Nucleosynthesis

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[1] Simple arguments lead to the conclusion that the large amount of ^{4}He could not have been produced in stars. The binding energy of ^{4}He is 28.3 MeV. When one nucleus of ^{4}He is formed, the energy released per one baryon is about 7.1 MeV $\simeq 1.1 \times 10^{-5}$ erg. Assuming that one quarter of all baryons has been fused into ^{4}He in stars during the last 10 billion years (3.2×10^{17} s), we obtain the estimate for the luminosity-to-mass ratio

$$\frac{L}{M_{\rm bar}} \simeq \frac{1}{4} \frac{1.1 \times 10^{-5}\ \text{erg}}{(1.7 \times 10^{-24}\ \text{gm}) \times (3.2 \times 10^{17}\ \text{s})} \simeq 5 \frac{\text{erg}}{\text{gm s}} \simeq 2.5 \frac{L_\odot}{M_\odot} \tag{1}$$

where $M_\odot$ and $L_\odot$ are the solar mass and luminosity respectively. However, the observed $L/M_{\rm bar} \leqslant 0.05 L_\odot/M_\odot$. If the luminosity of baryonic matter in the past was not much larger than at present, less than 0.5% of ^{4}He can be fused in stars.

1 Freeze-out of neutrons

[1]

[2]

References

[1] V. Mukhanov. *Physical Foundations of Cosmology*. Cambridge University Press, 2005.

[2] S. Weinberg. *Cosmology*. Oxford University Press, 2008.