Characteristics of $d + \alpha$ Bound and Resonant States from Analytic Continuation of the Effective-Range Expansion

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Asymptotic normalization coefficients (ANCs) for $a \to b + c$ processes are important characteristics of bound and resonant nuclear states. The ANC C_l is proportional to the vertex constant G_l which is expressed directly in terms of the residue of the partial bc scattering amplitude at the pole corresponding to the bound or resonant state a (l is the orbital angular momentum). In the present work one-[1] and two-channel [2] approaches using the expansion of the effective-range function $K(E)$ in powers of energy E are applied to the $d + \alpha$ system. The coefficients of the $K(E)$ expansion are found by fitting the $d\alpha$ phase shifts from the analyses [3,4]. By analytic continuation of $K(E)$ thus obtained to the corresponding poles we calculate characteristics of D wave $d\alpha$ resonances with $J^\pi = 1^+, 2^+, 3^+$. The ANCs C_l and VCs G_l ($l = 0, 2$) for the ground ^{6}Li state are also found. Note that the ANCs for ^{6}Li determine the cross section of the radiative capture reaction ^{4}He$(d,\gamma)^6$Li, which is the main process for the ^{6}Li creation in the Universe. The positions and widths of 2^+- and 3^+-resonances found in the one-channel approach with account of the Coulomb interaction are close to experimental ones [5]. The ANCs and VCs for these resonances are calculated for the first time. Their values are complex as distinct from the bound state case. The 1^+-resonance and the bound state of ^{6}Li ($J^\pi = 1^+$) are considered jointly in the two-channel ($S + D$) effective-range approach with the fixed binding energy of ^{6}Li in the $d + \alpha$ channel (1.47 MeV). The 1^+-resonance properties are mainly determined by the D channel whereas those of the bound state are determined by the S channel. For the bound state we obtain $C_0 = (1.96 \div 2.30)\text{fm}^{-1/2}$, which is close to the value given in [6]. Due to low accuracy of the phase-shift analyses the calculated $C_2 = (-0.12 \div 0.09)\text{fm}^{-1/2}$ turns out to be quite sensitive to the approximation details.

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