International Journal of Modern Physics: Conference Series
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$K^*(892)^0\Lambda$ & $K^+\Sigma^*(1385)^-$ Photoproduction on the Deuteron

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Received Day Month Year
Revised Day Month Year

Preliminary measurements of the differential cross sections of the $\gamma n \to K^*(892)^0\Lambda$ and $\gamma n \to K^+\Sigma^*(1385)^-$ reactions are shown using data from the Jefferson Lab Hall B CLAS g13 experiment. No experimental cross section data have yet been published on the $\gamma n \to K^*(892)^0\Lambda$ reaction, and the only published cross section data on the $\gamma n \to K^+\Sigma^*(1385)^-$ reaction are at forward angles, where t-channel K^+ and K^{*+} exchanges are predicted to dominate. These data can be used to contribute to the search for the "missing" N^* resonances, some of which are predicted to have non-negligible couplings to the excited strangeness channels.

Keywords: Photoproduction; N*; Deuteron; K*(892)0, Sigma*(1385)-, CLAS

PACS numbers: 11.25.Hf, 123.1K

1. Introduction

About a dozen N^* states have been well-established according to the Particle Data Group[1], but some relativized quark models[2] predict that many more N^* resonances exist. However, diquark models[3] predict that the N^* spectrum is limited by a correlated quark-pair in the nucleon. Some models of baryon decays[4] predict that some of the unobserved N^* states couple non-negligibly to the strangeness channels. Measurements of the cross sections and polarization observables of strangeness photoproduction reactions on the proton and the neutron can provide additional constraints on the extraction of the N^* resonance parameters, which will provide valuable information on the relevant degrees of freedom within the nucleon.

The CLAS detector[5] is located in experimental Hall B at Jefferson Lab in Newport News, VA. Its torus magnet bends charged particles through drift chambers, time-of-flight scintillator paddles, and other detector components with a large angular acceptance. The CLAS g13 experiment[7] ran between October 2006 and June 2007 with a 40-cm-long liquid-deuterium target located within CLAS. For the data used in this analysis, an ~80% circularly polarized photon beam was produced via bremsstrahlung by a 2.655 GeV electron beam incident on a photon tagger[6].

2. Analysis

Both the $\gamma n \to K^*(892)^0\Lambda$ and $\gamma n \to K^+\Sigma^*(1385)^-$ reactions were studied through their decays to $\gamma D \to K^+\pi^-\Lambda(p)$, with $\Lambda \to p\pi^-$. A series of cuts were placed on the g13 data to select these events, incuding particle identification cuts, a $\pm 3\sigma$ Λ invariant mass cut, and a $\pm 3\sigma$ spectator proton missing mass cut.

$\pm 1\Gamma$ overlap cuts on the Breit-Wigner fits to the resonance mass peaks were placed to remove the majority of the potential interference effects between the $\gamma n \to K^*(892)^0\Lambda$ and $\gamma n \to K^+\Sigma^*(1385)^-$ reactions. These cuts were only placed at photon energies greater than 1.9 GeV, as no $\gamma n \to K^*(892)^0\Lambda$ events were discernible at lower energies. By varying these overlap cuts and comparing the cross sections, the potential interference effects between these reactions were determined to be smaller than the uncertainties in the studies. Approximately 4100 $\gamma n \to K^*(892)^0\Lambda$ events and 18000 $\gamma n \to K^+\Sigma^*(1385)^-$ events were extracted.

However, some backgrounds from events with an additional missing photon in the final state were still present. Due to low statistics the angular dependence of these backgrounds was not determined. Instead, these backgrounds were assigned as scale uncertainties for each of the different photon energy bins. These uncertainties ranged between ∼5.4% and ∼18.0% for the $\gamma n \to K^*(892)^0\Lambda$ reaction, and were negligible for the $\gamma n \to K^+\Sigma^*(1385)^-$ reaction. This background in the $K^*(892)^0$ distribution is assumed to be from $\gamma n \to K^*(892)^0\Sigma^0$ events.

3. Preliminary Results

The preliminary differential cross section of the $\gamma n \to K^*(892)^0\Lambda$ reaction from the CLAS g13 experiment is shown in Figure 1 compared against the model prediction by Oh and Kim[8]. This model is based on effective Lagrangians, and is partially constrained by the preliminary total cross section measurement of the $\gamma p \to K^*(892)^+\Lambda$ reaction[9]. However, it was later found that this $\gamma p \to K^*(892)^+\Lambda$ preliminary total cross section was low by a factor of 1.5 due to a scaling error[10], and the model predictions have not yet been updated to take this into account. However both the model and the data exhibit a strong forward-angle peak, indicating that the reaction is dominated by t-channel interactions.

The preliminary differential cross section of the $\gamma n \to K^+\Sigma^*(1385)^-$ reaction from the CLAS g13 experiment is shown in Figure 2 compared against the published LEPS results[11] and the model prediction by Oh, Ko, and Nakayama[12]. While the g13 and LEPS results agree within the uncertainties, overall the model predictions are ∼57% less than the g13 data. These model predictions were also based on effective Lagrangians, and were partially constrained by a preliminary total cross section measurement of the $\gamma p \to K^+\Sigma^*(1385)^0$ reaction[9]. The forward-angle peak indicates that the $\gamma n \to K^+\Sigma^*(1385)^-$ reaction is dominated by t-channel interactions.

The g13 $\gamma n \to K^*(892)^0\Lambda$ preliminary cross section is shown compared against the ground-state $\gamma p \to K^+\Lambda$ cross section[13] in Figure 3(A) for one of the photon energy bins. Although there is no known measurement of the $\gamma n \to K^0\Lambda$ cross section, this comparison illustrates that the photoproduction cross section of the excited, $K^*\Lambda$ channel is sizable to that of the ground-state $K\Lambda$ channel, especially at larger angles. As shown in Figure 3(B), the LEPS and preliminary g13 $\gamma n \rightarrow K^+\Sigma^*(1385)^-$ cross sections are similar to that of the ground-state $\gamma n \rightarrow K^+\Sigma^-$ reaction[14] at larger angles. The similar scales of these cross sections indicate that it is important to include these excited channels in the coupled-channels analyses

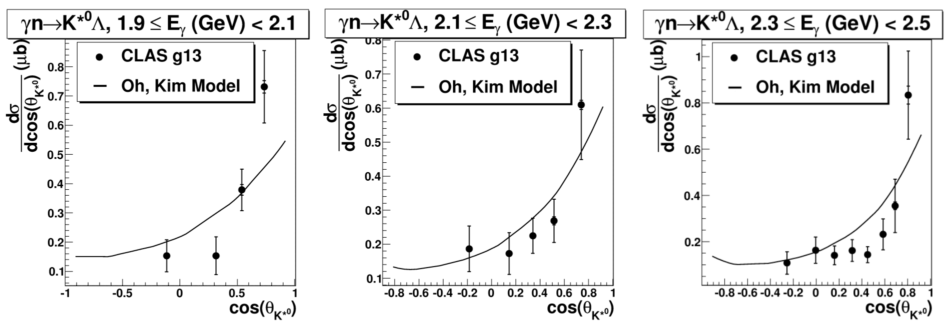

Fig. 1. The preliminary CLAS g13 differential cross section of the $\gamma n \rightarrow K^*(892)^0\Lambda$ reaction, compared against the model predictions by Oh and Kim[8]. Both the statistical and total uncertainties are shown for the CLAS g13 data.

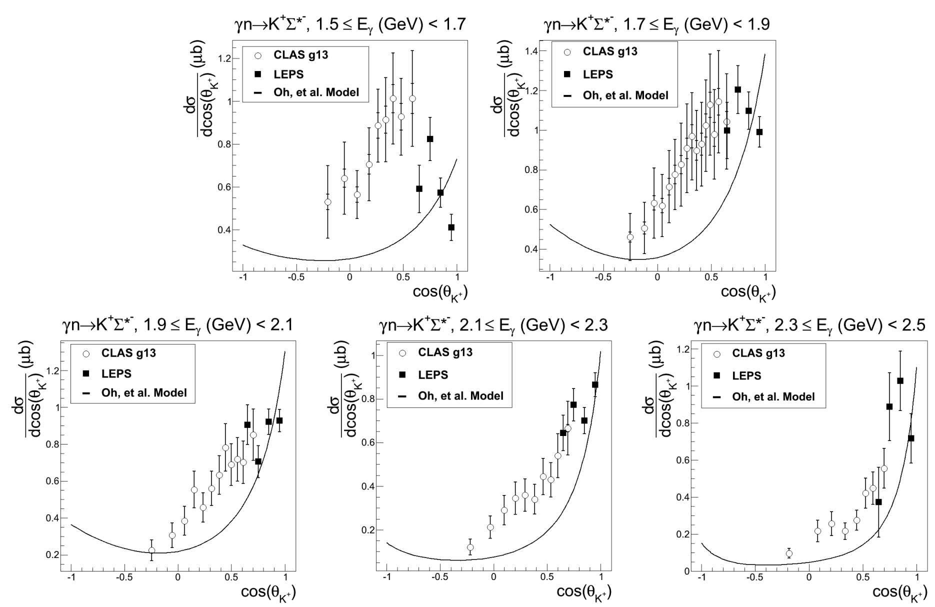

Fig. 2. The preliminary CLAS g13 differential cross section of the $\gamma n \rightarrow K^+\Sigma^*(1385)^-$ reaction, compared against the LEPS results[11] and the model predictions by by Oh, Ko, and Nakayama[12]. Both the statistical and total uncertainties are shown for the CLAS g13 data.

that are used for extracting the N^* resonance parameters.

Future improvements in yield extraction techniques and the determination of the CLAS acceptance will significantly reduce the systematic uncertainties on these preliminary cross section data. When finalized, these data can be used to contribute to the search for the missing N^* resonances.

Acknowledgments

The author would like to thank his graduate advisers and CLAS collaborators for their assistance on this research. This work was supported in part by a U.S. Department of Energy grant.

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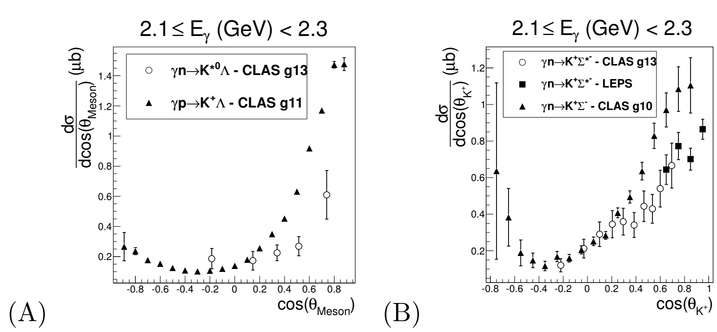

Fig. 3. (A) Comparison of the preliminary CLAS g13 $\gamma n \to K^*(892)^0\Lambda$ differential cross section and the CLAS g11 ground-state $\gamma p \to K^+\Lambda$ cross section[13] for one of the photon energy bins. (B) Comparison of the LEPS[11] and preliminary CLAS g13 $\gamma n \to K^+\Sigma^*(1385)^-$ differential cross sections to the CLAS g10 ground-state $\gamma n \to K^+\Sigma^-$ reaction[14].