TESTING A Δ-ISOBAR RESCATTERING MODEL OF PION PRODUCTION WITH THE ^{3}He(p,π^+)^{4}He REACTION

J.S. Conte
Purdue University Computing Center, West Lafayette, Indiana 47907

M. Dillig
Institute for Theoretical Physics, University of Erlangen-Nurnberg Erlangen, West Germany

R.D. Bent
Indiana University Cyclotron Facility, Bloomington, Indiana 47401

In the preceeding contribution to this annual report,[1] we discuss a microscopic approach to proton-induced exclusive pion production on nuclei at energies well below the 33-resonance. We focus on these energies because of the wealth of available data and because, from the standpoint of nuclear dynamics, this is the most informative energy regime. There is a price to be paid, however, which results from the complexity of the model near the pion threshold. In contrast to scattering energies near the 33-resonance, where the Δ-isobar dominates the nuclear dynamics, at very low energies there is no clearly outstanding agency in the reaction mechanism. Consequently, for a quantitative description of the production process, many elements - such as s-wave rescattering, resonant and nonresonant p-wave rescattering, heavy meson-exchange and short range correlations, medium corrections, proton and pion distortions, pionic radiation - to name only the most prominent ones, have to be incorporated in a microscopic model. Besides a dependence on many parameters, the application of such a model requires a large technical apparatus and extensive numerics.

Such a high degree of complexity, both in the formalism and particularly in the coding, necessitates extensive testing. To keep initial tests of the mathematical apparatus and the numerics transparent, we break the model into various pieces and start by applying it to simple nuclear systems. As a first step, we investigate various aspects of the two-nucleon re-scattering model in the context of pion production on ^{3}He. Explicitly, we keep only the leading microscopic term involving π meson exchange and isobaric degrees of freedom in the baryonic sector. In spite of its resctictive character, such a model covers a large portion of the physics of the (p,π) reaction. Beyond that, it represents the most complex piece in the transition amplitude. By applying it to a target and a residual nucleus with dominant 1s configurations, we obtain a stringent test for the general formulae. Furthermore, this case allows a simple analytical evaluation of the various invariants for comparison with the numerical results from the computer code. Finally, comparison with recent data[2,3] provides already a first, though crude, test of various ingredients in the isobar rescattering model.

Realistic ^{3}He and the ^{4}He wave functions involve significant p and d wave components. For a detailed comparison with experiment these subtle pieces in the nuclear wave function should be kept in the transition amplitude. Particularly, the d-state may have a significant influence on both the cross section and the asymmetry. At this stage, however, we keep only the s-wave parts of the nuclear wave functions.

The optical model codes SNOOPY[4] and DWPIES[5] were used to generate the proton and pion distorted waves. Both the proton-nucleus and the pion-nucleus optical potentials employed fit elastic scattering data for the corresponding nuclei at the appropriate scattering energies. For practical purposes, we use the technique of Charlton[6] to expand each partial distorted wave in a Bessel function series.

Figure 1 shows the results of calculations for the ^{3}He(p,π^+)^{4}He reaction and recent IUCF data.[3] The proton distortions lower the cross section by about a factor of three, without changing the angular distribution very much. The pion distortions, on the other hand, produce a surprisingly large effect, in view of the fact that most of the momentum sharing is incorporated microscopically in the two-nucleon reaction mechanism. Even with this large enhancement, the calculated cross sections are below the data by a factor of about 10.

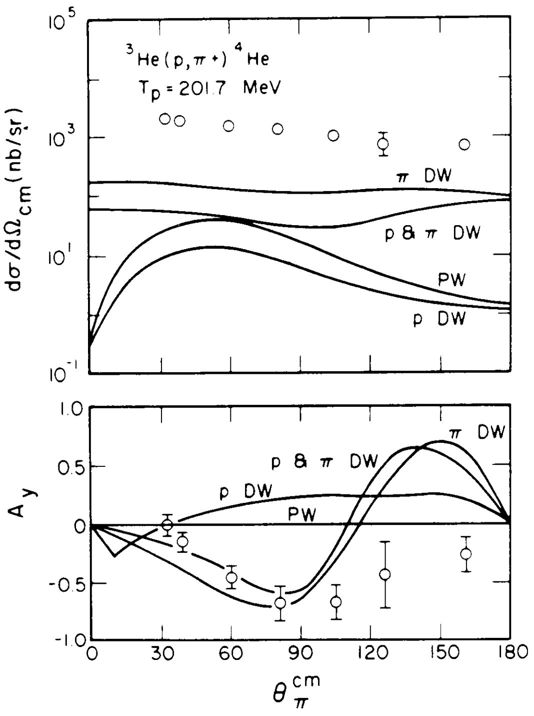

Figure 1. Calculated and experimental differential cross sections and analyzing powers for the reaction ^{3}He(p,π^+)^{4}He$_{g.s.}$. The different curves correspond to various plane wave (PW) and distorted wave (DW) calculations.

The above results show that the resonant p-wave (intermediate Δ) rescattering mechanism does not dominate the ^{3}He(p,π^+)^{4}He reaction at 200 MeV bombarding energy. Competing processes such as s-wave and non-resonant p-wave rescattering, as well as the one-nucleon mechanism, must be taken into account. The two-nucleon mechanism is expected to dominate the one-nucleon mechanism because of the more favorable momentum sharing; however, recently Sakamoto et al.[7] have shown that this is not the case for the ^{4}He(π^-,n)^{3}H reaction (which is related to ^{3}He(p,π^+)^{4}He by charge symmetry and time reversal invariance). For this case, the two mechanisms compete because of large momentum components of the overlap function $\langle\phi_{^3\mathrm{H}}|\phi_{^4\mathrm{He}}\rangle$, which determine the one-nucleon contribution. Work is in progress to add the one-nucleon term to our code.

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