Has Cosmology Advanced in Recent Years?

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Introduction

Cosmologists are astronomers who study the universe as a whole. The idea of *the universe as a whole* presents some difficulty both to science and philosophy. In science, because we can only study parts of a system unknown in its totality. Moreover there are features of scientific cosmology which set it apart from other sciences: we cannot in cosmology speak of experiments or verifiable predictions (Cosmologists are prophets of the past!). We can only check astronomical observations with theories and models. Philosophically, the connection between models of the universe and reality, the intelligibility of an universe as an independently existing entity and the perennial questions about the origin of the universe remain unsolved. (Munitz 1986)

We will in this essay consider the features of the universe as provided by modern astronomy and theoretical cosmology and see how far our understanding of the general scheme of things have advanced over the years. We will conclude that though advances in astronomy and cosmological model building have advanced remarkably, progress in our understanding of eternal philosophical questions have been minimal. (leaving aside religious and teleological answers completely). Did the world have a beginning in time? Is the universe finite or infinite in extension? Are some of the cosmological theories closer to the truth than others? What are meaningful (philosophically) questions and what are not? What about limitations of our capacity to understand?

The Story So Far

Man's view of the universe has changed steadily with time. As the scientific approach to heavenly objects progressed, the mystical element began to give way. Nicolaus Copernicus (1473-1543) started a revolution (the earth moves round the sun) which continued to the days of Isaac Newton (1643- 1727) and beyond speeding up the growth of observational astronomy. Today astronomers estimate the universe to contain over 100 billion galaxies each with many billions of stars. Our sun belongs to a galaxy, the Milky Way, a huge disc of a diameter of 100,000 light years containing 100,000 million stars. The most remote galaxies observed so far lie about 12 billion light years away. (Natl.Geog. Mag. 2003).

At this moment there are in sight no viable alternatives to the General Theory of Relativity as the basic conceptual framework for the modelling of the universe as a whole, and there are no working alternatives to the standard Big Bang cosmological model (Mosterin 2000) According to the Big Bang Theory, the universe originated in a big explosion some 15 billion years ago. According to cosmologists shortly after the big bang the Universe went through a brief period of extremely rapid expansion called inflation followed by steady expansion which is still going on. What happened before the Big Bang is not discussed in scientific cosmology. But Stephen Hawking, a pioneer cosmolgist, advanced what he called the *no-boundary proposal* according to which the entire history of the universe , all of space and all of time, forms a kind of four-dimensional sphere: space-time. Talking about the beginning or end of the universe is thus as meaningless as talking about the beginning or end of a sphere. (Horgan 1996)

Around 1930 it was noticed that the glow of galaxies was invariably shifted toward the red end of the visible spectrum. (Doppler Shift) Apparently the galaxies were hurtling away from the earth and from each other. The universe was expanding. (Expanding into what?). Recent work by astronomers have indicated that the visible part of the universe contains only a fraction of total mass of matter in the universe; there must exist some invisible, dark matter to bind the galaxies together. Various alternative solutions to the baffling question about what the dark matter might be, are under discussion. (Rees 1997) The mass of the dark matter has been estimated to be about nine times the mass of all visible matter. (Natl.Geog. Mag. 2003)

There are many strange facts reported by astronomers: black holes, neutron stars, quasars, supernova explosions, gamma ray bursts etc. Suffice it to say that the picture of the universe presented today is simply mind boggling, completely incompatible with our daily experience.(Sci. Am. 2002)

Added to the sheer vastness of numbers, we are in modern cosmology presented with new concepts of space, time and gravitation which are at variance with our accustomed ways of thinking in terms Euclidean geometry and Newtonian physics. Einstein's General Theory of Relativity GRT (1915), his Field Equations and their solutions have ushered in a completely new way of thinking (philosophically) about space and time. Even the language used in GRT about space and time sounds strange: *The spce-time is a 4 dimensional differentiable manifold described by a semi-Riemannian metric which satisfies Einstein's Field Equations . The phenomenon of gravitation is to be understood as intrinsic curvature of the space-time. Gravitation is a matter of geometry and nothing else.*(Callender and Hoefer 2002) A theory of the the universe would thus appear to represent a language game with its own grammar. (Munitz 1986 p.83)

Nature of Cosmology

Because of its pecularity, cosmology can be likened to a historical science though reconstruction of the initial state has proved to be difficult. Today cosmology as a science has become a science of mathematical theories for the construction of cosmological models. As such it can be defined as the study of the global properties of cosmological solutions of certain field equations, notably Einstein's.

The big bang theory, mentioned earlier, has prevailed largely because of the prediction, observation and interpretation of a phenomenon known as the Cosmic Background Radiation discovered in 1964. The rival Steady State Model of the Universe predicted no such radiation. According to the Steady State model matter is created continuously at a rate just sufficient to compensate for the matterthat is disappearing from the visible universe. The Steady State theory says that the universe always looks the same. This has been contradicted by observation of very remote stars (Sci. Am. 2002).

Despite its successes the standard big bang theory cannot answer several profound questions, e.g. why is the universe so uniform? Somehow the uniformity of the universe must have predated the expansion but the theory does not explain how. To meet this and other difficulties in early1980s the theory of inflation waw introduced: the baby universe went through a period of very rapid expansion. After the inflation, lasting perhaps only 10^{-35} second, the slower bg bang expansion started.

By quantum cosmology one means the application of quantum mechanics to the universe at large. It deals with what happened before the big bang or how to account for the creation of the universe out of nothing. To answer how everything began, quantum cosmologists refer to the concept of small fluctuations in the vacuum. (According to quantum mechanics empty space is not entirely empty). The no boundary proposal of Hartle and Hawking, mentioned earlier, also addresses this question. Whether such answers will satisfy a philosopher or a critical layman is a moot question.

In studying cosmology one should take particular care to distinguish between what is well established and what isn't. Speculations about whether there are other universes governed by different laws, whether the physical laws were different in the very early universe , whether there was really an exponential inflation in the beginning, whether the string theory is acceptable, these questions are still being debated. For a sceptic, the cosmological models need not have any relation to the external world. All one could say is that the current theories of cosmology are tentative and just applied mathematics or mathematical physics, scenarios, unable to explain anything of the external world or part of it. (Goenner 1994 p.163) According to Goenner, scientists doing pioneering work in the field of cosmology should be aware of the "fictitiousness" of the reality they are producing. Reading through some of the popular books on cosmology, he says, one gets the impression that the authors are often carried away by their speculations. Goenner(1994) concludes by saying: *the science of cosmology especially in dealing with the early and earlist epochs of the universe, is producing cosmological myths adequate for our time.*

So Where Do We Stand?

Fired by indomitable curiosity man has tried to seek knowledge about the structure, origin and evolution of the universe he inhabits. Man has used ever powerful telescopes and other instruments to map the sky. Working hand in hand with astronomers, mathematical physicists have produced cosmolgical theories covering different phases of cosmic evolution. The picture of the universe presented, though not free from difficulties or controversies, can be followed even by the layman thanks to the many popular books and articles by competent scientists. To appreciate the overall significance of cosmology, however, we may need a modicum of philosophical doubt.

Nature of Philosophy

Answers to the outstanding philosophical questions of how the world began, whether it has an end, can the human brain at all grasp everything etc. still remain speculations which no scientist will deny. Cosmologists like all other scientists should exercise special care not to give the impression that they have found an answer to perennial questions.We can live happily with this state of incomplete knowledge with a philosophical attitude close to Wittgenstein's. His views on the nature of philosophy can be summarised with the following quotations (Sanatani 2001):

Philosophy is wholly distinct from science, and its methods and products are not those of the sciences. (NL)

The object of philosophy is the logical clarification of thought.

Philosophy is not a theory but an activity.

A philosophical work consists essentially of elucidations. (T 4.112)

Philosophy is not a cognitive pursuit; there are no new facts to be discovered by philosophy; only new insights. ((PR; PG 256)

Philosophy seeks to establish an order in our knowledge of the use of language (PI § 132)

The philosopher's treatment of a question is like the treatment of an illness. (PI 255)

Conclusion

Modern cosmology is characterized by two features:

i) Unlike physics it cannot make verifiable prdedictions but can only interpret current observations with the help of theories and models. The theories must, of course, tally with the observations.

ii) The large scales of space, time and mass (energy) discussed in astronomy and cosmology are way beyond our day-to-day experience or even beyond human capacity of visualisation.

This makes it very difficult to apply familiar concepts to questions of cosmology.

At this moment there are in sight no viable alternatives to the General Theory of Relativity as the basic conceptual framework for the modelling of the universe as a whole, and there are no working alternatives to the standard Big Bang cosmological model. According to this model the universe originated in a big explosion some 15 billion years ago. What happened before the Big Bang is outside the scope of scientific cosmology. This discipline comprising both theory and observation of the sky, has advanced remarkably in recent years. Yet it cannot finally answer our deepest questions about the origin, structure, purpose and future of cosmos. The fundamental philosophical questions remain unanswered. Are space and time finite or infinite? Has the universe a beginning and an end? Is there a purpose, design or meaning in the scheme of things (teleology)?

Though unable to give definitive answers philosophy has an important role to play. Philosophy does not progress in the sense that science does but it clarifies the questions in our mind and cures our intellectual unrest as pointed out by Wittgenstein. Cosmologists, like all other scientists, should exercise special care not to give the impression that they have found an answer to perennial questions.

References

Callender, C. and Hoefer, C. 2002 *Philosophy of Space-Time Physics* (in the Blackwell Guide.to the Philosophy of Science)

Cowe, R. 2003 *Galaxy Hunters*, National Geographic Magazine, February 2003.

Goenner H.F.M. 1994 *What Kind of Science is Cosmology?* (in E. Rudolph and I. Stamatescu (eds) Philosophy, Mathematics and Modern Physics, Springer Verlag).

Horgan, J. 1997 *The End of Science*, New York: Broadway Books.

Mosterin, J. 2000 *Observation, Construction and Speculation in Cosmology* (in E.Agazzi and M.Pauri (eds): The Reality of the Unobservable. Dordrecht: Kluwer, 219-229.

Munitz, M.K. 1986 *Cosmic Understanding*, Princeton: Princeton University Press.

Rees, Martin 1997 *Before the Beginning*, London: Simon & Schuster.

Sanatani, S. 2001 *Philosophy as a Guide to Life*, Contributions 24th International Wittgenstein Symposium, Kirchberg, Vol. 2, 264.

Scientific American 2002 *Understanding Cosmology*, New York: Warner Books.