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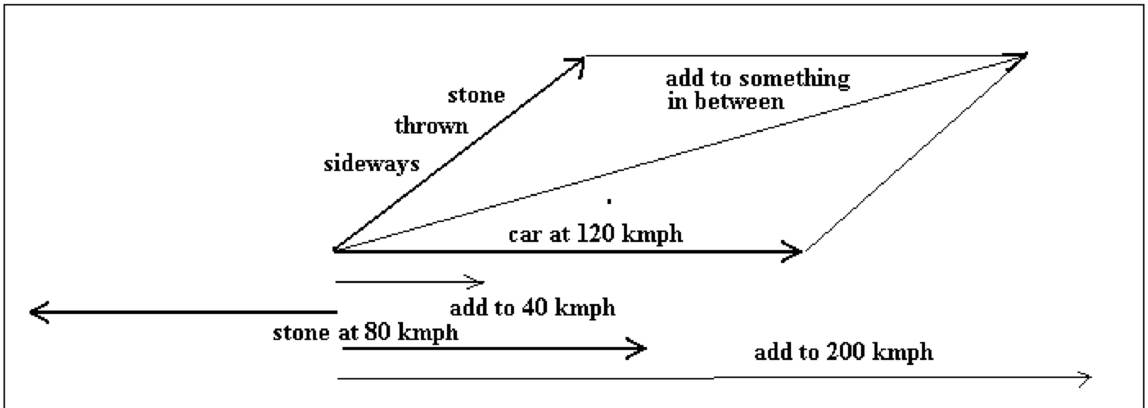
What came before the 'Big Bang'?

This is a question that examines what we understand by 'before', says S.Ananthanarayanan.

The 'big bang' theory of the origin of the universe grows straight out of Einstein's General Theory of Relativity and in fact has a meaning quite different from the popular picture of an explosion, which is of a bomb going off. The 'explosion' is in the '4 dimensional space-time continuum' and it does not make sense to represent it by things that we have seen in our 3-dimensional world.

Origin of the theory

The simple science of the 19th century stood firm on the Galilean transform, which said that one could add or subtract the speed of things in relative motion - if one threw a stone at a speed of 80 kmph from a car moving at 120 kmph, the stone would move at 200 kmph or at 40 kmph, depending on whether it was thrown forwards or backwards. And if it were thrown sideways, we could still find out the speed, somewhere in between.



The Galilean transform

This easy thinking was disturbed by the Michelson-Morley experiment of 1887, which was an arrangement that attempted to add the speed of the earth in orbit (some 30 km per second) to the speed of light. The result was that for light waves (or radio waves or X Rays, electromagnetic waves, in general) you could not add velocities like this - light moved at the same speed, regardless of the motion of the source, or the receiver!

Einstein resolved the contradiction by questioning the bases of thinking that time and space were invariant when measured from points that were in relative motion. His celebrated Theory of Relativity goes on to show that lengths and time intervals are measured *shorter* when measured from a moving position. Speeds then do not add up quite to the sum of the two speeds, but always to a little less, in such a way that when adding very large velocities, the total could never add up to the speed of light! (The results get significant only for speeds comparable to that of light, and in ordinary activities, like throwing stones from cars, the Galilean transform is not far wrong). And time intervals also appear to be longer when the observer is moving – a result that has been verified with radioactive particles that take longer to decay when they are moving, at high speed, than when they are at rest.

A new vocabulary

The interdependence of time and space leads to new, 4-dimensional ‘space’, measured not by length, breadth and depth alone but also by time and the involvement of the imaginary square root of -1 in the mathematics! When the laws of motion and gravity are worked out in this interrelated ‘space-time’, mass and energy get connected by the famous $\mathbf{E=mc^2}$ relation and gravity, which is an effect created by mass, gets explained as being a ‘curvature in space-time’. The new world is quite counter-intuitive and even our ideas of ‘now’, ‘before’ or ‘after’ do not remain valid any more!

It is in this basically ‘non-intuitive’ view of things that ‘space-time’ is seen to start from a ‘point’ and then ‘expand’ in its 4 dimensions, as the ‘big bang’.

An analogy that is used to explain how the additional dimension changes the meaning of ‘expand’ is that of an ant that lives on the surface of a large, very large balloon. Let us take it that the ant knows nothing of the ‘depth’ dimension and imagines the world to be just the ‘2-dimensional’ surface on which it lives. When the balloon is blown up some more, this ant would only see that any two points on the balloon are moving apart. It is partly in this sense that astronomers have discovered that faraway galaxies are receding and also that the furthest objects are receding the fastest!

This observed fact of the distant universe moving away, is the view of the ‘expanding universe’. And, if the expansion is worked backwards, there is a smaller universe in times past and conceivably a starting point, which is literally a ‘point’. This point, from which everything spewed forth, is the foundation stone of the ‘big bang’ theory itself!

But the simple picture gets complicated if we consider the relativity of space and time. As we go back in time towards this primeval origin, there would be speeds and energies, and over the very large time that it would take, the pace of passage of time itself would be appreciably affected – it may be like approaching a black hole, where speeds grow very high and time slows, so that the journey may take so long as never to get done.

The theory of relativity affects concepts of simultaneity and could place the time of a past event, for an observer in the present, at a point which is infinitely far away. The question of ‘before’ that event may not be meaningful, as the event itself is out of reach.

Questions like, “so what came before the big bang”, which depend on our usual understanding of ‘now’ and ‘before’, hence do not make sense in the relativistic syntax from which it was a departure when the catchphrase, ‘big bang’ was coined.