that we are now witnessing the ripples of the primordial creation, that the ultimate question about the origin of the universe was finally answered.

Polemics and hyperboles apart, what was the excitement all about? How much wiser are we today two years since the revelation? Have the scientists really solved the "ultimate question"? To answer these queries let us first examine the announcement of two years ago in its proper historical perspective.

Sixty-five years ago, Edwin Hubble, an astronomer at the Mount Wilson Observatory on the outskirts of the city of Los Angeles, made a major discovery. In the 1920s it was becoming increasingly apparent that our universe stretches far beyond the Milky Way, the galaxy of stars to which our sun also belongs. What the astronomers earlier mistook for faint clouds of gas in our galaxy turned out to be large and distant galaxies in their own right. By examining their light spectra Hubble concluded that almost all of them are rushing away from our Milky Way and that too in a very systematic manner: the farther the galaxy, the faster it seems to be receding from us.

Blowing Up

Hubble's observations were soon explained by the hypothesis of the "expanding universe". Imagine that the galaxies are all embedded in space which itself is blowing up so that all the individual galaxies move away from one another. As the Russian physicist, Alexander Friedmann, had shown a few years earlier, this picture fitted very well into Einstein's theory of relativity. Indeed, cosmology, the subject devoted to the study of the structure of the universe, truly came into its own only after Hubble's discovery.

The Friedmann models imply that the expansion of the universe began in a singular event when the universe suddenly appeared out of an explosion. The astronomer Fred Hoyle gave the name "big bang" to this phenomenon, more as a joke but it has got stuck! In a recent survey conducted by a popular astronomy magazine people were asked to suggest new names but none matched the pithiness of "big bang". Theory suggests that the universe close to the epoch of big bang was extremely hot and turbulent but has now calmed and cooled down as a result of continuous expansion over some ten billion years.

A measure of this activity is of course the temperature of the universe which is supposed to have been dropping steadily. Back in the 1940s George Gamow calculated that the temperature was as high as ten billion degrees at an epoch when the universe was barely a second old. He suggested that during the moments that followed sub-atomic particles like neutrons and protons fused together to form the nuclei of the various chemical elements that we see around us today.

As a theory, Gamow's idea turned out to be right but only partially. The current wisdom is that most elements are manufactured by nuclear fusion deep inside stars; but in making light nuclei like deuterium (heavy hydrogen) and helium the stars prove to be inadequate. This is where Gamow's early hot universe fulfils the desired role. Moreover, Gamow and his colleagues, Ralph Alpher and Robert Hermann, made the important prediction that today we should be seeing the relic of those hot moments in the form of a very cool radiation background. Here again the expansion of the universe is responsible for cooling the radiation.

Almost Forgotten

However, these ideas were almost forgotten till 1965 when two scientists, Arno Penzias and Robert Wilson, from the Bell telephone laboratories accidentally discovered a smooth diffuse background of radiation in the microwaves. Coming from no specific source in the cosmos this radiation was the ideal candidate for the relic of big bang. Efforts were on therefore to measure this background at many different wavelengths and also to see how smooth it really is. This discovery in any case reinforced belief in the overall big bang scenario.

Simultaneously with the observational efforts, work also began in a big way to piece together the past history of the universe from moments as close to the big bang as theory would permit. Theoreticians addressed themselves to questions like these: What was the sequence of events that led to the formation of galaxies like the Milky Way? How did they come to be grouped in clusters and clusters of clusters (called superclusters)? How did these groups acquire fairly large speeds that have been observed relative to the expanding frame of the universe? What is the nature of vast quantities of dark matter that is believed to exist well beyond the observed limits of a typical galaxy and even in clusters of such galaxies?

The plethora of questions and conundrums is a tribute to the remarkable growth that observational astronomy has achieved over the last three decades. Thanks to the technologies of fibre optics, thin telescope mirrors, active and adaptive optics, charged coupled devices, satellite-based telescopes, automatic plate-measuring machines, computers and image processing, the cosmologist of today has his plate overflowing with data that he must make sense of.

The Cosmic Background Explorer satellite (COBE) was an important development in this hi-tech cosmology. This satellite was launched by NASA in 1989 for the specific purpose of studying the microwave radiation background. Late in the same year COBE came up with the spectrum of the background which fitted very well into what was expected from its relic interpretation. While this caused considerable jubilation in the big bang camp, there were further tests to come. Theoreticians were predicting that the process of galaxy formation should leave its identifiable imprint on the background. Previous experiments had failed to find any and even COBE initially gave negative results. The radiation background was embarrassingly smooth. To argue for a primordial process of galaxy formation that left no effect whatsoever was like arguing for a supercriminal who left no clues behind at the scene of crime.

While things were getting desperate, relief came when in 1992 COBE began to detect some patchiness in the background. This was the main cause for the euphoria two years ago. COBE was able to spot very minute fluctuations in the temperature of the radiation background, as tiny as few parts in a million. All previous efforts having failed to detect anything, one may perhaps understand why George Smoot, the leader of the COBE team, felt the urge to invoke God.

But since then, analysis and reanalysis of the COBE data, its relationship to other data on galaxies and the observations by other experimental groups have made the picture more confusing, to say the least. So far none of the popular scenarios for structure formation fit into this picture. The universe, in short, is unwilling to release its secret so easily and so soon.

Several Problems

There are several other problems with the standard hot big bang picture. For example, the theory does not explain why the temperature of the radiation background is what is observed, that is, about 270 degrees below zero (on Celsius scale). Theorists assume the dark matter in galaxies to be in various estoeric forms that have never been observed on the earth. Moreover, there are indications that the entire past timespan of the most popular version of the big bang model will be insufficient to explain how even older star systems seem to exist in the universe. Whenever these and other outstanding problems are mentioned in any discussion, the response of the typical big bang cosmologist is to ignore them in the fond hope that they will eventually go away.

Meanwhile, some doubting Thomases have emerged asking whether the entire big bang picture is right at all. Fred Hoyle, from the U.K., Geoffrey Burbidge, from the USA, Chip Arp, from Germany, and this author have begun a reappraisal of the cosmological evidence to see whether viable alternatives to the big bang cosmology exist that better explain the astronomical observations, including the COBE results.

The job of producing a theory that is better than the established one has never been easy, but that of overcoming the prejudice of the scientists against new ideas is much more difficult as we are discovering from our experience. However, unless a free discussion between alternative ideas is encouraged, cosmology as practised today is in danger of becoming indistinguishable from theology.