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Analysis of hidden-charm pentaquarks as triangle singularities via deep learning

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The nature of the three narrow pentaquark states observed by the LHCb in 2019 remains a puzzle to the hadron physics community. While the hadronic molecule picture is favored by most analyses due to their proximity to two-hadron thresholds, a compact or even virtual state interpretation have yet to be completely ruled out. In addition, a purely-kinematic rescattering mechanism involving a triangle loop has been suggested as a possible origin for enhancements in the invariant mass, where the signal does not correspond to any unstable quantum state. Although this interpretation was shown to be unlikely for the $P_\psi^N(4312)^+$ and $P_c(4440)^+$ states due to lack of proper hadron-rescattering thresholds, it is still a plausible explanation for the $P_c(4457)^+$, requiring further amplitude analysis. In our study, we solve this general classification problem via machine learning, which works as a valuable tool in identifying the nature of enhancements. We develop, for the first time, a deep neural network (DNN) capable of distinguishing triangle singularity from pole-based amplitudes. After applying the trained DNN on the $P_\psi^N(4312)^+$ state, we reach a conclusion consistent with previous analysis that a pole-based interpretation is favored, and the triangle singularity may be ruled out for this signal. Similar DNN models are developed to classify the other two states. Finally, using our model-selection framework, we attempt to provide an interpretation for the $P_c(4457)^+$ state.

Keywords: pentaquark, triangle singularity, machine learning

session

B. Hadron Spectroscopy

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