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Material content of the Universe: chairman's introduction

By J. D. Barrow

The question before us at this Discussion Meeting differs from many of the fundamental problems of contemporary science in that it can be stated concisely without the introduction of technicalities: how much material is there in the Universe and in what forms does it reside?

This simple question appears to possess a very convoluted and, as yet, incomplete answer. It has become clear that a satisfactory answer to it must go hand-in-hand with the development of a mature theory of how galaxies form and cluster, together with an understanding of the complete catalogue of elementary particle types that exist in Nature. The reason for this last stipulation has only been adequately recognized during the last six years, throughout which astronomers have witnessed burgeoning interest in the possibility that the Universe may consist primarily of weakly interacting elementary particles of a sort as yet undetected in terrestrial laboratories. This interest has been motivated by the success of the high-energy physics theories that predict the existence of such particles and by the accumulation of observational evidence for the existence of large quantities of non-luminous matter in the Universe.

The idea that there might be more to the content of the Universe than meets the eye is not a recent one. As early as 1783 John Mitchell, F.R.S., suggested that invisible bodies from which light could not escape might populate space undetected unless they partner visible stars in binary pairs. During the 1930s, Jan Oort and Fritz Zwicky claimed that studies of the motions of stars and galaxies pointed to the existence of large quantities of unseen gravitating material within our own Galaxy and in distant clusters of galaxies. Throughout the 1950s, Einstein dwelt on these dilemmas in the many editions of his book *The meaning of relativity* and suggested that non-radiating objects might resolve the astronomers' missing mass problem.

In the papers that follow, four things should become evident with regard to our study of the Universe's material content. First, the ubiquity of the problem of non-luminous matter; there is evidence that it exists within our own Galaxy, around external galaxies, within clusters of galaxies and beyond. Secondly, the growing suspicion that new types of weakly interacting elementary particle might dominate the material content of the Universe and the challenging practical problems their detection presents to experimentalists. Thirdly, the way in which astronomical observations are now able to place important constraints upon the existence and properties of hypothetical elementary particles and the theories that govern them. Finally, the manner in which the advent of ready access to fast computers has revolutionized the study of many key cosmological problems by allowing portions of the evolution of the Universe to be simulated. This practice of experimental mathematics allows us to make predictions about the pattern of galaxy clustering that should be observed as a result of assuming different conditions to exist in the earliest moments of the Big Bang.

It is this find balance between theory, observation and numerical experiment that will form the substance of this Discussion Meeting and which explains the diversity of the speakers' expertise. To provide a less anecdotal introduction, Professor Tayler will outline the observational and theoretical aspects of the subjects that will be discussed in detail in the subsequent papers.

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