Clear indication of a strong $I=0$ $\bar{K}N$ attraction in the $\Lambda(1405)$ region from the CLAS photo-production data

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The possible existence of deeply bound kaonic nuclear systems was proposed[1)] more than a decade ago, based on an ansatz that $\Lambda^* \equiv \Lambda(1405)$ mass is 1405 MeV/c^2, where Λ^* is a $\bar{K}N$ quasi-bound state decaying to $\Sigma\pi$. Recently, a large number of data on the photo-production of $\Lambda(1405)$ in the $\gamma p \to K^+\pi^{0\pm}\Sigma^{0\mp}$ reaction were provided by the CLAS collaboration[2)], and the double-pole structure of Λ^* has been intensively discussed by chiral dynamics analyses[3–5)].

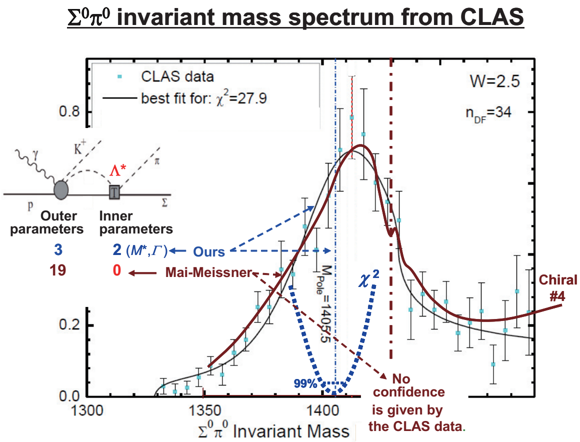

Fig. 1. Analyses of a $\Sigma^0\pi^0$ invariant mass spectrum from CLAS. Mai-Meissner's analysis (brown) with chiral theory and Hassanvand-Akaishi-Yamazaki's analysis (black and blue) are compared.

We have analyzed the CLAS data. Figure 1 compares two CLAS-data analyses. The most essential question is what the pole position of Λ^* extracted from the CLAS data themselves is. To answer it, we classified χ^2 fitting parameters into "inner" and "outer" ones, where the "inner" indicates the parameters appearing inside the T-matrix which can vary the pole position and width of Λ^*. The double pole positions recommended in Ref.[5)] are cases selected using only "outer" parameters, holding the pole position unchanged in χ^2 fitting processes. Therefore, the chiral pole position in Ref.[4)], for example, gets no confidence from the CLAS data. On the other hand, we used the Λ^* pole position and width as fitting parameters and found the χ^2 minimum at 1405.5 MeV/c^2, rejecting the chiral result with more than 99% statistical significance.

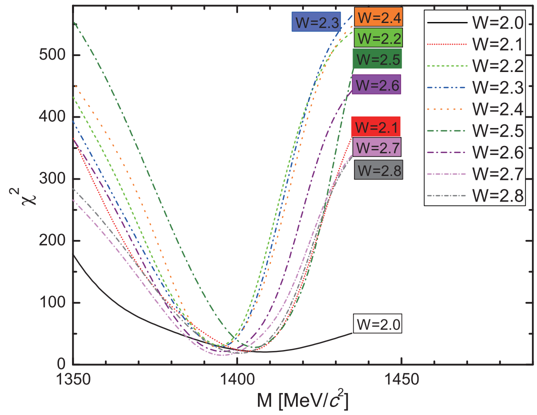

Fig. 2. Variation of χ^2 values with respect to Λ^* pole position parameter M for the $\Sigma^0\pi^0$ invariant mass spectra at γp total energies, $W = 2.0 - 2.8$ GeV, from CLAS. The χ^2 minimum appears around 1400 MeV/c^2.

Figure 2 shows the variation of χ^2 values with respect to the Λ^* pole position for all the $\Sigma^0\pi^0$ invariant mass data from CLAS. The χ^2 minimum $\chi^2_{\rm min}(M = M_{\rm pole})$ appears around $M_{\rm pole}$ = 1400 MeV/c^2 in all cases. Statistical confidence of the Λ^* pole position $M_{\rm pole}$ can be obtained incrementing $\Delta\chi^2(M) \equiv \chi^2(M) - \chi^2_{\rm min}(M_{\rm pole})$: $\Delta\chi^2 = 2.36, 4.74, 9.23$, corresponding to confidence levels of 68.3%, 95% and 99.9%, respectively. Thus, the confidence of the Λ^* pole position, that is of our main concern, was obtained through the "inner" fitting parameters. It is again stressed that the "outer" parameters used in Ref.[4)] (see also Table in Ref.[5)]) cannot get any *quantitative* confidence about the Λ^* pole position, in spite of the seemingly beautiful reproduction of all the global neutral and charged spectra of CLAS.

In summary, the pole position for $\Lambda(1405)$ extracted from the CLAS photo-production is not shallow-$\bar{K}N$-binding ones, 1421 $\sim$ 1434 MeV/c^2 [5)], but is consistent with the deep-$\bar{K}N$-binding PDG value $1405.1^{+1.3}_{-1.0}$ MeV/c^2.

References

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