

Precise spectroscopy of the $3n$ and $3p$ systems via the ${}^3\text{H}(t, {}^3\text{He})3n$ and ${}^3\text{He}({}^3\text{He}, t)3p$ reactions at intermediate energies[†]

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The three-neutron ($3n$) system was studied via the ${}^3\text{H}(t, {}^3\text{He})3n$ reaction at 170 MeV/nucleon at RIBF using the SHARAQ spectrometer. This experiment represents the first realization of RI-RI scattering at intermediate energy. In addition to the triton beam, which was readily available at RIBF, this experiment required a radioactive tritium target. To meet this requirement, a thick tritiated titanium ($\text{Ti-}{}^3\text{H}$) target with a tritium thickness of 3.5 mg/cm^2 was developed at the University of Toyama.¹⁾ The target was introduced at the target position of the spectrometer along with appropriate safety equipment.

Figure 1 represents examples of $(t, {}^3\text{He})$ spectra for $\text{Ti-}{}^3\text{H}$ (red) and Ti (black) targets. The ${}^3\text{H}(t, {}^3\text{He})3n$ component is clearly distinguished due to the high atomic loading ratio of ${}^3\text{H}/\text{Ti} = 1.5$ in the $\text{Ti-}{}^3\text{H}$ target. The double differential cross sections for the ${}^3\text{H}(t, {}^3\text{He})3n$ reaction were extracted after subtracting the background contributions from Ti as well as those from ${}^3\text{He}$ and ${}^1\text{H}$, originating from the beta decay of ${}^3\text{H}$ and isotopic impurities, respectively.

Following the observation of peak structures in four-neutron ($4n$) systems in previous studies,^{2,3)} significant interest has been directed toward the $3n$ system to determine whether a similar peak structure exists. While some theoretical calculations predict the existence of $3n$ resonances, others do not.

The top panel of Fig. 2 presents the $3n$ spectrum obtained in this study. The results indicate that the $3n$ system does not exhibit a pronounced peak structure near the threshold, in sharp contrast to the previously

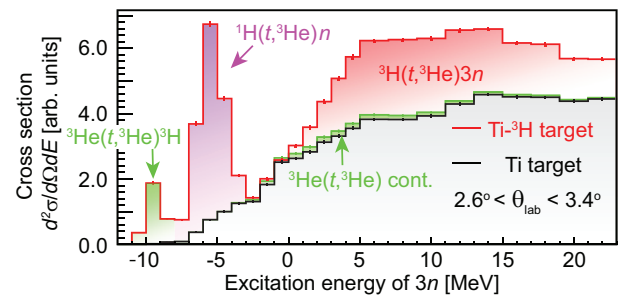


Fig. 1. Typical $(t, {}^3\text{He})$ spectra obtained in this study.

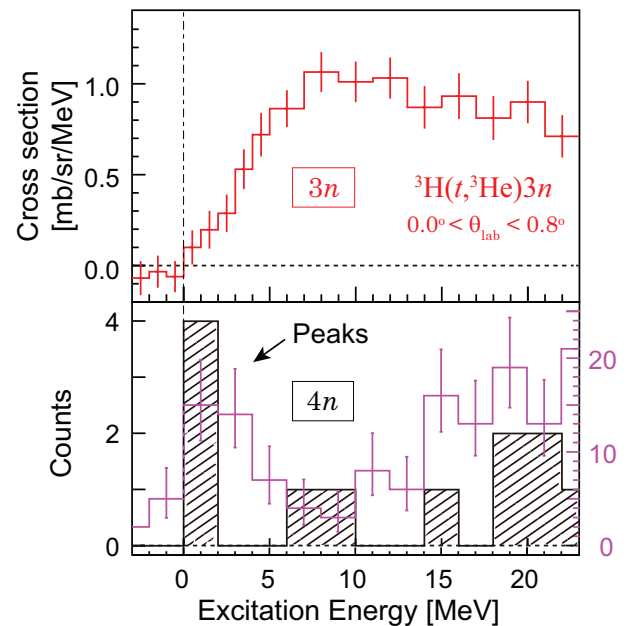


Fig. 2. Measured $3n$ spectrum (top) compared with previously reported $4n$ spectra from Refs. 2) (black) and 3) (pink).

observed $4n$ results in Refs. 2) (black) and 3) (pink). This finding provides the first indication of odd-even effects in multineutron systems.

References

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