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The effects of coupling variations on BBN

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Abstract. The effect of variations of the fundamental nuclear parameters on big-bang nucleosynthesis are modeled and discussed in detail taking into account the interrelations between the fundamental parameters arising in unified theories. Considering only ^{4}He, strong constraints on the variation of the neutron lifetime, neutron-proton mass difference are set. We show that a variation of the deuterium binding energy is able to reconcile the ^{7}Li abundance deduced from the WMAP analysis with its spectroscopically determined value while maintaining concordance with D and ^{4}He.

Keywords. cosmology: theory, nuclear reactions, nucleosynthesis, abundances

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Big bang nucleosynthesis (BBN) is one of the most sensitive available probes of physics beyond the standard model. The concordance between the observation-based determinations of the light element abundances of D, ^{3}He, ^{4}He, and ^{7}Li, and their theoretically predicted abundances reflects the overall success of the standard big bang cosmology. Many departures from the standard model are likely to upset this agreement, and are tightly constrained.

It has also become generally accepted that there is a problem concerning the abundance of ^{7}Li. WMAP has accurately fixed the value of the baryon-to-photon ratio, $\eta = (6.23 \pm 0.17) \times 10^{-10}$ corresponding to $\Omega_B h^2 = 0.02273 \pm 0.00062$. At that value, the predicted abundance of ^{7}Li is approximately 4 times the observationally determined value, Cyburt *et al.* (2008). Several attempts at explaining this discrepancy by adjusting some of the key nuclear rates proved unsuccessful.

In unified theories of particle interactions, one generally expects that a change in the fine structure constant would directly imply a change in other gauge couplings, as well as and perhaps more importantly, variations in the QCD scale Λ_{QCD}. In addition, one might expect variations in the Yukawa couplings and Higgs vev as well. These relations can then be implemented in a BBN calculation. The resulting limit, Coc *et al.* (2007), can be expressed in terms of a limit on the variation in α

$$-3.2 \times 10^{-5} < \frac{\Delta h}{h} < 4.2 \times 10^{-5}. \qquad (0.2)$$

References

Coc, A., Nunes, N. J., Olive, K. A., Uzan, J.-P., & Vangioni, E. 2007, Phys. Rev. D, 76, 023511
Cyburt, R. H., Fields, B. D., & Olive, K. A. 2008, Journal of Cosmology and Astro-Particle Physics, 11, 12