St.Xavier's College Physics Club

(SXCPC)

Maitighar, Kathmandu

Question Of the Month-September Series

The critical density of the Universe is the density at which the gravitational attraction of matter within the universe is balanced with its expansion in such a way that neither will ultimately prevail. If the density of the universe were lower than this critical density, expansion will continue indefinitely. On the other hand, if the density of the universe were any higher, it would re-collapse upon itself.

Question:

(a) The critical density of the universe is given by:

$$\rho_c = \frac{3{H_0}^2}{8\pi G}$$

It is possible to arrive at this result through classical means. By modeling the universe as having infinite extent and uniform density, expanding linearly with velocity $v = H_0x$, derive the above expression.

(b) The density of ordinary (baryonic) matter in the universe is determined to be about 3.8×10^{-28} kg m^{-3} . Hence, provide a justification for the existence of dark matter. (Latest estimates of the Hubble constant suggest a value of 2.20×10^{-18}/s)