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Weak-binding relation in the zero range limit

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The ordinary hadrons consist of two quarks for mesons or three quarks for baryons. The hadrons with the other structures such as the multi-quark states or the hadronic molecular states are called exotic hadrons. Here, we would like to determine the structure of exotic hadrons using the weak-binding relation for the near-threshold hadrons. In the weak-binding relation, we can determine compositeness of the hadron X defined as the weight of the hadronic molecule component. The relation is expressed by the observables such as the scattering length a_0 and the radius R. Determining X from the observables, we can analyze the internal structure of exotic hadrons without any model calculations. The relation has the correction terms, which are estimated by the typical length of the interaction R_typ. Therefore the corrections terms vanish in the exact zero range limit R_typ=0. We show that there are exceptional cases which violate the weak-binging relation, when the zero range limit is taken with a fine tuning of parameters. We propose a suitable modification of the correction terms of the weak-binging relation with the redefinition of R_typ, so that the relation is valid also in the zero range limit. Originally, R_typ was given by the interaction range R_int, but we define R_typ as the largest value among R_int and R_eff. R_eff is defined as the length scale in the effective-range expansion expect for the scattering length a_0. We apply the modified weak-binding relation to the concrete model and evaluate the correction terms. We expect that the the system with large R_eff such as Lambda_c(2595) can be analyzed with the modified weak-binding relation.

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