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Experimental status toward the direct lifetime measurement of Hypertriton using the (K-, pi0) reaction at J-PARC

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The hypertriton (3ΛH) is the lightest hypernucleus consisting of a proton, a neutron, and a Λ hyperon. From old emulsion experiments, the Λ separation energy of the hypertriton has been measured as 130 ± 50 keV. Theoretical calculation shows that Λ hyperon is separated by ~10 fm from the deuteron inside hypertriton. Therefore, as a very loosely bound system, the lifetime of the hypertriton has been estimated to be close to that of free Λ particle (τ = 263 ps). However, in recent years, the lifetime of hypertriton in heavy-ion based experiments (ALICE, STAR and HypHI) has been found to be 30-40% shorter than expectation. This has been recognized as the hypertriton lifetime puzzle. In heavy-ion based experiments, the hypertriton events have been identified using invariant mass and the lifetime of hypertriton is derived from decay length. In order to shed light on this puzzling issue, we propose to measure the hypertriton lifetime in time domain directly as an independent and complementary approach.

Our proposal has been approved as the E73 experiment at J-PARC in Japan. The E73 experiment employs the (K-, pi0) reaction to populate hypertriton. This reaction is a novel production method to convert a proton into Λ hyperon by detecting pi0 meson. The high energy gamma-ray (>500 MeV) decayed from the forward projectile pi0 is used to select Λ events with smaller recoiling momentum, which has higher formation probability for hypertriton. These high energy gamma-ray are detected by the calorimeter installed in the downstream of the beamline. Hypertriton events can be identified with mono-energic pi- at ~114 MeV/c from two-body mesonic weak decay, which is measured by Cylindrical Detector System (CDS) composed of a solenoid magnet, a drift chamber and timing counters. The lifetime of hypertriton can then be derived from the time difference between start counter and stop counter after subtracting TOF obtained from tracking. The advantage of this approach is that it allows us to carry out a direct lifetime measurement, which is different from the heavy-ion based experiments. Another merit of the E73 experiment is to selectively populate hypertriton ground state and avoid any contribution from the postulated 3/2 excited state.

We have performed a test experiment with 4He target to demonstrate the feasibility of (K-, pi0) reaction in June 2020.The pilot run with 3He target has been carried out in May 2021. We have successfully identified 4ΛH and 3ΛH events. For case of 4ΛH, our new method allows us to drastically improve the precision of 4ΛH lifetime. For the just completed experiment with 3He target, we will derive the production cross section as a reference for the final data taking run planed in 2022~2023. In this talk, we will describe the details of our experimental method and present the current status of the E73 experiment.

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