Theoretical analysis of $\Lambda(1405) \rightarrow (\Sigma\pi)^0$ mass spectra produced in $p + p \rightarrow p + \Lambda(1405) + K^+$ reactions

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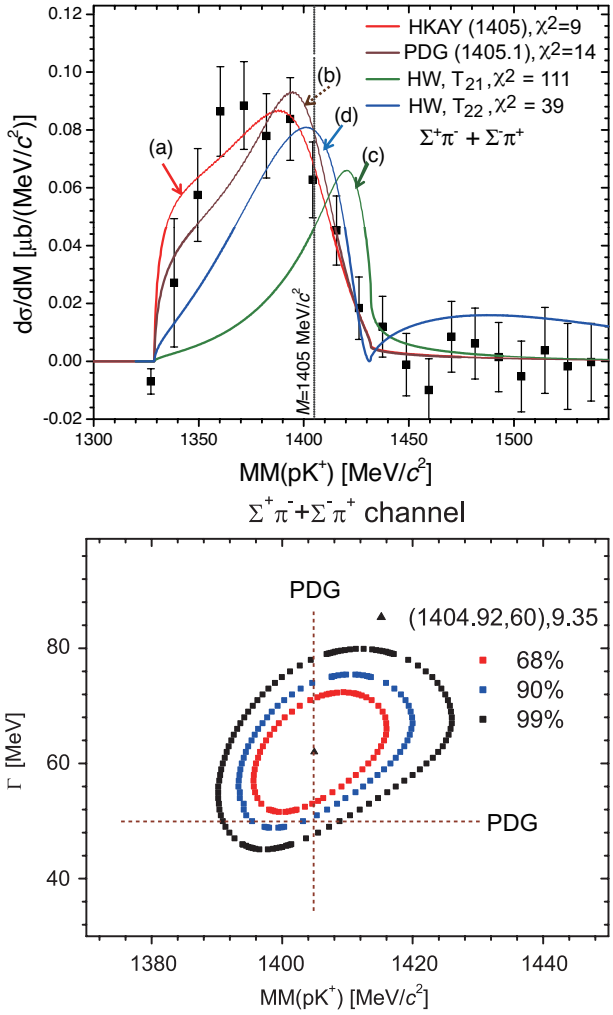

Fig. 1. (Color online) (Upper) Comparison of HADES data ($\Sigma^+\pi^- + \Sigma^-\pi^+$, closed squares) at $T_p = 3.50$ GeV[?)] with best-fit theoretical spectral functions $S(x)$. a) Best-fit HKAY curves (with $\chi^2 = 9.5$, $M = 1405^{+11}_{-9}$ MeV/c^2 and $\Gamma = 62 \pm 10$ MeV). b) AY model with the PDG parameters (with $\chi^2 = 14$, $M = 1405.1^{+1.3}_{-1.0}$ MeV/c^2 and $\Gamma = 50$ MeV[6)]). The *Chiral* model using HW's T_{21} (with $\chi^2 = 111$, c)) and T_{22} (with $\chi^2 = 40$, d)). (Lower) Confidence level contours from χ^2 fitting of the HADES data of $\Sigma^+\pi^- + \Sigma^-\pi^+$ at $T_p = 3.50$ GeV. The PDG12 values are also shown.

We formulated the $\Lambda(1405)$ (abbreviated as Λ^*) $\rightarrow (\Sigma\pi)^0$ invariant-mass spectra produced in $p + p \rightarrow p + \Lambda^* + K^+$ reactions, in which both the incident channel for a quasi-bound K^-p state and its decay process to $(\Sigma\pi)^0$ were taken into account realistically[1)]. We calculated $M(\Sigma\pi)$ spectral shapes for various theoretical models for Λ^*. They are asymmetric and skewed, and were compared with recent experimental data of HADES[2)]. The nearly isotropic proton distribution observed in DISTO[3)] and HADES is ascribed to a short collision length in the production of Λ^*, which justifies the high sticking mechanism of Λ^* and the participating proton into K^-pp[4)].

In the present work we formulate the spectral shape of the $(\Sigma\pi)^0$ mass to provide theoretical guides to analyze experimental data of $(\Sigma\pi)^0$ mass spectra from the above reaction. We take into account both the formation and the decay processes of Λ^* in pp reactions realistically, following our $\bar{K}N - \Sigma\pi$ coupled-channel formalism[5)]. In this way, we derive the general form of the spectral function, which is not symmetric, but skewed with respect to the pole position. Then, we analyzed $(\Sigma^{+-}\pi^{-+})^0$ spectra from HADES at $T_p = 3.50$ GeV[2)], and obtained: $M(\Lambda^*) = 1405^{+11}_{-9}$MeV/$c^2$ and $\Gamma = 62 \pm 10$ MeV, where the interference effects of the $\bar{K}N$-$\Sigma\pi$ resonance with I= 0 and 1 $\Sigma\pi$ continuum are considered. Whereas the HADES spectrum shows a very broad peak centered around 1385 MeV/c^2, significantly lower lying than 1405 MeV/c^2, we have clarified that it is due to kinematical distortion. The present result on M and Γ is in good agreement with the PDG12 and PDG14 values[6)]. The Hyodo-Weise (HW) spectra[7)], shown as the curves (c) and (d) in the figure, do not account for the experimental spectrum.

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