Title: Big Bang Nucleosynthesis

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Collection: Everpresent Lambda: Theory Meets Observations

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Big Bang Nucleosynthesis

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Outline

- Lithium Problem
- Possible Solutions
- Everpresent Λ as Solution to Lithium Problem
- Results
- Conclusion

Primordial Lithium-7 Abundance

- Big Bang Nucleosynthesis (BBN) predicts the abundance of light cosmological elements (D,^{3}He,^{4}He,^{7}Li) produced 10sec $\sim$ 20 Min after the Big Bang.
- ΛCDM predicts the right abundance for (D,^{4}He) but about three times more for ^{7}Li.

Possible Solutions

The solution for the Lithium Problem might come from:

- Nuclear Physics: If BBN calculations have been leaving out some reactions or using incorrect rates.

Possible Solutions

The solution for the Lithium Problem might come from:

- Nuclear Physics
- Dark matter processes : Dark matter introduces new processes which can alter light elements abundance during and after BBN.

Possible Solutions

The solution for the Lithium Problem might come from:

- Nuclear Physics
- Dark matter processes
- Observations : Lithium-7 present in halo stars does not reflect the initial abundance because some of the Lithium-7 was destroyed through nuclear binding. Some groups have found a certain amount of Lithium depletion.
  -In metal-poor stars (where less depletion is expected) Lithium-7 abundance is nowhere near the predicted value.

Possible Solutions

The solution for the Lithium Problem might come from:

- Nuclear Physics
- Dark matter processes
- Observations
- Cosmology.

Everpresent Λ

In Everpresnt Λ dark energy is ever present. The expansion rate is determined by the Friedmann equation,

$$H^2 = \frac{1}{3}(\rho + \Lambda(t))$$

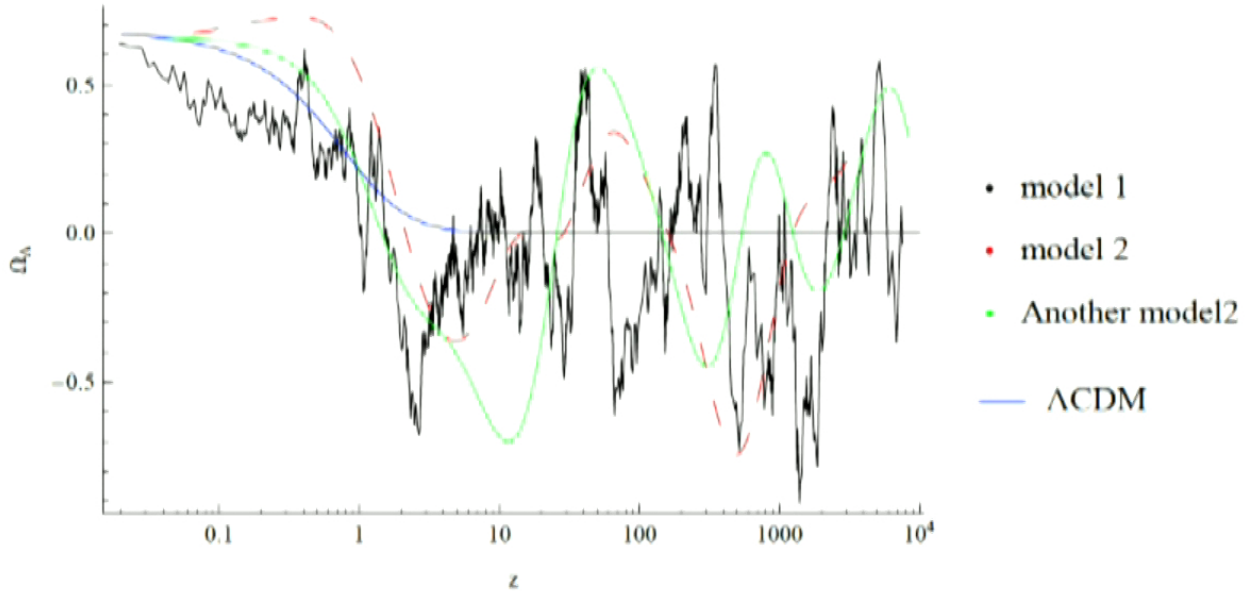


Figure : Ω_{DE} for different Cosmological Models.

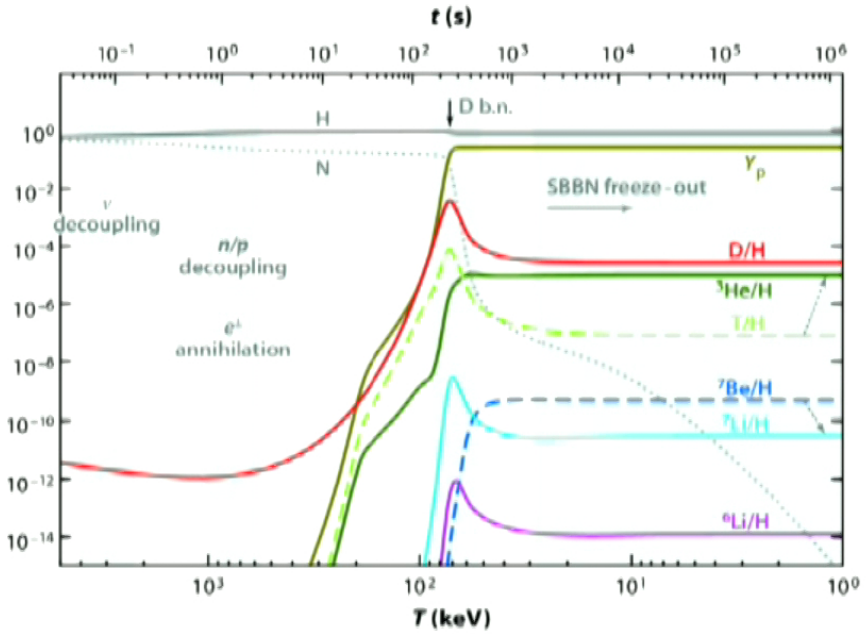


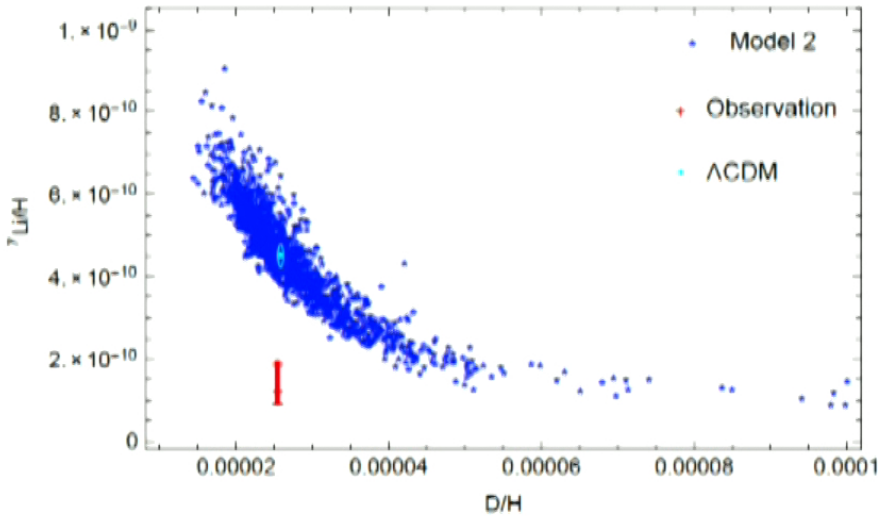
Figure : Standard BBN

Primordial Lithium-7 Abundance

We run Timmes's BBN code using $N_{eff} = 3$ and for photon-baryon ratio $\eta = 2.7377 \times 10^{-8}\Omega_b h^2$.

	Observation	Model 2	ΛCDM
D/H ($\times 10^{-5}$)	2.547 ± 0.033	3.305	$2.584^{+0.036}_{-0.035}$
^{3}He/H ($\times 10^{-5}$)	1.1 ± 0.2	1.009	$1.026^{+0.005}_{-0.006}$
^{4}He	0.249 ± 0.009	0.2512	2.462 ± 0.001
^{7}Li/H ($\times 10^{-10}$)	$1.62^{+0.34}_{-0.16}$	2.632	$4.507^{+0.08}_{-0.268}$
χ^2		57	89

Primordial Lithium-7 Abundance



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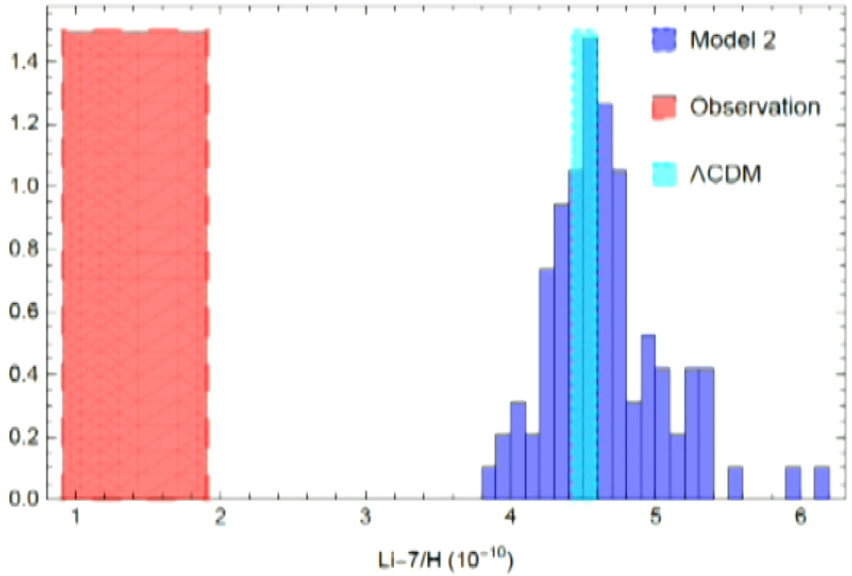
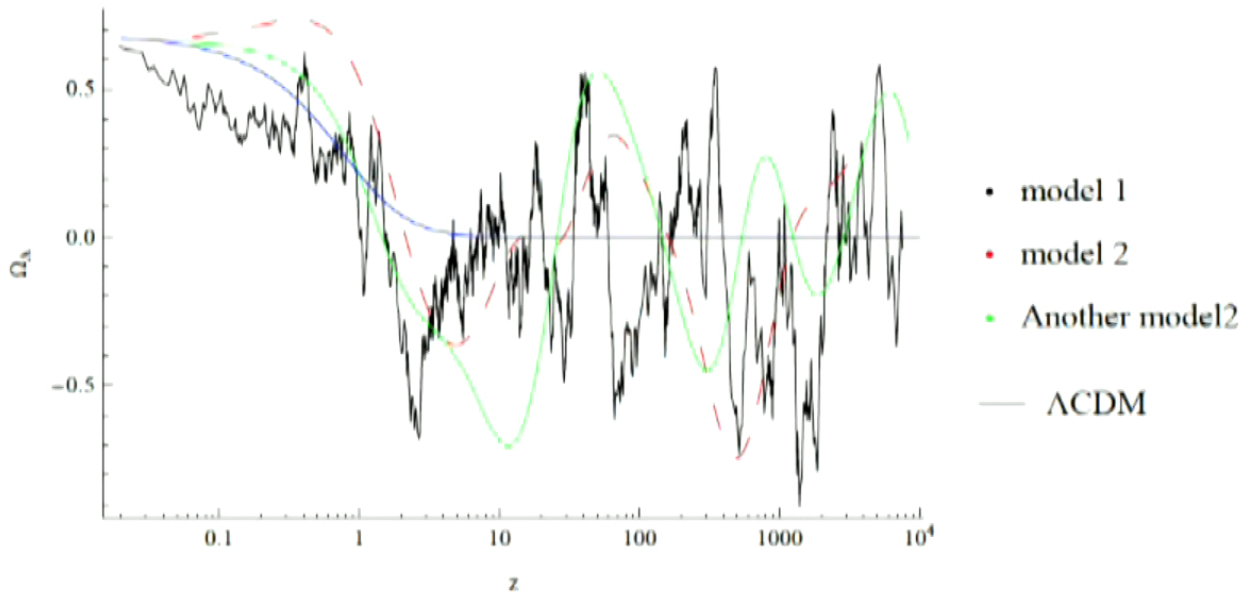
Primordial Lithium-7 Abundance

Distribution of Lithium-7 abundance given that Deuterium abundance is $2.547 \pm 0.033 \times 10^{-5}$.





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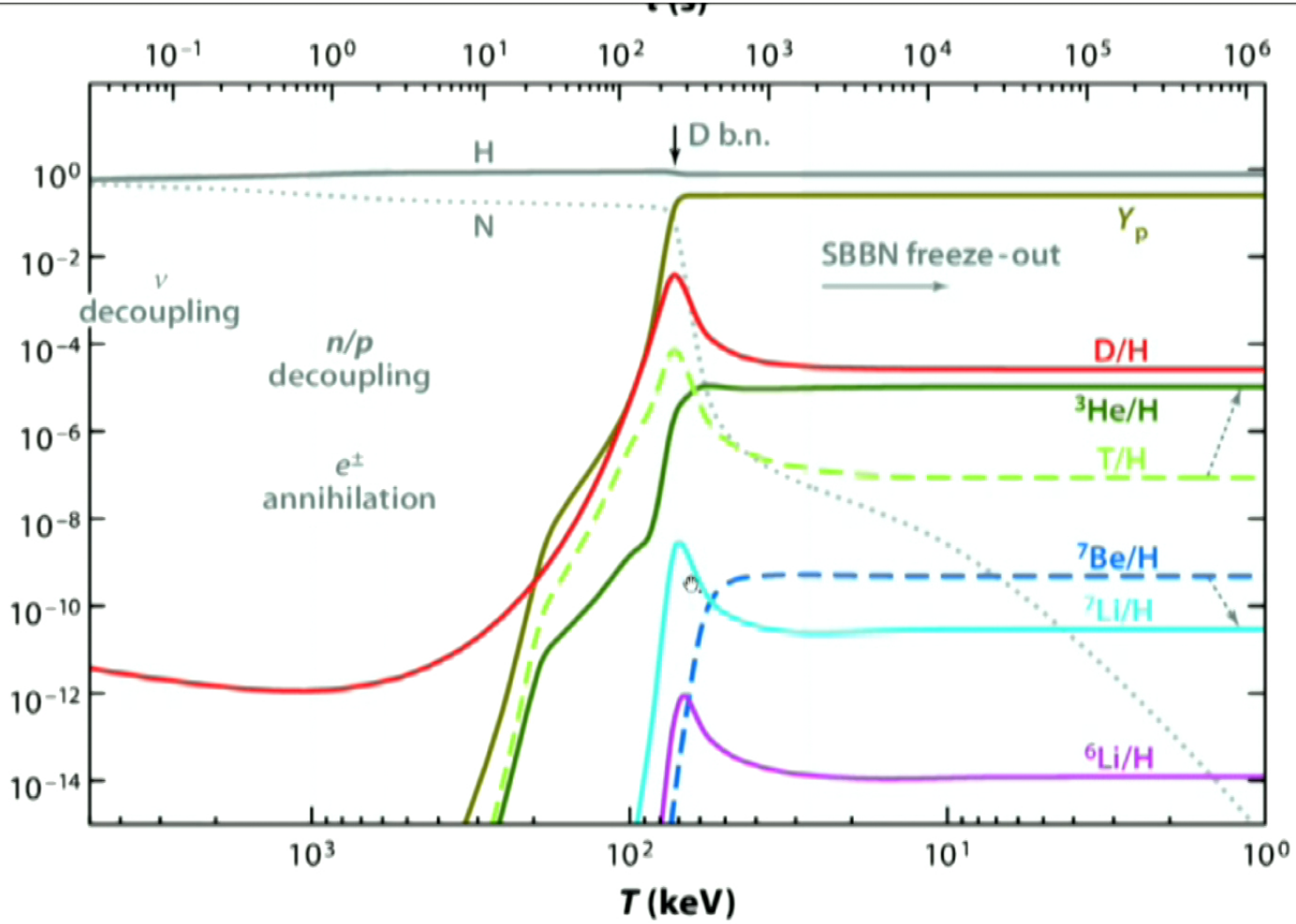
H
D b.n.
N
Y_p
SBBN freeze-out
ν decoupling
n/p decoupling
$e^{\pm}$ annihilation
D/H
^{3}He/H
T/H
^{7}Be/H
^{7}Li/H
^{6}Li/H
T (keV)

Summary

- Does not completely solves the Lithium-7 problem but predicts about twice more Lithium-7.
- Histories that solve the Lithium-7 problem create a Deuterium problem.

Primordial Lithium-7 Abundance

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