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First measurement of Ξ^- polarization in photoproduction

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ABSTRACT

Despite decades of studies of the photoproduction of hyperons, both their production mechanisms and their spectra of excited states are still largely unknown. While the parity-violating weak decay of hyperons offers a means of measuring their polarization, which could help discern their production mechanisms and identify their excitation spectra, no such study has been possible for doubly strange baryons in photoproduction, due to low production cross sections. However, by making use of the reaction $\gamma p \to K^+K^+\Xi^-$, we have measured, for the first time, the induced polarization, P, and the transferred polarization from circularly polarized real photons, characterized by C_x and C_z, to recoiling Ξ^-s. The data were obtained using the CEBAF Large Acceptance Spectrometer (CLAS) at Jefferson Lab for photon energies from just over threshold (2.4 GeV) to 5.45 GeV. These first-time measurements are compared, and are shown to broadly agree, with model predictions in which cascade photoproduction proceeds through the decay of intermediate hyperon resonances that are produced via relativistic meson exchange, offering a new step forward in the understanding of the production and polarization of doubly-strange baryons.

1. Introduction

The polarization of hyperons can be measured through the angular distribution of their parity-violating weak decay products, providing insight into the mechanisms behind their production. Such measurements involving the photo- and electroproduction of Strangeness number $S = -1$ hyperons [1–12] have led to significant progress in understanding the excitation spectrum of $S = 0$ nucleons [13–25]. A similar opportunity exists in studying the polarization of $S = -2$ cascades, which could prove vital for understanding their production mechanism and in gaining an understanding of the excitation spectrum of $S = -1$ hyperons. However, because of the cascade's low production cross section and the resulting lack of available data, no previous cascade polarization measurements exist in either photo- or electroproduction.

The CLAS collaboration has reported cross-section measurements for cascade photoproduction [26,27]. In these data, a strong back-angle peaking in the center-of-momentum cascade angular distribution ($\cos\theta_\Xi$) was observed, which along with the invariant mass distributions of the $K^+\Xi^-$ system, suggested the significant role that intermediate hyperon resonances with masses of about 2 GeV play in cascade photoproduction. These results generated theoretical interest in understanding the production mechanism behind $S = -2$ states. In particular, Refs. [28,29] found it is necessary to include the contributions from the decay of high-mass hyperons (up to $\Lambda(1890)$) that are predominately produced in t-channel K/K^* exchange, as illustrated in Fig. 1, to explain the CLAS cross-section measurements [27]. Furthermore, Ref. [29] investigated the role of the addition of high-spin hyperon states around 2 GeV and found significant contributions from spin/parity $J^P = \frac{5}{2}^\pm$ and $\frac{7}{2}^\pm$ resonances. In particular, the inclusion of the $\Sigma(2030)\frac{7}{2}^+$ state improved the model's agreement with the data.

These earlier photoproduction data from CLAS did not have either beam or target polarization, and no study on induced polarization was carried out. But as pointed out in Ref. [29], both the induced and transferred polarization of the cascade ground state are sensitive to the production mechanism, particularly, the mass, spin and parity of intermediate hyperon resonances, as well as to the mesonic exchange mechanisms.

The majority of early data for hyperon and cascade spectroscopy was generated using K^- beams on nuclear targets. However, the significance of the $Y^* \to K\Xi$ decay has never been firmly established except for the small branching ratios and branching-ratio upper limits reported for $\Lambda(2100)\frac{7}{2}^-$ and $\Sigma(2030)\frac{7}{2}^+$ [30–33] in the 1960's and 1970's. In general, the excitation spectrum for $S = -1$ hyperons also remains under-explored, particularly in the high mass (> 2 GeV) region. When compared with model predictions, cascade polarization measurements can build on the evidence for or against intermediate hyperon resonances as the dominant production mode, discriminate among the

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