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Development of ^{10,11}B Targets and Data Acquisition Systems for the Measurement of the ^{10,11}B(^{3}He,t)^{10,11}C Reactions

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Big Bang Nucleosynthesis (BBN) refers to the nuclear reactions that occurred approximately from 10 seconds to 20 minutes after the birth of the universe. These reactions produced light elements, mainly ^{2}H, ^{3}He, ^{4}He, and ^{7}Li. The standard BBN model reproduces the abundances of these elements with high precision, except for ^{7}Li. This agreement is regarded as strong evidence that the universe was once in a hot and dense state in the early phase of its evolution. However, BBN has an unresolved major issue known as the "cosmological lithium problem." The abundance of ^{7}Li calculated by BBN is approximately three times higher than the value inferred from astronomical observations. This discrepancy remains a serious challenge in modern physics.

Our research aims to address this ^{7}Li problem from the perspective of a nuclear experiment. ^{7}Li was produced primarily through the electron capture decay of ^{7}Be, which was synthesized during BBN. Many studies have already investigated the production of ^{7}Be, and there is little room to significantly alter its abundance in standard BBN calculations.

We investigate the possibility that ^{7}Be is transformed into nuclei other than ^{7}Li through unknown reaction channels before it undergoes electron capture. Theoretical studies have proposed that unknown resonant states exist in ^{10}C and ^{11}C. These nuclei are formed through the ^{7}Be + ^{3}He and ^{7}Be + ^{4}He reactions, respectively. If such resonant states exist and allow the conversion of ^{7}Be into other nuclei via these resonances, the final abundance of ^{7}Li in BBN would decrease.

We plan to measure the (^{3}He,t) reactions on ^{10}B and ^{11}B to search for these resonant states. The ^{7}Be + ^{3}He and ^{7}Be + ^{4}He resonances are expected to appear at excitation energies of 14.9–15.2 MeV in ^{10}C and 7.79–7.90 MeV in ^{11}C, respectively. Therefore, we will conduct high-resolution measurements using the Grand Raiden (GR) spectrometer at RCNP. In addition to detecting tritons with GR, we will also identify the decay particles from the excited states of ^{10}C and ^{11}C using Si detectors.

To conduct this experiment, we have carried out two technological developments. First, in collaboration with MicroMatter Technologies in Canada, we fabricated a self-supporting ^{11}B thin film target using pulsed laser deposition. The impurity content of this target was evaluated through the ^{10,11}B(d,p) reaction, which revealed approximately 8% contamination from ^{12}C. We are also planning to develop a ^{10}B target in July and to evaluate its impurity content using the same method. The results will be presented in this poster.

Second, we addressed the challenge of identifying coincident events between GR and Si detectors. The GR system is based on a trigger-less streaming DAQ, whereas the Si detectors use a trigger-based DAQ system. Since these two systems employ different data acquisition methods, reconstructing events between them required a creative approach. We solved this issue by reading the accepted trigger signal from the Si detectors with the GR system.

This poster presents the development of thin film targets, impurity evaluation results, and the integration of DAQ systems between GR and silicon detectors.

Research field of your presentation

Experimental Low-energy nuclear physics

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