

Experimental challenge to the big-bang nucleosynthesis

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The primordial nucleosynthesis (BBN) right after the big bang (BB) is one of the key elements that support the BB model. The BBN is well known that it produced primarily light elements, and explains reasonably most of the element abundances. However, there remains some interesting and serious questions.

One is an abundance problem, called the Li problem. The BBN simulations using recent detailed micro-wave background measurements explain most light elements including D, 4He , etc, but the 7Li abundance is over predicted roughly by a factor of three, which is called the Li problem in BBN.

The primordial 7Li was considered to be produced mostly by the electron capture of 7Be in the late stage of BBN. Thus, the question for nuclear physics side is whether 7Be is overproduced or less destructed during the BBN stage. Since the production of 7Be is by the $3\text{He}(\alpha,\gamma)$ reaction which is quite well known, the problem may be the destruction rate of 7Be . The $7\text{Be}(n,p)$ reaction is considered to be the main destruction reaction, but it is well investigated. Thus, it seems hard to change the rate by a factor of three. The next possible channel was the $7\text{Be}(n,\alpha)$ reaction, and almost no experimental works reported before [1]. Recently, several experiments [2,3] were performed or being performed by the direct and indirect methods. I will discuss the reaction studies of $7\text{Be}(n,\alpha)$ including our result[3]. The conclusion is that the reaction rate proposed by Wagoner et al., which is currently being adopted, is roughly one order of magnitude too large. Thus, the Li problem was not solved, giving a more difficulty.

Another interesting question for the BBN is the production of heavier elements like B, C, and O in the primordial nucleosynthesis. This production would have influenced the evolution of the first generation stars. But, it is not known well because lack of experimental data and astronomical observations. This problem is also a common question of breakout from the pp-chain region to the CNO region at high temperatures like in the vp-process in type II super novae. For this problem, alpha induced reactions are expected to play a crucial role. I will touch also on this subject.

References:

- [1] S.Q. Hou, J.J. He, S. Kubono, and Y.S. Chen, Phys. Rev. C 91 (2015) 055802
- [2] M. Barbagallo, et al., Phys. Rev. Lett. 117 (2016) 152701
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