Results for Photoproduction of the Λ (1405) Hyperon at CLAS

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The precise nature of the Λ(1405) hyperon has remained unsettled for decades. Observed as a resonance just below N-Kbar threshold and decaying into a $\Sigma\pi$ final state, its internal structure and its place in the spectrum of hyperons are still debated. Previous experiments dating back to the 1970's have observed a distortion of its invariant mass spectrum (line shape) from a simple Breit-Wigner form. Most theories agree that the closeness of the N-Kbar threshold and the strong coupling of the Λ(1405) to that final state has a strong influence on the line shape, but until recently, there was not enough experimental data to draw strong conclusions among various theories.

The CLAS collaboration at Jefferson Lab has conducted an analysis of photoproduction of the Λ(1405) on a proton target, with unprecedented statistics[1]. The large acceptance of the CLAS detector allowed measurement and comparison of the line shapes of the three decay modes $\Sigma^+\pi^-$, $\Sigma^0\pi^0$, and $\Sigma^-\pi^+$ for the first time from the same experiment for energies near production threshold up to a center-of-mass energy of 2.85 GeV. In all cases, the line shapes were qualitatively different from a simple relativistic Breit-Wigner form. Furthermore, as was predicted by a theory based on the chiral unitary approach [2], each of the $\Sigma\pi$ line shapes are significantly different from each other.

We have characterized all three line shapes across all energy bins by a single fit. In our model, coherent isospin I = 1 amplitudes are allowed to interfere with the dominant I = 0 amplitude, and the opening of the N-Kbar threshold was taken into account via a Flatté formalism. Our results show that the data prefer the centroid of the I = 0 amplitude to be near the $\Sigma\pi$ threshold, and that the opening of phase space, together with the strong coupling to the N-Kbar channel, explain the appearance of the Λ(1405) line shape peaking near 1400 MeV/c^2. The region around the Λ(1405) has non-negligible I = 1 contributions, and we characterize these as additional Breit-Wigner line shapes.

In addition to the mass distributions of the Λ(1405), we report first-time measurements of the differential cross section. We compare this with the cross sections for the neighboring excited hyperons, the Σ(1385) and the Λ(1520), that were measured at the same time.

References:
[1] K. Moriya, R. Schumacher et al. (CLAS collaboration)
arXiv:1301.5000 (nucl-ex) (submitted to Phys. Rev. C)
[2] J. C. Nacher, E. Oset, H. Toki, A. Ramos, Nucl. Phys. B455, 55 (1999)