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HIGH RESOLUTION SPECTROSCOPY OF THE $^{12}_{\Lambda}$B HYPERNUCLEUS PRODUCED BY THE $(e, e'K^+)$ REACTION

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The first electroproduction experiment of a hypernucleus was undertaken at the Thomas Jefferson National Acceleration Facility. The $(e, e'K^+)$ reaction was used on a ^{nat}C target resulting in the observation of the $^{12}_{\Lambda}$B hypernucleus. The excitation spectrum is presented and discussed.

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1. Introduction

The general advantages of using electromagnetic probes in structural studies are well known. However, the cross sections for electromagnetic processes, when compared to hadronic ones, are significantly smaller. Therefore, a number of novel experimental concepts are necessary to perform, and experimentaly observe, the electroproduction of a hypernucleus. The most important among these are the use of

1) a high energy, high intensity CW beam of electrons,
2) the use of the zero-degree enhancement of the flux of virtual photons [1,2], and
3) high pion and electron rejection from the reaction events.

Hypernuclear spectroscopic data are important as one hopes to determine indirectly the lambda-nucleon effective interaction. The parameters of this interaction are extracted after it is folded into the hadronic many-body system, and the resulting spectrum fitted to the data. Additional advantages of electroproduction include better energy resolution, and the production of hypernuclei, charge symmetric to those which are accessible through hadronic (K^-, π^-) and (K^+, π^+) processes. Finally, the electromagnetic process has a large spin-flip component producing states of non-natural parity.

2. *Experiment*

The layout of the experiment is shown in Fig. 1. The 1.8 Gev electron beam strikes the target and the unscattered component is transported to a beam-dump. The reaction products with positive charge are separated from the scattered and unscatterd beams by the splitting magnet (SM). The quadrupole (Q) accepts the positive projectiles, and focuses them into the short orbit spectrometer (SOS). Its short orbital path length allows more K^+s to reach the detectors. A number of paricle indentifying detectors (PIDs) and tracking chambers identify the reaction kaons, and determine the trajectories of the reaction products. In particular, the kaons must be identified in a large background of pions, protons and electrons. Electrons of approximately 300 MeV/c are accepted by the split pole, ENGE, spectrometer. This spectrometer had in its focal plane, a specifically designed position-sensitive solid-state-detector package in order to correlate the electron impact point with its momentum. Kinematical completeness was achivied in the off-line analysis by

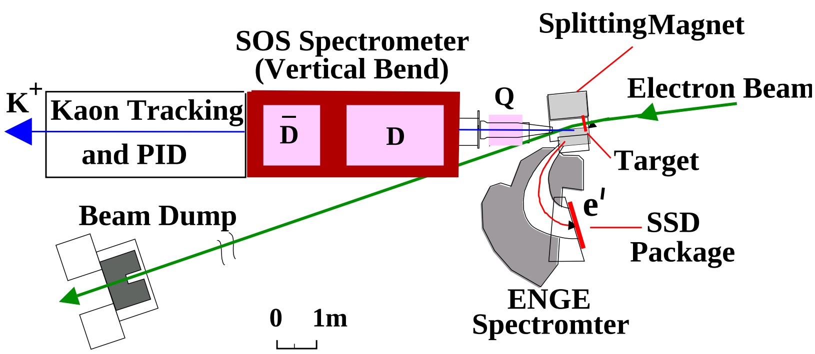

Fig. 1. The layout of the first hypernuclear electroproduction experiment at the Jefferson Lab.

requiring a tight timing cut between the SOS and ENGE arms. Fig. 2 is a typical timing spectrum in the SOS spectrometer, which shows the separation of various hadrons in the spectrometer.

The entire system, including the focal plane positions vs. momenta, was calibrated by observing the position of the Λ and Σ peaks in the $H(e, e')Y$ reaction from a CH_2 target.

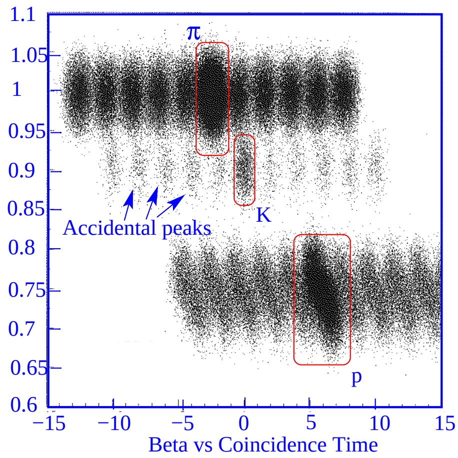

Fig. 2. TOF between the beam and the SOS focal plane showing separation between the various reaction hadrons.

3. Results

The experimentally accumulated ${}^{12}_{\Lambda}$B missing mass spectrum is shown in Fig. 3. The accidental background is obtained by averaging the spectra from eight out-of-time peaks. The curve over the data is a theoretical calculation using Gaussian

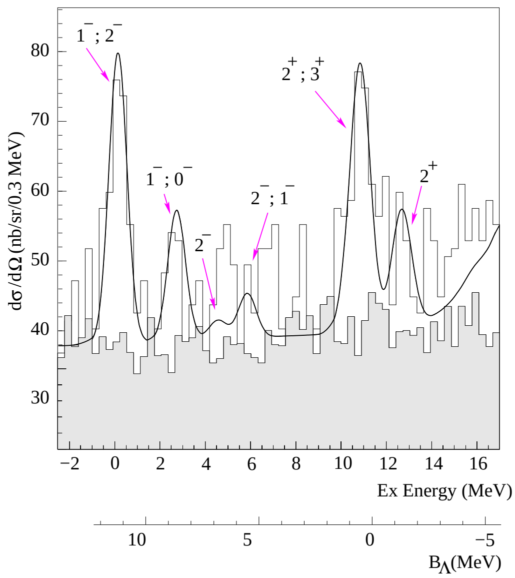

Fig. 3. The ${}^{12}_{\Lambda}$B spectrum showing accidental background and a theoretical prediction.

peaks of 900 keV FWHM at the predicted positions of the excited states. The strength of the excitations comes from a prediction [3,4] of Motoba et al. This curve is overlayed on, not fitted to the data. One sees similarities between the theory and the experiment, and several important features are well reproduced. The ground state doublet $(1^-, 2^-)$ and the $(2^+, 3^+)$ excitations, although not resolved, dominate the data. The remaining spectrum, having much smaller statistics, shows partial agreement and leaves some interesting questions. This suggests that more careful treatment of weaker excitations and increased experimental statistics are needed.

4. Conclusion

Several novel techniques were combined with the qualities of the Thomas Jefferson National Acceleration Facility accelerator to produce the first electroproduced hypernuclear spectrum. This spectrum has the best experimental resolution yet attained by reaction spectroscopy, and promises to provide new insights into hypernuclear physics. The use of the $(\mathrm{e}, \mathrm{e'K^+})$ reaction examines hypernuclei complementary to those produced by mesonic induced reactions. Studies of this kind in heavy hypernuclei may provide new insights into the nuclear interior, using the Λ as a probe. Finally, they show the power of the new CW electron accelerators when addressing long-standing problems in nuclear physics.

Acknowledgements

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SPEKTROSKOPIJA VISOKOG RAZLUČIVANJA HIPERJEZGRE $^{12}_{\Lambda}$B PROIZVEDENE REAKCIJOM $(\mathrm{e}, \mathrm{e'K^+})$

U Thomas Jefferson National Acceleration Facility načinili smo prvo mjerenje elektrotvorbe hiperjezgre. Primijenili smo reakciju $(\mathrm{e}, \mathrm{e'K^+})$ na meti prirodnog C i opažali hiperjezgre $^{12}_{\Lambda}$B. Raspravljamo spektar uzbude.