Cosmic Microwave Background Radiation

1. Introduction

One of the most important pieces of evidence in support of the Hot Big Bang model is the discovery of the Microwave Background Radiation (CMBR) by Penzias and Wilson in 1965. They could not explain the 'hiss' noise by any known sources, but after careful investigation admitted that they may have discovered the relic of the initial extremely hot radiation of the the early phase of the universe. Soon a group of theorists at Princeton University, including Dicke and Peebles realized the possibility that the 'hiss' was a relic radiation, a leftover from the hot phase in the evolution of the early universe (P. Coles et al, 2008) and their paper (Dicke et al, 1965) was published together with the paper from Penzias and Wilson in 1965.

2. Importance of the Cosmic Microwave Background Radiation

(P. Coles et al, 2008) stated the enormous importance of the CMBR as a source of observational and theoretical interest at present. Two important properties are mentioned here.

The first important property is the near perfect *black body* radiation it possesses. In the beginning explanations other than a relic of the hot big bang were put forward to explain the thermal spectrum of the CMBR. Advocates of the steady state theory argued that we are merely seeing starlight reprocessed by dust. The models constructed to explain the thermal spectrum of the CMBR at the time accounted for the observations fairly well. However measurements of the CMBR spectrum the last 30 years, in particular the COBE satellite's measurements, showed the temperature of the CMBR to be 2.725±0.002 K (P. Coles et al). Attempts by the steady state model to account for the CMBR's black body radiation in terms of non-thermal processes were unsuccessful. The CMBR's black body radiation so close to an ideal black body confirms the Big Bang model.

The second important issue is the observed isotropy of the CMBR because:

(1) It provides evidence for the isotropy of the universe;
(2) Explanations for the origin of the radiation as galactic or is produced by random distribution of sources, also by its near black body spectrum' and
(3) It gives important information on the origin nature and evolution of density fluctuations thought to be the result of the fluctuations of energy at the quantum level in the early universe. The density fluctuations are

thought to give rise to stars, glaxies and the large scale structures of the universe (P. Coles et al, 2008).

The COBE satellite has detected anisotropy on the scale of a few degrees up to the quadrupole (180^0). Anisotropies also exists on smaller scales of 90^0 down to a few arc seconds.

3. Origin of the Cosmic Microwave Radiation

The radiation known as the Cosmic Microwave Background Radiation originated about 379,000 years after the Big Bang when the temperature of the universe was at 3,000 K. At that time the content of the universe consisted of a hot plasma of matter and radiation in thermal equilibrium. The matter and radiation 'decoupled' and the photons could travel freely in the form we observed today at infrared wavelength known as the Cosmic Microwave Background Radiation.

Frikkie de Bruyn

References

Coles P. and Francesco Lucchin 2008. Cosmology. The Origin and Evolution of Cosmic Structure. Second edition. John Wiley and Sons, Ltd. Chichester U.K.
Dicke RH, Peebles PJE, Roll PG and Wilkinson DT 1965 Cosmic black-body radiation. Astrophys.. J 142, 414-419..