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The Study of the Universe when it was forming

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Abstract :

In this paper, we shall discuss what the equations of cosmology says about the universe?

Introduction :

The dynamical equations of cosmology are

$$\dot{R}^2 + k = \frac{8\pi}{3}\rho R^2 \tag{I}$$

and $$2R\ddot{R} + \dot{R}^2 + k = -8\pi p R^2 \tag{II}$$

where $R(t)$ is the scale function.

The beginning of the universe :

The epoch, starting with the birth of the universe to the matter-dominated era, will be called the early universe. The dynamical equations of cosmology simplify in the early universe. Because of deacceleration, the expansion rate $\dot{R}(t)$ increases as we go back in time, the expansion rate of the early universe $\dot{R}(t)$ is evidently much larger than the expansion rate today, $\dot{R}(t) \geq \dot{R}(t_0)$. The spatial curvature constant k, is simply $(2q - 1)\,\dot{R}^2\,(t_0)$.

When we discuss the early universe, the constant k is dropped from the equation (I), getting

$$\dot{R}^2 = \frac{8\pi}{3}\rho R^2 \qquad \text{(III)}$$

An intermediate consequences of the above equation is that the evolution of the early universe proceeds independently of its future density be it closed or open.

From the behaviour of energy densities it is seen that, as we go back in time, the contribution of relativistic particles to grow at a rate which is αR^{-4} faster than that of non-relativistic particles αR^{-3}.

Therefore, the energy-density of the early universe will be dominated by the contribution of relativistic particles provided that they exist in the early universe.

The idea that our universe underwent an initial phase is due to Gamov. From a study of the proplem of synthesis of elements in the early universe, he estimated that at a time when the temperature was about 10^9 K the nucleon number density n_1, must have been about 10^{18} cm^{-3}.

Before proceeding further we should make few comments on the significance of there two numbers.

In Gamov's theory, elements are formed through the successive capture of neutrons starting with the formation of deuteron via photo production $n + p \rightarrow d + r$ as the first stop. The temperature 10^9 K is the photo dissociation temperature of deuteron. Above this temperature deuterons are broken up by the reverse reaction $r + d \rightarrow n + p$ as fast as they are formed.

We thus can expect to obtain a fairly good estimate of the order of the present black-body temperature using the foregoing estimate of n.

Finally we should note that these estimates of T_1 and n_1 correspond, via

$$\sigma = \frac{4aT^3}{3nk} \text{ to } \sigma \simeq 10''$$

so that what we have here is a very hot universe indeed.

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