The Beginning of Theoretical Cosmology

Cosmology deals with the large scale structure and evolution of the universe. Over several centuries, philosophers and religious thinkers had spent considerable intellectual efforts on this topic. But these were largely speculative exercises. Modern science got into the act in the early part of this century. If the discovery by Hubble (Parsecstone 14) may be called the beginning of *observational* cosmology, the papers by Albert Einstein and W. de Sitter, twelve years earlier, marked the beginning of *theoretical* cosmology.

In his times, Isaac Newton had also grappled with the problem of modelling the universe with his law of gravitation. In Newton's model, the universe was an infinite homogeneous and isotropic distribution of matter which remained in static equilibrium because each particle of matter was equally attracted to the rest in all directions and so stayed put in its place. Newton discoverd, however, that this equilibrium was highly unstable and the universe would undergo gravitational collapse towards any local excess of matter density.

In 1917, Einstein tried a similar model (static, homogeneous and isotropic) within the framework of his newly proposed general theory of relativity. He discovered that to ensure a static model he had to postulate an additional "cosmological" term in his equations. This term represented a cosmic force of repulsion between any two particles that varied in direct proportion to the distance between them. By countering gravity it made the universe static but also required that it has a positive curvature. That is, the space of the Einstein universe is the three dimensional boundary of a four dimensional hypersphere.

The Einstein universe thus had a finite volume with no boundary: imagine it as the two dimensional analogue of the surface of an ordinary sphere. Einstein thought that this model was a unique cosmological solution of his equations. He also hoped that this model would underscore the basic philosophy of general relativity that the spacetime geometry and matter distribution are uniquely related in this way. This expectation was, however, vitiated by the work of de Sitter that followed shortly after in which, he proposed a model universe which was empty and expanding! That such solutions were also possible from his theory came as something of a shock to Einstein.

As at that time the expansion of the universe was not known, the general expectation was that the actual model would indeed conform to the Einstein version. During 1922-24 Alexander Friedmann from Russia worked out a whole range of expanding models in which the universe was non-empty. Again physicists and astronomers, Einstein included, ignored these models and later similar work by Abbe'Lemaitre and H.P. Robertson during 1927-28.

But after the discovery of Hubble's law, the situation changed and the Friedmann models became the pillars on which the cosmological theory came to rest. Einstein himself recognized this fact and saw that since the simplest Friedmann models did not require the cosmological term, it was unnecessary. He went a step further and denounced the term as the "greatest blunder" in his life. Other cosmologists, however, have not thought so as will be clear in the future parsecstones of this series.