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Compositeness of T_{cc} and $X(3872)$ with decay and coupled-channel effects

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The compositeness is useful to quantitatively characterize the internal structure of states whether it is composite dominant (molecular dominant) or not. There have been many studies to analyze the internal structure of the exotic hadrons with the compositeness, in particular, for weakly bound states [1,2]. It is known that the near-threshold states are dominated by the molecular structure in the limit of the vanishing binding energy [3]. However, the decay and coupled-channel effects modify the compositeness as shown in Ref. [1], and therefore the composite nature of the near-threshold states with finite binding might be affected by these contributions.

In this study, we focus on the compositeness of weakly bound states with the effective field theory. At first, to consider the nature of shallow bound states, we introduce a simple model with the coupling of the single-channel scattering to the bare state. The compositeness of the typical and shallow bound states is studied by varying the model parameter. In contrast to the naive expectation for shallow bound states, we demonstrate that a non-composite state can always be realized even with the small binding energy. At the same time, however, it is shown that a fine tuning is necessary to obtain the non-composite weakly bound state. In other words, the probability to find a model with the composite dominant state becomes larger with the decrease of the binding energy in accordance with the low-energy universality.

For the application to the exotic hadrons, we then discuss the modification of the compositeness by the decay and coupled-channel effects. We quantitatively show that these contributions suppress the compositeness, because of the increase of the fraction of other components. Finally, as the examples of the near-threshold exotic hadrons, the structure of T_{cc} and $X(3872)$ is studied by evaluating the compositeness. We find the importance of the coupled-channel and decay contributions for the structure of T_{cc} and $X(3872)$, respectively. Details of this study can be found in Ref. [4].

[1] Y. Kamiya and T. Hyodo, PTEP 2017, 023D02 (2017)
[2] T. Kinugawa and T. Hyodo, Phys. Rev. C 106, 015205 (2022)
[3] T. Hyodo, Phys. Rev. C 90, 055208 (2014)
[4] T. Kinugawa and T. Hyodo, arXiv:2303.07038 [hep-ph]

Collaboration

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