p-^{4}He Scattering and Non-Local Imaginary Potential

Hiroyuki Kanada and Tsuneo Kaneko

Department of Physics, Niigata University, Niigata, Japan

From the investigation on the reactions of the five- and six- nucleon systems,[1] we have made clear that the microscopic treatment, considering the full nucleon exchange effect, is very useful for the reaction of a few nucleon system. Especially, it was shown that[2] the characteristic property of the p-^{4}He interaction, that is, this interaction have a strong state and a weak energy dependences, has been quantitatively very good understood by the microscopic study based on the realistic effective potential (REP) obtained from the G-matrix calculation of the nuclear matter.[3] In this case, the experimental phase shifts of the S- and P-waves in the low energy region ($E_p^{cm} \lesssim 30$ MeV) were excellently reproduced by this treatment.

Here, we will examine the p-^{4}He scattering in the higher energy region where the contribution from the inelastic channels must be included, and the latter contribution is taken into account by a phenomenological imaginary potential within a framework of one channel approximation. In this calculation, for the ^{4}He nucleus both S- and D-states (the mixing ratio being 1:C) are taken into account, since a part of the ℓs splitting comes through the S-D coupling by the tensor potential. The width parameters (α and β) and the mixing parameter C have been so determined as to fit the mean square radius, the binding energy and the D-state probability of the ^{4}He nucleus ($\alpha = 0.14$ fm^{-2}, $\beta = 0.295$ fm^{-2} and C = -0.35).

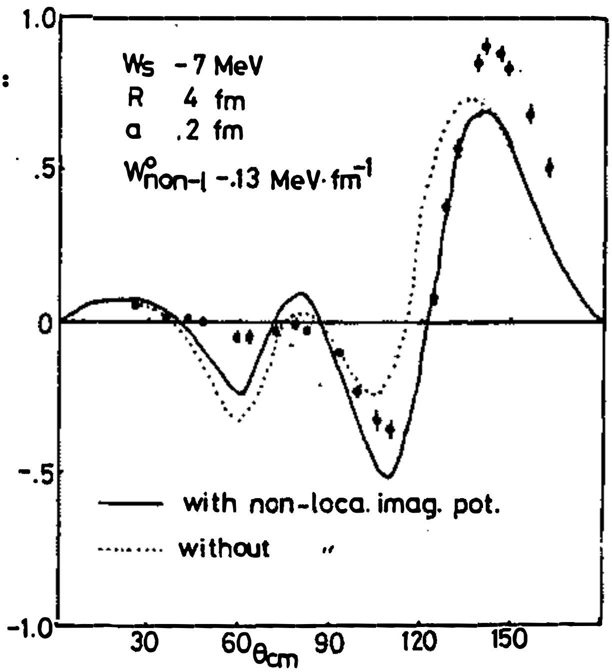
As mentioned in the previous papers[1], the reaction kernel k_{pd}, which couples the p-^{4}He channel to the other channel (in this case, the d-^{3}He channel), can be decomposed two terms, that is, the direct term $k^{(D)}$ (corresponding to the neutron pick-up process) and the exchange term $k^{(E)}$ (corresponding to the deuteron pick-up process). In the previous paper[1c], the characteristic properties of these reaction kernels and those effects to the elastic and the inelastic scatterings were explained in detail. These some important points were as the followings: (i) Each kernel holds a characteristic relation as follows: $k_\ell^{(D)} \cdot k_{\ell+1}^{(D)} > 0$ and $k_\ell^{(E)} \cdot k_{\ell+1}^{(E)} < 0$. (ii) the direct kernel $k^{(D)}$ has stronger steepness than the exchage

$k^{(E)}$, and then the direct kernel shows a rather strong locality. (iii) The contribution from coupling of the d-^{3}He channel to the p-^{4}He channel shows rather surface type as seen in the calculated scattering amplitudes a (See Table I in the paper 1c).

From such results, here, we introduce an imaginary local potential of the usual derivative Woods-Saxon type (corresponding to the contribution from the direct process) and an imaginary non-local one (corresponding to the one from the exchange process) as the following type:

$$iW^0_{NON}\cdot \mathrm{Exp}(-A\cdot(r^2 + r'^2) - Dr\cdot r'),$$

where the parameters A and D are chosen as $A = 0.2\ fm^{-2}$ and $D = 0.28\ fm^{-2}$ (See Fig.1 in the paper 1c). By this non-local imaginary potential, the imaginary phase shifts also take an even-odd parity dependence,[4] and then the differential cross section and the polarization are reformed very well. For an example, the calculated polarizations at $E_p^{cm} = 36$ MeV are compared with the recent experimental data[5] in Fig.1.



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