Turk J Phy
24 (2000) , 93 – 104.
© TÜBİTAK

The Effect of Iterative Solutions in the Quasi-adiabatic Treatment of Transfer Reactions Involving Deuterons

M. YILMAZ & B. GÖNÜL
Department of Engineering Physics, University of Gaziantep, 27310 Gaziantep-TURKEY

Received 12.10.1999

Abstract

Using an iterative scheme, the effects of a more correct treatment of large n-p components of deuteron channel wavefunction in the continuum, which are associated with near-side contributions of transition amplitude, are investigated in the framework of the reformulated quasi-adiabatic model for the ^{116}Sn (d,p) ^{117}Sn reaction at 79 MeV bombarding energy. As the ℓ_n-transfer rises, the far-side amplitude increases with improvements in the linear and angular momentum responce, which results in a relative suppression of the near-side components of the amplitude. Therefore, one might expect that the iteration of the quasi-adiabatic model calculations could provide significant improvements for the momentum mismatched reactions associated with low ℓ_n-transitions at medium energies. However, the modifications brought by the iterative solution are analyzed quantitatively and shown not to be significant for both the angular momentum mismatched-volume dominated low ℓ_n-transitions and well angular momentum matched-surface dominated large ℓ_n-transitions, as there has been found no considerable effect on the angular distributions of the reaction observables in going from the zeroth order to the iterated calculations for the reaction of interest.

1. Introduction

The application of adiabatic ideas [1] to nuclear breakup effects played a key role in the development of models for the treatments of quantum mechanical three-body systems. The calculations [2] using the quasi-adiabatic approximation showed significant deviations and systematic improvements over the adiabatic model in the description of experimental data for large transferred neutron angular momentum-ℓ_n (d,p) transfer reactions at medium energies.

More recently, quite general alternative approximations [3] have been developed for more exact treatment of three-body wavefunctions in the breakup processes, which are extensions of ideas and methods of the original quasi-adiabatic technique [4], clarifying the assumptions underlying the model. The model represent the continuum by a single, average excitation energy function and use iteration methods for numerical solution, in which the adiabatic theory [1] is taken as a starting point .

The accuracy and the range of validity of these developments have been investigated [3] carefully and precisely by comparing their predictions with those of the essentially exact Coupled Discritized Continuum Channels (CDCC) technique [5] using the ^{66}Zn (d,p) ^{67}Zn reaction with large ℓ_n well-matched angular momentum transitions at 88.2 MeV. It has been shown [3] that the alternative models developed and quasi-adiabatic theory are reliable techniques for the treatment of the deuteron breakup process at intermediate energy, and zeroth order calculations of the quasi-adiabatic-like models are in fact sufficiently accurate for large ℓ_n transitions.

For completeness, we aim also, in this paper, to clarify the importance of the iteration procedure in mismatched transfer reaction calculations carried out by the reformulated quasi-adiabatic model. For this reason, we focus here on the recently studied [6] transfer reactions, the ^{116}Sn (d,p) ^{117}Sn system at 79 MeV with a number of transitions for different transferred neutron orbital angular momentum ℓ_n including both highly angular mom entum-mismatched and more volume-dependent transitions, well angular momentum-matched and, thus, surface-dominated transitions. To indicate the importance of the breakup corrections to the transfer reaction observables, we also include the adiabatic calculations in this work.

Current experimental activity in the area of light neutron rich and drip-line nuclei is now associated with the rapid development of calculable theoretical models for reactions and scattering of few-body systems. Quasi-adiabatic ideas may play an important role to improve Glauber-based non-eikonal adiabatic models [7] used to analyze such exotic systems. We therefore first concentrate, in the following section, on the proper formulation of the quasi-adiabatic model within the three-body context. Section 3 and 4 discuss calculation methods used and the results obtained, respectively. Concluding remarks are given in section 5.

2. An Alternative Formulation of The Quasi-Abiabatic Model

We present here an alternative development of a formal theory for the quasi-adiabatic method, which clarifies that such a model can be introduced by making only one single approximation, unlike the formulations of the model in Ref. [2,4]. Another advantage of this formulation is that one sees how to treat corrections to both the elastic and breakup components of the wavefunction, and to derive an iterative scheme for such changes. This was a significant uncertainty in the original quasi-adiabatic formulation of Amakawa et al. [4], in which it is stated that the elastic wavefunction is assumed unchanged, regardless of changes made in the breakup piece of the wavefunction.

Under the restriction to S-wave relative $n-p$ configurations, a formal development

of the quasi-adiabatic theory proceeds by decomposing the projectile-target three-body wavefunction into adiabatic wavefunction plus correction term, i.e.,

$$\Psi(r,\bar{R}) = \Psi^{AD}(r,\bar{R}) + \Delta\Psi(r,\bar{R}), \tag{1}$$

where $\Delta\Psi$ accounts for non-adiabatic corrections to the breakup and elastic channels, and has only outgoing waves since Ψ^{AD} already satisfies incoming wave boundary conditions. Upon substitution in the Schrödinger equation, then

$$\big[E - H_{np} - T_R - U(r,\bar{R})\big]\Delta\Psi(r,\bar{R}) = (H_{np}+\epsilon_d)\Psi^{AD,BU}(r,\bar{R}), \tag{2}$$

since $[E+\epsilon_d - T_R - U(r,\bar{R})]\Psi^{AD}(r,\bar{R}) = 0$ (see Ref. [1]). In the above equation, $H_{np}(= T_r + V_{np})$ is the $n-p$ Hamiltonian, T_R the center-of-mass kinetic energy operator and $U(r,\bar{R})$ is the sum of the neutron- and proton-target phenomenological optical potentials evaluated at half the incident deuteron energy. The proton-target Coulomb interaction, which is included in $U(r,\bar{R},)$ is assumed to act on the center-of-mass of the $n-p$ system. On the RHS of Eq. (2), $\Psi^{AD,BU}$ and ϵ_d represent the breakup part of the adiabatic model three-body wavefunction and the deuteron binding energy, respectively. To proceed, as the source term in Eq. (2) has an infinite range due to the incorrect behavior of $\Psi^{AD,BU}$ in the asymptotic region of R [1-6], one needs to use a proper description here for $\Psi^{AD,BU}$ such as [3]

$$\Psi^{AD,BU} = \big[E_{c.m.} - T_R - U(r,\bar{R})\big]^{-1}\big[U(r,\bar{R}) - U^{AD,opt}(\bar{R})\big]\Psi^{AD,EL}(r,\bar{R}), \tag{3}$$

where we have defined the so-called adiabatic optical potential $U^{AD,opt}$ which generates the elastic piece of the total adiabatic wavefunction, i.e.,

$$\big[E_{c.m.} - T_R U^{AD,opt}(\bar{R})]\Psi^{AD,EL}(r,\bar{R}) = 0 \tag{4}$$

with $E_{c.m.} = E + \epsilon_d$.

The substitution of Eq. (3) into Eq. (2) yields

$$\begin{aligned}\Delta\Psi(r,\bar{R}) = {} & \big[E - H_{np} - T_R - U(r,\bar{R})\big]^{-1}(H_{np}+\epsilon_d)[E_{c.m.} - T_R - U(r,\bar{R})\big]^{-1} \\ & \times\big[U(r,\bar{R}) - U^{AD,opt}(\bar{R})\big]\Psi^{AD,EL}(r,\bar{R}).\end{aligned} \tag{5}$$

It follows that

$$\begin{aligned}\Delta\Psi(r,\bar{R}) = {} & \Big\{\big[E - H_{np} - T_R - U(r,\bar{R})\big]^{-1} - \big[E_{c.m.} - T_R - U(r,\bar{R})\big]^{-1}\Big\} \\ & \times\big[U(r,\bar{R}) - U^{AD,opt}(\bar{R})\big]\Psi^{AD,EL}(r,\bar{R}),\end{aligned} \tag{6}$$

and hence we can write

$$\Delta\Psi(r,\bar{R}) = \Delta\Psi_1(r,\bar{R}) - \Delta\Psi_2(r,\bar{R}),$$

with

$$\big[E - H_{np} - T_R - U(r,\bar{R})\big]\Delta\Psi_1(r,\bar{R}) = \big[U(r,\bar{R}) - U^{AD,opt}(\bar{R})\big]\Psi^{AD,EL}(r,\bar{R}) \qquad (7)$$

$$\big[E_{c.m.} - T_R - U(r,\bar{R})\big]\Delta\Psi_2(r,\bar{R}) = \big[U(r,\bar{R}) - U^{AD,opt}(\bar{R})\big]\Psi^{AD,EL}(r,\bar{R}). \qquad (8)$$

The equation for $\Delta\Psi_1$ leads to the original quasi-adiabatic wavefunction [4]. $\Delta\Psi_2$ is precisely the adiabatic breakup wavefunction [1, 2] and has no overlap with the elastic channel. Thus $\Delta\Psi_1$ must include both elastic and breakup non-adiabatic corrections. The elastic piece can be extracted by projection. This makes clear that the assumption $\Psi^{EL} \approx \Psi^{AD,EL}$ of the original formulation [4], and of the extended one [2], is unnecessary. Therefore the reduction of the exact three-body equation to the quasi-adiabatic model requires only the replacement of H_{np} by an average breakup energy $\bar{\epsilon}$ in Eq. (7). The details of the resulting partial wave expansions and solution of the equations can be found in Sec. III of Ref. [2].

The quasi-adiabatic based calculations are iterated [3] in the sense that the mean excitation energy $\bar{\epsilon}$ [2] in each partial wave can be calculated from the latest best estimate of the associated wavefunction, i.e.

$$\bar{\epsilon}^{(i)}_{JL}(R) = \frac{\left\langle \chi^{(i)}_{JL}(r,R)\phi_d(r)\middle|H_{np}\middle|\chi^{(i)}_{JL}(r,R)\phi_d(r)\right\rangle}{\left\langle \chi^{(i)}_{JL}(r,R)\phi_d(r)\middle|\chi^{(i)}_{JL}(r,R)\phi_d(r)\right\rangle}, \qquad (9)$$

where the bra-kets denote the radial integration over r, χ_{JL} is the partial wave form of $\Delta\Psi_1$, and ϕ_d is the deuteron ground state wavefunction. In the above equation, JL indicates the inclusion of spin orbit interactions and (i) stands for the iteration number. The zeroth order iteration starts with use of the wavefunction produced by the adiabatic model.

In the context of (d,p) reactions, the total three-body wavefunction Ψ enters the transition amplitude as

$$T_{dp} = \left\langle \chi^{(-)}(\bar{r}_p)\phi_n(\bar{r}_n)\middle|V_{np}(r)\middle|\Psi(r,\bar{R})\right\rangle, \qquad (10)$$

with ϕ_n as the neutron bound state and $\chi^{(-)}$ the proton distorted wavefunction.

3. Calculations

Since the iterated quasi-adiabatic approach provides modifications to the three-body deuteron-channel wavefunction, one expects the calculations resulting from this method to

improve the predictions of the zeroth order quasi-adiabatic theory on reaction observables. In order to establish the significance of the modifications introduced by the iterative solution, we will evaluate the reaction observables, the cross section $d\sigma/d\Omega$ and vector analyzing power iT_{11}, and the trends of these observables will be compared with those of the zeroth order quasi-adiabatic and adiabatic model calculations.

Recent calculations [6] on the reaction considered here, including an adiabatic prescription for the deuteron channel wavefunction, finite range with the deuteron D-state, and non-locality corrections for both channels, have succeeded in providing a satisfactory qualitative description of angular distributions for large momentum mismatched reactions. Problems arising from the neglect of the non-S-wave breakup component in the adiabatic prescription were not apparent from the quality of the agreement obtained between theory and the measured angular distributions.

However, the adiabatic model had some difficulty [6] with the better-matched transitions. The inclusion in these calculations of finite-range effects, including transfer from the deuteron D-state, and non-locality corrections, while making significant improvements in the reaction observables, did not result in good agreement with the data, especially with the angular distributions of the analyzing powers. Such discrepancies between the adiabatic model transfer reaction calculations and the measurements were attributed [6] to an underestimate of the near side component of the reaction.

Here in particular, relaxing the assumed (adiabatic model) degeneracy of the $n-p$ center-of-mass energy in all breakup states, by means of the quasi-adiabatic calculations, could be of great importance. The presence of lower energy components in the center-of-mass wavefunction would favor an increased near-side amplitude, as appears required by the data [6]. This center-of-mass energy sensitivity is studied within the context of the present paper and the results are shown and discussed in the next section. Hence, the work presented in this paper clarifies not only the effect of iterative solutions in the quasi-adiabatic model calculations for transfer reactions but also gives an insight into the power of an extended adiabatic approach in analyzing well-matched transitions of interest here.

It is stressed however that the aim here is not the rigorous reproduction of experimental data but to understand the effects of the self-consistent mean energy calculations on the reaction observables for both volume- and surface-dominant transitions. In addition, at present, the ability to include all the important ingredients, such as the deuteron D-state effects and infinite range, are not at hand for the quasi-adiabatic model. Nevertheless, we feel that extended adiabatic ideas such as quasi-adiabatic calculations offer the best hope for a practical and better model of intermediate energy transfer reactions and therefore we intend to prepare such techniques for an eventual full implementation in the future. In the present analysis, due to the reasons mentioned above, the non-S-wave breakup continuum of the deuteron ground state D-wave component are not included. The calculations are carried out including the nucleon-target spin-orbit interactions, with dominant $^3S_1$ component of the deuteron ground state and $^3S_1$ breakup states.

The calculated three-body wavefunctions, in partial wave form, provided by the adiabatic, zeroth order and iterated quasi-adiabatic models, are employed in TWOFNR [8]

for the evolution of the reaction observables, performing the zero-range approximation. As the zero-range calculations of the stripping amplitude are determined by the total wavefunction at coincidence $\Psi(r = 0, R)$ [1], the physical interest in our work is therefore associated with the wavefunction at $n - p$ coincidence, $r = 0$.

The entrance channel nucleon-nucleus potentials used in the construction of the quasi-adiabatic and adiabatic model deuteron channel wavefunctions are obtained from the global parametrization of Bechetti and Greenlees [9]. The $n-p$ interaction is taken to be the central Hulthen potential. The final state interactions for the outgoing proton and bound neutron are as tabulated in [6].

The radial integrals are carried out from 0-20 fm in steps of 0.1 fm. The maximum number of partial waves used is 30 for both entrance and exit channels. The spectroscopic factors are set to 1 throughout the calculations.

4. Results and Discussion

The iterated mean energy is applied to the ^{116}Sn+d system at 79 MeV. We present here the mean energy only in the asymptotic region of R for $J = L(S = 0)$ because, at values R well outside the nucleus, the average continuum energy is constant, whereas it is a complicated function of R at short distances in every J and L state. The iteration $\bar{\epsilon}$ of shows considerable effects, especially for low center-of-mass partial waves. Fig. 1 displays the zeroth order calculations of the mean energy and its iterated results in the absence of spin-orbit interactions. One can easily see that the calculations converge quickly.

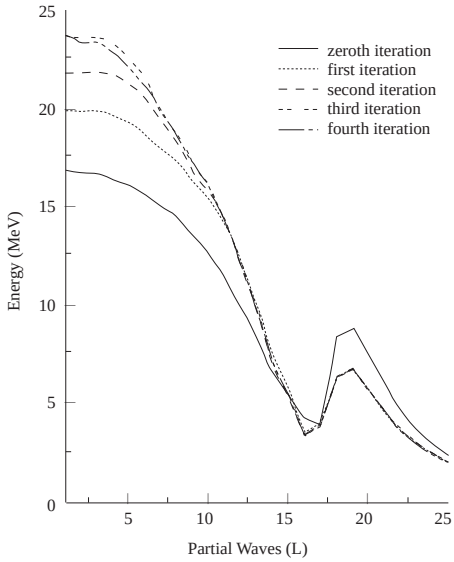

Figure 1. Large R behaviour of the iterated mean energy expressed in Eq. (9), in the absence of spin-orbit interaction, as a function of the $n - p$ center-of-mass partial wave L.

The iterated energy gives a larger expectation value for low partial waves, removes a greater amount of energy from the $n-p$ center-of-mass motion, and suggests an increase in the importance of high momentum components in the breakup channel. This an encouraging result since it is consistent with the requirement of the recent near-/far-side analysis [6]. The modifications to the mean energy at high partial waves are however fully introduced by the first order iteration. Overall, Fig. 1 suggests that the dominant relative momenta in the breakup continuum decrease with the increasing c.m. angular momentum in the asymptotic region of R. This is quite reasonable. Because the large momenta are associated with the near-side (the side toward to the detector) contributions [6].

The importance of the breakup wavefunction, and its modifications due to the iterative solution, in a transfer reaction calculation depends on the degree of linear and angular momentum matching between the entrance and exit channels, i.e.,

$$L_d \cong k_d R_S \quad L_p \cong k_p R_s, \tag{11}$$

where k_d and k_p are the linear momenta of the deuteron and proton respectively, and R_s is the transfer point in the surface of the target, while L_d and L_p are the corresponding angular momenta. So the larger contributions will be from partial waves that satisfy

$$L_d - L_p \cong (k_d - k_p) R_s \cong \ell_n, \tag{12}$$

where ℓ_n is the transferred neutron orbital angular momentum. From the above equation, good momentum matching emphasizes contributions from the nuclear surface region and the exterior, poor-matching involves greater contributions from the interior. Since the breakup wavefunction and the modifications brought by the iteration procedure will be largest in the interior according to Fig. 1, one may expect that the iteration procedure to play a limited role and give rather modest contributions to the reaction observables for well-matched stripping reactions while the iterative solution of the continuum channel wavefunction calculations in the framework of the quasi-adiabatic model may substantially change the results for low partial waves and could provide significant improvements for the momentum of mismatched reactions.

Nevertheless, use of the iterated mean energy in the calculations has shown that the modifications brought by the iteration procedure are not so significant and have no dramatic effects on the transfer reaction observables.

The cross section and vector analyzing power angular distributions calculated by the zeroth order and iterated quasi-adiabatic techniques, together with the adiabatic model results, for the ^{116}Sn (d,p) ^{117}Sn reaction at 79 MeV bombarding energy are shown in Figs. 2 and 3 for transitions with ℓ_n-transfer values ranging from 0 to 5. From Fig. 3 it is clear that the large momentum mismatch to the (d,p) reaction suppresses contributions from the surface deuteron partial waves and thus prevents the deuteron spin-orbit distortion from making a significant contribution to the spin-dependent observables iT_{11} in the $\ell_n = 0$ reaction.

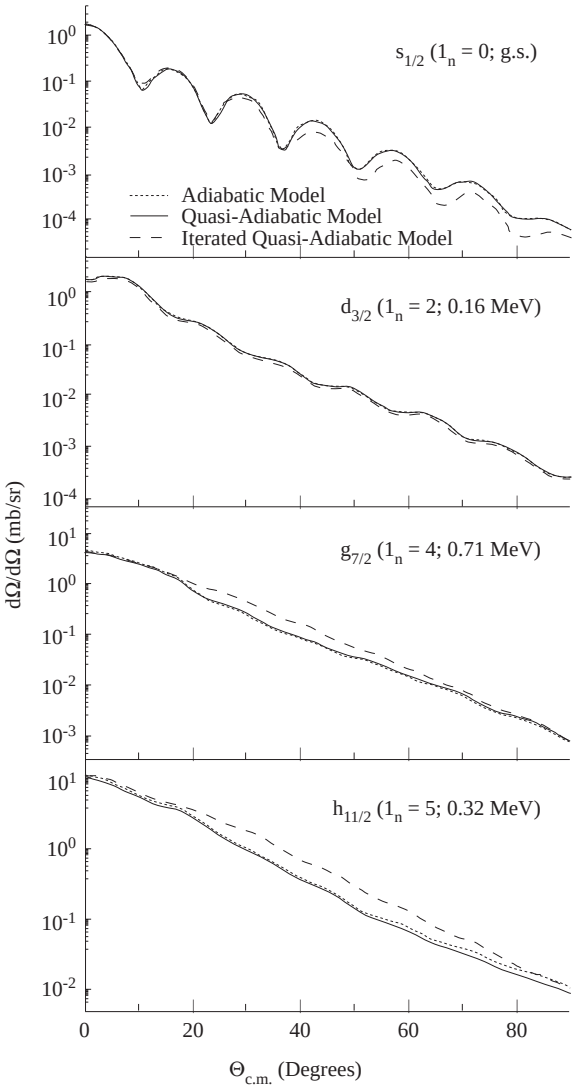

Figure 2. The zeroth order (solid curve) and iterated (dashed curve) quasi-adiabatic model calculated cross section angular distributions, together with those of the adiabatic approach (dotted curve), for the ^{116}Sn (d,p) ^{117}Sn reaction to the four lowest energy states in ^{117}Sn($j^\pi = 1/2^+, 3/2^+, 7/2^+$, and $11/2^-$). The spectroscopic factor is 1.0 for all calculations.

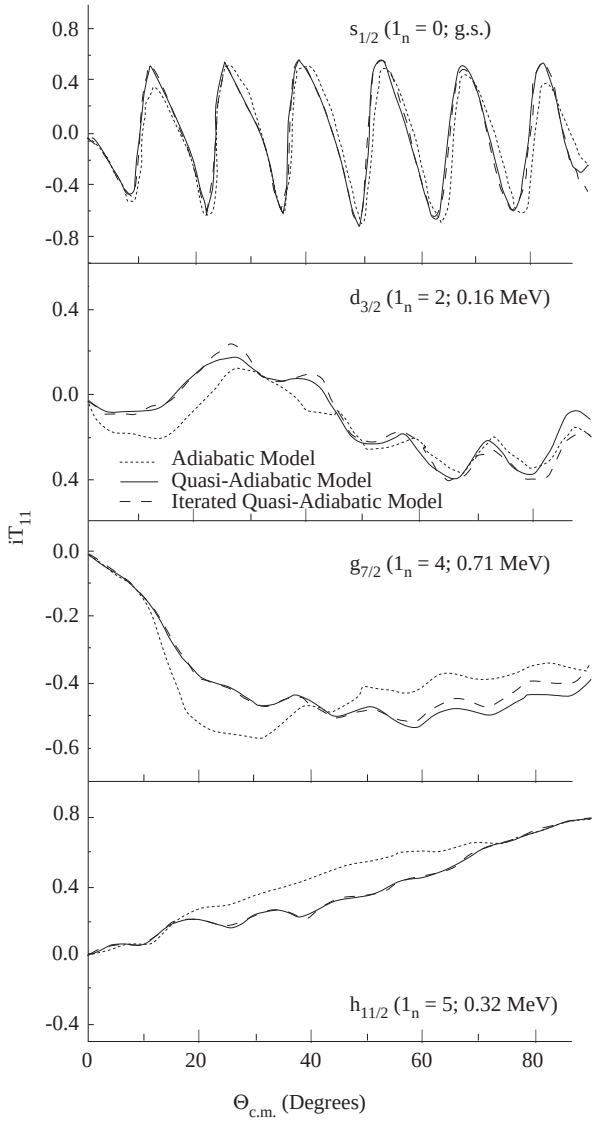

Figure 3. The same as Fig. 2, but the calculations are carried out for the vector analyzing power.

The cross section calculations for ℓ_n -transfer values of 0, 2 $j^\pi = 1/2^+, 3/2^+$) show comparable near-and far-side contributions and oscillatory angular distributions for the entire range of the scattering angle. This means that two sides of the nucleus are involved in the reaction. As the momentum matching improves with increasing ℓ_n-transfer, the

reactions become far-side (the side away from the detector) dominated. The interference pattern present in particular for the $\ell_n = 0$ transition gradually disappears with increasing ℓ_n value. The transitions with $\ell_n = 4$ and $\ell_n = 5$ are well-matched in angular momentum at the nuclear surface hence the angular distributions fall exponentially with angle. At large angles scattering form the near-side is very small, and the forward angle oscillations, which come from the interference of comparable sized near- and far-side amplitude, die out. While the vector analyzing power in particular for ℓ_n=5 shown in Fig. 3 saturates near unity. This saturation is a result of the large spin orbit effects which suppress scattering from all but one spin state at large angles.

However, on the near side of the nucleus, momentum and angular momentum matching within the adiabatic model are poor, suppressing the near-side amplitude overall due to the fixed value of the $n - p$ center-of-mass energy. The adiabatic model explicitly assumes that breakup exists only for low-energy relative $n - p$ configurations. Since the near-side amplitude would like to emphasize through the larger $n-p$ relative momentum at transfer, a major contribution is missing because of the incorrect dynamics of the $n-p$ relative and center-of-mass motion. This would indicate the need to replace the adiabatic approximation with a more powerful, such as quasi-adiabatic, approach.

From the quasi-adiabatic calculations, it is obvious that relaxing this assumed degeneracy of the $n-p$ center-of-mass energy in all breakup states is of great importance. The inclusion of higher energy components in the center-of-mass wavefunction leads to an increase in the near-side amplitude and thus gives a better description for the experimental data.

Therefore, use of the iterated solution within the quasi-adiabatic approach for more correct treatment of the continuum state involving large $n-p$ components associated with the near-side contributions are therefore expected to play an important role in further enhancement of the reaction observables. However, in contrast to this expectation, we have found no considerable effect on the angular distributions of the reaction observables in going from the zeroth order to the iterated calculations for the reaction of interest.

This may be understood as follows. If the L-dependence of the transition amplitude is expressed in terms of the radial overlap integrals, one can easily see that partial wave contributions to the transition amplitude are significant over many L-values, but gather most of their strength between L=8 and L=17 [6] through which there is no significant difference between our zeroth order and iterated mean energy calculations shown in Fig. 1.

Therefore, the work presented in this paper has justified the reliability of the zeroth order quasi-adiabatic calculations for transfer reactions involving deuterons at medium energies.

5. Concluding Remarks

The extended adiabatic models can be seen as an important tool for those hoping to understand the mechanism of transfer reactions involving loosely bound systems, and is worthy of further investigation. In particular, such theories should find application when

the rapidly increasing data based on reactions induced by light neutron-rich radioactive nuclei, especially for one neutron-halo nuclei at first hand.

The only established one-neutron halo nucleus so far is ^{11}Be, where relative S-motion dominates the ground state. The ^{11}Be nucleus has been extensively studied [10] during the last few years and has provided a testing ground for single neutron-halo theories. Recently experimental evidence for another one-neutron-halo candidate has become available [11], namely the ^{19}C nucleus. Using the extended adiabatic ideas might shed some light on the problems involved in the investigation of the structure of these and other loosely bound halo nuclei. Work along these lines are in progress.

The extended adiabatic models might be helpful also in solving some problems involved in analyzing the reactions induced by three-body projectiles. The more precise CDCC technique is unlikely ever to find application to solution of such a four-body problem.

Acknowledgments

The authors gratefully acknowledge the financial support of the Scientific and Technical Research Council of Turkey (TUBITAK, project no: TBAG 1601).

References

[1] R. C. Johnson and P. J. R Soper, *Phys. Rev.* **C1** (1970) 976.

[2] E. J. Stephenson, A.D. Bacher, G. P. A. Berg, V. R. Cupps, C. C. Foster, N. Hodiwalla, P. C. Li, J. Lisantti, D. A. Low, D. W. Miller, C. Olmer, A. K. Opper, B. K. Park, R. Sawafta, S. W. Wissing, J. A. Tostevin, D. A. Coley and R. C. Johnson, *Phy. Rev.* **C42** (1990) 2562.

[3] J. A. Tostevin, and B. Gönül, Genshikaku Kenkyu, **Vol. 40** No.2, (1995) 95; B. Gönül, PhD Thesis, Department of Physics, University of Surrey, Guildford, England, 1994.

[4] H. Amakawa, N. Austern, and C. M. Vincent, *Phys. Rev.* **C29** (1984) 699.

[5] M. Kamimura, M. Yahiro, Y. Iseri, H. Kameyama, Y. Sakuragi, and M. Kawai, Prog. Theor. Phys. Suppl. 89 (1986) 1; N. Austern, Y. Iseri, M. Kamimura, M. Kawai, G. Rawitscher, and M. Yahiro, *Phys. Rep.* **154** (1987) 125.

[6] E. J. Stephenson, R. C. Johnson, J. A. Tostevin, V. R. Cupps, J. D. Brown, C. C. Foster, J. A. Gering, W. P. Jones, D. A. Low, D. W. Miller, H. Nann, C. Olmer, A. K. Opper, P. Schwantdt, J. W. Seubert, and S. W. Wissing, *Phys. Lett.* **B171** (1986) 358; E. J. Stephenson, V. R. Cupps, J. A. Tostevin, R. C. Johnson, J. D. Brown, C. C. Foster, W. P. Jones, D. W. Miller, H. Nann, P. Schwantdt, *Nucl. Phys.* **A469** (1987) 467; R. C. Johnson, E. J. Stephenson, and J. A. Tostevin, **A505** (1989) 26.

[7] I. J. Thompson, J. S. Al-Khalili, J. A. Tostevin and J. Bang, Phys. Rev. **C47**, R1364 (1993); J. S. Al-Khalili, I. J. Thompson, and J. A. Tostevin, Nucl. Phys. **A581**, 331 (1995); J. S. Al-Khalili, J. A. Tostevin, and J. M. Brooke, *Phys. Rev.* **C55**, R1018 (1997).

[8] M. Igarashi, M. Toyoma and N. Kishida, Computer Program TWOFNR (Surrey University-version).

[9] F. D. Bechetti and G. W. Greenlees, *Phys. Rev.* **182,** 1190 (1969).

[10] F. N. Nunes, I. J. Thompson and R. C. Johnson, *Nucl. Phys.* **A596**,171 (1995); H. Esbensen, B. A. Brown, and H. Sagawa, *Phys. Rev.* **C51,** 1274 (1995); N. Vinh. *Mau, Nucl. Phys.* **A592,** 33 (1995); D. Ridikas and J. S. Vaagen, ECT* preprint #: **ECT*-96-006**, 6 (1996).

[11] D. Bazin et al., *Phys. Rev. Lett.,* **74,** 3569 (1995); F. M. Marques et al., *Phys. Lett.* **B381**, 407 (1996); D. Ridikas, M. H. Smedberg, J. S. Vaagen and M. V. Zhukov, *Europhys. Lett.,* **37,** 385 (1997).