論文題目要旨

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論文題目：Study of the ^{7}Be$(d,p)^8$Be Reaction and its Impact on the Cosmological Lithium Problem

論文要旨：

The aim of the thesis is to potentially resolve the Cosmological Lithium Problem (CLP) with the cross section measurement of the ^{7}Be$(d,p)^8$Be reaction. The CLP is a well-known unsolved issue in astrophysics that is an overestimation of the primordial ^{7}Li abundance in the standard Big Bang nucleosynthesis (BBN) model compared to astrophysical observations. The majority of ^{7}Li nuclei were produced by the electron capture decay ($t_{1/2} = 53.22$ days $= 4.5 \times 10^6$ seconds) of ^{7}Be. ^{7}Be nuclei were considered to be produced in several hundred seconds during the BBN, resulting in a timescale difference of 10^4 between the ^{7}Li and ^{7}Be productions.

One of the possible scenarios to resolve the CLP is that ^{7}Be nuclei were more destroyed during the BBN with a lesser abundance of ^{7}Li than the BBN model prediction. The ^{7}Be$(d,p)^8$Be reaction is focused in this thesis following a theoretical suggestion that the reaction played a significant role in the destruction of ^{7}Be nuclei during the BBN [1]. The measurement of the absolute cross section in the Big Bang energy region ($E_{c.m.} = 0.1 - 0.4$ MeV) was crucial for understanding the nuclear reactions in the primordial universe.

We produced a radioactive ^{7}Be target and measured the ^{7}Be$(d,p)^8$Be reaction cross section in the BBN energy region at the tandem facility of Kobe University. A 2.36 MeV proton beam irradiated a natural Li target with a thickness of 30 μm, transmuting ^{7}Li nuclei to ^{7}Be through the ^{7}Li$(p,n)^7$Be reaction. 2.82×10^{13} ^{7}Be nuclei were produced in the Li host target by two days of the proton irradiation. Following the target production, a deuteron beam was accelerated to energies of 1.6 and 0.6 MeV to measure the ^{7}Be$(d,p)^8$Be reaction cross section. The outgoing proton's energy and yield were measured by two sets of four-layered silicon telescopes placed at scattering angles of 45 and 30 degrees.

The thick target analysis method was applied to obtain the cross sections. The measured cross sections were 0.89 ± 0.18 (0.76 ± 0.24) mb at $\theta_{\rm lab} = 45$ $(30)^\circ$ at $E_{c.m.} = 0.35$ MeV and 0.17 ± 0.13 (0.21 ± 0.20) mb at $\theta_{\rm lab} = 45$ $(30)^\circ$ at $E_{c.m.} = 0.12$ MeV. The impact of the measured cross sections on the CLP was found to be small. The cross section was obtained at the lowest energy of $E_{c.m.} = 0.12$ MeV with the highest sensitivity compared to the available data [2, 3, 4].

Reference

[1] S. Q. Hou *et al.*, Phys. Rev. C **91**, 055802 (2015).
[2] R. Kavanagh, Nucl. Phys. **18**, 492-501 (1960).
[3] C. Angulo *et al.*, ApJ **630**, L105 (2005).
[4] N. Rijal *et al.*, PRL **122**, 182701 (2019).