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New Approaches to Light Hypernuclei with Heavy Ion Beams, Image Analyses and Machine Learning

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Studies of hypernuclei have been contributing for understanding the fundamental baryonic interactions as well as the nature of dense nuclear matters. They have already been studied for almost seven decades in reactions involving cosmic rays and with meson- and electron-beams. In recent years, experimental hypernuclear physics enters a new era. Hypernuclei can also be studied by using energetic heavy ion beams, and some of these experiments have revealed unexpected results on the lightest hypernucleus, the hypertriton, on its short lifetime and large binding energy. One of the experiments has also shown a signature of the unprecedented bound state with a Lambda hyperon with two neutrons. We are studying those light hypernuclear states by employing different approaches from the other experiments. We employ heavy ion beams on fixed nuclear targets with the WASA detector and the Fragment separator FRS at GSI (the WASA-FRS project) in Germany for measuring their lifetime precisely. The experiment was already performed in 2022. We also analyze the nuclear emulsions with machine learning, that were irradiated by kaon beams in the J-PARC E07 experiment. We have already uniquely identified events associated with the production and decays of the hypertriton, and the binding energy of the hypertriton is to be determined. We also search events of other single-strangeness hypernuclei and double-strangeness hypernuclei in the E07 emulsion to understand the nature of Lambda-nucleon, Lambda-Lambda and Xi-nucleon interactions. We are using Machine Learning techniques for all our projects with heavy ion beams and nuclear emulsions. We'll discuss on these project and the current status of data analyses, we'll also present future plans of these projects.

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