Effect of three-body final-state interactions on meson resonances in $\gamma p \to \pi\pi\pi N$ reaction

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Meson properties are important information for understanding the confinement mechanism of QCD. In recent years, more emphasis has been placed on the study of mesons with quantum numbers beyond the classification of conventional constituent quark model. Such mesons, called exotic mesons, are expected to have explicit gluonic and/or four-quark components in their structure. Therefore the search for exotic mesons has been an important goal in the experiments on $\pi N \to M^* N \to \pi\pi\pi N$ at BNL and CERN, and $\gamma N \to M^* N \to \pi\pi\pi N$ at JLab, where the intermediate excited mesons M^* could be exotic. However, the existence of exotic mesons, such as $\pi_1(1600)$ ($J^{PC} = 1^{-+}$) has not been conclusive so far. The forthcoming experiments to be performed at JLab after the 12 GeV upgrade are aimed at providing high precision data for making progress in this direction. In addition to searching for exotic mesons, the new data can also be useful for investigating some mesons that could have exotic structure and can be revealed in their characteristic decay patterns, as discussed in Ref. [1] with the $^3P_0$ model.

We are here interested in the excited mesons that decay into three light mesons ($\pi\pi\pi$, $\pi\pi K$, etc.). Since these excited mesons are unstable and couple with multi-mesons continuum to form resonances, the meson spectroscopy can be determined only by analyzing the resonances extracted from the meson production reaction data. Conventionally, these data were analyzed by using the so-called isobar model (IM) in which two of the three mesons form a light flavor excited meson R (f_0, ρ, K^*, etc.) and the third meson is treated as a spectator of the propagation and the decay of R into two light mesons. This approach obviously violates the three-body unitarity and neglects the coupled-channels effects since the outgoing R can have multiple scattering with the third meson, as illustrated in Fig. 1.

Recently we developed a unitary coupled-channels model [2] that describes the three-mesons decays of the meson resonances, and applied it to analyze the $\gamma p \to M^* n \to \pi^+\pi^+\pi^- n$ reaction (Fig. 2) and study the importance of three-body unitarity and coupled-channels effects in extracting the excited meson properties [3]. We have found that while the IM can fit the same Dalitz plot data generated from our unitary model (UM), the extracted resonance parameters are rather different. Our finding indicates the limitation of the IM in establishing the meson spectroscopy.

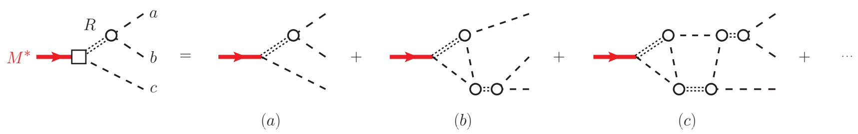

Figure 1: M^*-decay amplitude.

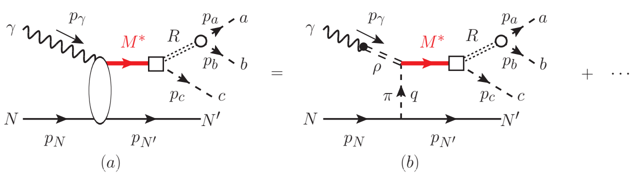

Figure 2: Graphical representation of the $\gamma N \to abcN'$ reaction.

References

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