# A public code for precision big bang nucleosynthesis with improved Helium-4 predictions

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Now that the number of neutrino families and the baryonic density have been fixed by laboratory measurements or CMB observations, big bang nucleosynthesis has no free parameter. Hence, it is possible to accurately calculate the abundances of the produced "light elements": $^4He$, $D$, $^3He$ and $^7Li$. It is now well known that there is a, yet unexplained, discrepancy of a factor of ≈3 between the primordial $^7Li$ abundance deduced from observations of halo stars, and the BBN predictions [1]. Recently, the precisions on primordial abundances of both deuterium and helium-4, deduced from observations, have been drastically improved and are now close to the percent level. Accordingly, the BBN predictions should reach the same level of precision. For most isotopes, the dominant sources of uncertainty come from those on the laboratory thermonuclear reactions rates. The exception is helium-4 whose predicted primordial abundance depends essentially on the theoretical weak interaction rates which control the neutron-proton ratio. These rates depend on the experimentally measured neutron lifetime, but also includes numerous corrections that affects both deuterium and helium-4 predictions at levels comparable to the observational uncertainties.
A *Mathematica* primordial nucleosynthesis code that incorporates, not only these corrections but also a full network of reactions, using the best available thermonuclear reaction rates, allowing the predictions of primordial abundances of helium-4, deuterium, helium-3 and lithium-7 but also of heavier isotopes up to the CNO region is now publicly available at `http://www2.iap.fr/users/pitrou/primat.htm` [2]. It can be used to reproduce the Ref. [2] standard calculations, implement new physics, or simply test new reaction rates.

## References

[1] A. Coc & E. Vangioni, *Int. J. Mod. Phys. E.* **26** (2017) 1741002, `arXiv:1707.01004`.

[2] C. Pitrou, A. Coc, J.-P. Uzan & E. Vangioni, (2018), `arXiv:1801.08023`