DISCUSSION

With enough reactions one can calculate the amount of any isotope produced by the Big Bang. Table (1) to the left lists the mass fractions of 40 isotopes. But note that the Big Bang produces most heavy isotopes in very small amounts. In reality, these isotopes are produced overwhelmingly by stars. So to make any experimental observations of Big Bang amounts, one has to observe regions in space with very low abundances of heavy elements, or low metallicities.

This figures in this poster all correspond a ratio of the total numbers of baryons to photons, $\eta = 10^{-9}$ ($\eta_{10} = 10$). Note that the equation for the NSE mass fractions depends proportionately to η. So if one increases η_{10} from 1 to 10 all the mass fractions increase when the isotopes are in NSE. Because of that deuterium reaches an abundance amount necessary for nucleosynthesis to start at an earlier time/higher temperature. So more free neutrons are present during nucleosynthesis, and the final mass fraction of ^{4}He is higher. Thus $X_{^4He}$ increases with increasing η_{10}. Also, note in Figure (3) that deuterium and ^{7}Li peak and then decrease before reaching a final value, while ^{7}Be flattens out to its final value. The destruction rates dominate the production rates for those first two isotopes, which the reverse is true for ^{7}Be. All reaction rates increase with increasing η_{10} at first, because all mass fractions increas at first. So an increasing η_{10} tends to amplify the difference between the production and destruction rates, and so deuterium and ^{7}Li decrease while ^{7}Be increase.

But the unstable ^{7}Be decays to ^{7}Li over time. Not significantly decayed during a code's run, but completely converted to ^{7}Li by the ‘ present. So one conventionally looks at the sum of ^{7}Li and ^{7}Be as the final amount of ^{7}Li.

Figure (9) to the right shows the baryon-to-photon ratio dependence of the mass fraction of ^{4}He and the abundance ratios of deuterium and ^{7}Li to hydrogen (free protons). We use this ratio because experimental observations of the light elements are determined in terms of $\log(Y_i/Y_p)$. So we can use this graph to test the validity of the standard BBN model and determine a range for the value of η_{10}. The ranges shown here come from a 1995 ApJ article by Hata, et. al. and a 1997 PRD article by a different Hata, et. al.

$$\begin{aligned} X_{^4He} &= 0.232 \pm 0.003(\text{stat}) \pm 0.005(\text{syst}) \\ \left(\frac{Y_d}{Y_p}\right) &= (2.4 \pm 0.5) \times 10^{-5} \\ \left(\frac{Y_{^7Li}}{Y_p}\right) &= (1.2^{+4.0}_{-0.5}) \times 10^{-10} \end{aligned}$$

$X_{^4He}$ is measured from interstellar hydrogen clouds (HII regions) with low metallicities. (Y_d/Y_p) is directly measured from old age quasars and $(Y_{^7Li}/Y_p)$ from low metallicity stars. Currently, the ranges for ^{4}He and deuterium do not overlap. So people are now trying to determine if the standard model needs to be modified or, as it's currently believed, the range for ^{4}He has to be changed.