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Results on light hypernuclei in the WASA-FRS and E07 emulsion experiments

The study of light hypernuclei, subatomic nuclei containing strange quarks, is an active area of research explored by multiple collaborations [1,2,3,4,5,6]. Recent investigations using high energy heavy ion collisions have yielded surprising insights into the three body hypernuclear state, Λ3H (hypertriton). Experimental measurements of its lifetime [1,2,3,7,8,9,10] and binding energy [4,11,12] have led to the so called "hypertriton puzzle", still an open topic in hypernuclear physics. Addressing this issue, our European-Japanese collaboration, including CSIC (Spain), GSI-FAIR (Germany), and RIKEN (Japan), focuses on data analysis from the WASA-FRS HypHI experiment at GSI-FAIR and the E07 experiment at J-PARC.
As part of the WASA-FRS collaboration within the Super-FRS Experiment collaboration, we investigate light hypernuclei produced in heavy-ion collisions at 1.96 GeV/u on a fixed carbon target. This experiment, conducted in early 2022 using the WASA detector and the Fragment Separator (FRS) at GSI-FAIR [6], is currently undergoing data analysis. Additionally, in the J-PARC E07 experiment [13], we lead efforts to identify and analyze hypernuclei using deep learning techniques applied to nuclear emulsions irradiated by kaon beams. Our primary objective is to measure the hypertriton binding energy with unprecedented precision [6].
This presentation will provide an overview of our hypernuclear research, focusing on the ongoing analysis of the WASA-FRS HypHI experiment and the first observation of a hypernuclear signal. We will then discuss the measurement of the hypertriton binding energy using nuclear emulsion analysis and deep learning techniques [14], presenting our first results for Λ3H and Λ4H binding energies with statistical and systematic uncertainties of 100 keV and 50 keV, respectively [15]. Finally, we will highlight the first double-strangeness hypernucleus uniquely identified by our AI analysis pipeline [16] in the E07 emulsion experiment. This discovery provides only the second experimental measurement of binding energy of 2Λ, BΛΛ, and of ΛΛ interaction energy, ΔBΛΛ, offering new perspectives on the potential of AI in advancing a "Double-Strangeness Factory".

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