FRAGMENTATION OF THE PRIMORDIAL GAS CLOUDS

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We discuss the fragmentation of primordial gas clouds in the universe after decoupling. Comparing the timescale of collapse (t_{dyn}) with that of fragmentation (t_{frag}), we obtained the minimum mass of a fragment analytically as following way.

We consider the fragmentaiton of the cylidrical cloud which consists of hydrogen molecules. The condition for the collapsing cloud to fragment is $t_{dyn} \sim t_{frag}$ and, for the cylindrical cloud which collapses isothermally, it becomes $t_{dyn} \sim (\gamma - 1)\, t_{cool}$, where t_{cool} is the cooling timescale. Each timescales are estimated as follows,

$$t_{frag} \sim \frac{1}{\sqrt{G\rho}}, \qquad t_{cool} \sim \frac{\frac{1}{\gamma-1}\frac{M}{\mu m_{\rm H}} k_B T}{2\pi R \sigma T^4 \frac{\Delta\nu}{\nu} \alpha_c}, \tag{1}$$

where $\Delta\nu/\nu = v_{\rm H_2}/c = k_B T/m_{\rm H} c^2$, $k_B T = \mu m_{\rm H} GM/2$, and M, R, T are the line density, radius, temperature of the cylindrical cloud and α_c is the effective number of line emissions. From the above equations we obtain

$$M_{frag} \sim 2\pi RM \sim \sqrt{\frac{1}{\alpha_c}} \frac{1}{\mu^{9/4}} \frac{m_{Pl}^3}{m_{\rm H}^2}, \tag{2}$$

where $m_{Pl} = \sqrt{hc/G}$ is the Planck mass.

Above estimate shows that the minimum mass of a fragment of the primordial gas cloud is essentially determined by the *Chandrasekhar mass.*

References

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