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Measurement of Hyper-Hydrogen Lambda-Binding Energy via Decay Pion Spectroscopy

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The hypertriton ($^{3}_{\Lambda}$H) is the lightest Lambda-hypernucleus, consisting of one proton, a neutron, and a Lambda. This simplest Lambda hypernucleus has been an essential benchmark for hypernuclear physics. However, the primary properties, mass and lifetime, still have systematic experimental uncertainties. The Lambda-binding energy (B_{Λ}) is reported to be 130 ± 50 keV based on emulsion data summarized by Jurič $et\ al.$[1]. The shallow binding energy suggests a hypertriton lifetime similar to a free Lambda particle ($\tau_{\Lambda} = 263$ ps)[2]. The recent heavy ion collision experiments have generated considerable interest. After 2010, the STAR and ALICE collaborations have reported a $20 - 30\%$ shorter lifetime than τ_{Λ}[3,4]. Furthermore, there are still significant discrepancies in the B_{Λ} values reported by these two groups, differing by a factor of four[5,6]. Accurate and independent measurement of these values is crucial for understanding the hypertriton's lifetime and mass simultaneously, making this one of the hot topics in hypernuclear physics the 'Hypertriton puzzle.'
In October 2022, we conducted decay pion spectroscopy experiments on s-shell hypernuclei at the Mainz Microtron MAMI in Germany. The method was established, and the mass of $^{4}_{\Lambda}$H was successfully measured with an accuracy of approximately 80 keV in 2016[7].
To enhance the yield of hypertriton and reduce background events, we selected a 4.5 cm long and 0.75 mm wide Lithium target aligned along the beam direction to increase luminosity[8]. Additionally, a new beam energy measurement technique[9] was introduced to reduce the systematic error of hypernuclear mass to $10 - 20$ keV.
In this session, I will present this experimental method and provide a new result from the latest analysis.

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Primary author: KINO, Ryoko (Tohoku University)

Co-authors: ACHENBACH, Patrick (Thomas Jefferson National Accelerator Facility); KLAG, Pascal (Johannes Gutenberg University Mainz); NAKAMURA, Satoshi Nue (The University of Tokyo, Tohoku University); NAGAO, Sho (The University of Tokyo); NISHI, Kotaro (The University of Tokyo); POCHODZALLA, Josef (Johannes Gutenberg University Mainz, GSI, Helmholtz Institute Mainz); SHAO, Tianhao (Fudan University); ., for the A1 hypernuclear collaboration

Presenter: KINO, Ryoko (Tohoku University)

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