Exact Three-Body Approach to the Vertex Form Factor and the Asymptotic Normalization Coefficient for the Virtual Decay ^{6}Li |∀+ *d*

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Static observables of light nuclei as well as their wave functions can nowadays be determined using as input only the fundamental two- and three-nucleon forces (see, e.g., [1]). Since, however, such calculations require an enormous computational effort it still seems desirable to further develop models which are based on a characteristic property of many light nuclei, namely their pronounced cluster structure. Besides, not necessarily microscopic calculations neglecting clusterization and treating light nuclei as a bound state of nucleons would provide a better description than more simple cluster models.

Theoretical studies of the clustering properties in light nuclei have been performed within the resonating group method (RGM), the generator coordinate method (GCM), the *K*-harmonic method, the multicluster stochastic variational method (MSVM), the Lagrange-mesh method, and the three-body integral equations approach. In this way not only physical insight into the structure of nuclei was gained, but also a fair quantitative description of both static properties could be achieved without free parameter. In particular, sensitivities to different forms of the nucleon-nucleon, and in particular also of the effective nucleon-cluster and cluster-cluster interactions can be studied, at moderate computational expense. In recent years, special attention has been devoted to a further characteristic property of a nucleus, namely the so-called asymptotic normalization coefficient (ANC) [2]. Specifically, the ANC determines the magnitude of the amplitude of the virtual decay A | $B + c$ (or of the fusion reaction $B + c$ | A) of a nucleus A, and belongs to the fundamental nuclear constants like binding energy, magnetic moment, and electric quadrupole moment. This ANC plays an important role in investigations of peripheral nuclear reactions, with particularly important applications to the radiative capture reactions of astrophysical interest [3, 4].

The purpose of our work is to calculate the formfactor for the virtual decay ^{6}Li |∀ + *d* and its on-shell value, the ANC, within the three-body approach using the coupled Faddeev type integral equations. We also study the sensitivity of the ANC to different forms of the effective nucleon-∀ and ∀ - ∀ interactions. We modify the *N* - ∀ potentials to take into account the identity of the external nucleons and the nucleons in ∀-particle. Hence our three-body approach may be considered as a generalized three-body model.

The ANC for the virtual decay ^{6}Li |∀+*d* has been determined by analytic continuation from the ^{4}He + *d* phase shift analysis, with a good accuracy [5]. Theoretical investigations concerned the ANC's for the virtual decay ^{6}Li | ∀ + *d*, calculated with the three-body Schrödinger equation in momentum space, by interpreting ^{6}Li as a bound state of (∀ + n + p) [6, 7]. There it was shown in particular that the value of the ANC is very sensitive to the form of the two-cluster and NN-potentials used. For investigations of the ^{6}Li nucleus three-body methods are particularly appropriate as the (∀ + n + p)-configuration has a very large probability in the ^{6}Li ground state, at sufficiently small excitation energy so that the ∀-particle can be considered as elementary. In this context we emphasize that knowledge of reliable value of the ANC for the virtual decay ^{6}Li |∀ + *d* are of great importance, for several reasons. Firstly, they yield additional insight into the structure of ^{6}Li considered as a system of the three interacting particles ∀, *n* and *p*, thereby improving our knowledge of the relative contributions of the different states of the (∀ + *n* + *p*)-system. Secondly, comparison with experimental data [8, 5] allows for the extraction of valuable information about the effective ∀*N* potentials and for tests of the sensitivity to various aspects of the *NN* potential. And, last but not least, reliable ANC values play an extremely important role both in the determination of the dominant reaction mechanisms, an example being the exchange reaction ^{6}Li(∀, ^{6}Li) ∀, and in nuclear astrophysics [9, 10, 11].

For the first calculations we adopt the next potentials. We use Malfliet-Tjon (MT)-potential for the NN-interaction and Sack-Bidenham-Breit (SBB)-potential for the ∀*N*-interaction. To take into account the internal degrees of freedom of ∀-particle we eliminate the forbidden s-wave states for proton and neutron in ^{6}Li. It is achieved by adding the pseudopotential which projects out the s-wave bound states of both nucleons. Our preliminary result for the ANC for ^{6}Li |∀ + *d* is C^2 = 5.735 fm^{-1}. Even with the first tested potentials we achieve significantly better agreement with the experimental ANC C^2 = 5.29 $\pm$ 0.55 fm^{-1} [5] than the ANC C^2 = 3.7 fm^{-1} calculated in [12] using 6-nucleon microscopic approach.

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