STUDY OF THE (p,π) REACTION IN THE TWO-NUCLEON MODEL

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Recently acquired high-quality data on the (p,π) reaction,[1] especially in the near-threshold region,[2] have stimulated new theoretical efforts to understand the reaction mechanism and associated nuclear structure. It is evident, in some cases, that both single-particle states and 2p-1h states in the residual nucleus are strongly excited in the (p,π^+) reaction. Significant differences are observed, however, in the energy dependence of the reaction leading to final states of different structures.[3]

We have carried out preliminary calculations of the (p,π^+) reaction based on the two-nucleon model taking into account the increasing importance of S-wave pion rescattering in the near-threshold region. We assume that the basic mechanism of coherent pion production from nuclei is a two-nucleon process in which the essential ingredient is the $NN \rightarrow NN\pi$ amplitude. We use non-relativistic time-ordered perturbation theory. At the pion production vertex, the operator form used is $\vec{\sigma}\cdot\vec{q}$, which comes from the non-relativistic reduction of the covariant form of the pseudo-scalar coupling γ_5.

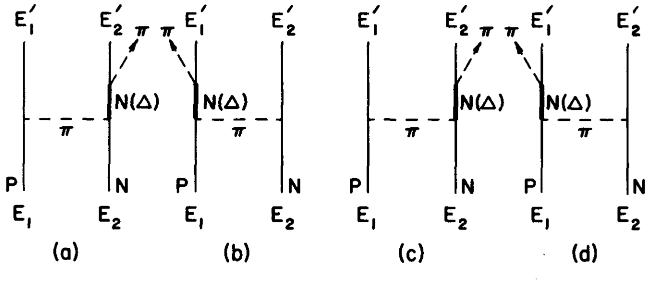

Figure 1. Four different diagrams (a) Direct (b) Operator Exchange (c) Final-State Exchange (d) Operator and Final-State Exchange.

It is well known that πN scattering is dominated by the P-wave interaction, and an operator form $(\vec{\sigma}\cdot\vec{q})(\vec{S}\cdot\vec{q})$ is used for the $NN \rightarrow N\Delta$ transition potential[4] ($\vec{q}$ is the momentum of the virtual exchanged pion; $\vec{\sigma}$ and $\vec{S}$ are the spin matrices for the nucleon and Δ respectively). Four different diagrams are calculated (see Fig. 1).

As we are interested in the near-threshold region, the S-wave pion scattering amplitude is also incorporated together with the P-wave term. For the S-wave rescattering term, the parametrization of the scattering lengths for the σ and the ρ meson exchange and the hard core contribution are included in the amplitude.[5]

The distorted waves for the incident proton and the outgoing pion are calculated using the pionic stripping model code of Tsangarides.[6] Several options for the pion optical potential are available (Kisslinger potential and Laplacian potential with and without local off-shell damping).

The bound state wave functions are calculated using either a harmonic oscillator or a Woods-Saxon potential well. Our initial calculations are for a closed-shell target nucleus and either single-particle or 2p-1h

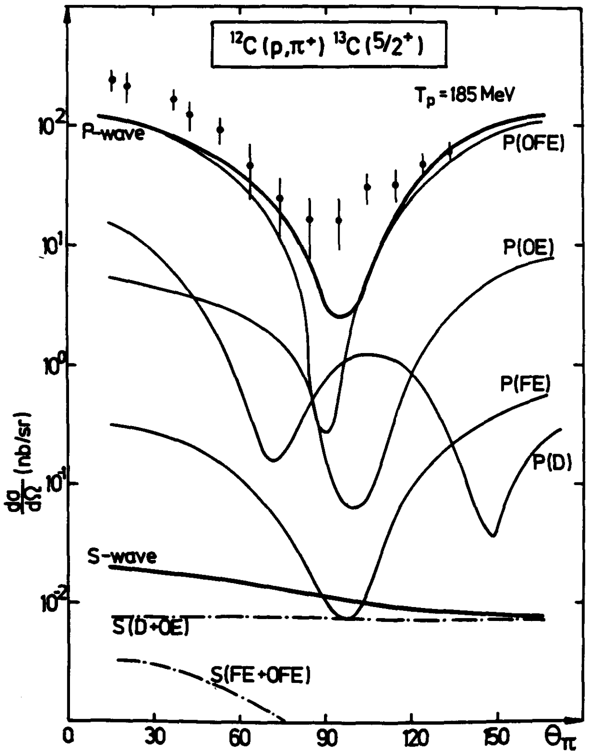

Figure 2. Angular distribution of the differential cross section for the 6.86 MeV state in ^{13}C at T_p=185 MeV. The calculation uses the Laplacian potential with off-shell damping. The cross sections are decomposed into different components.

final states.

To illustrate the capabilities of the code, we show in Fig. 2 preliminary results for the $^{12}C(p,\pi^+)$ reaction leading to the 6.86 MeV 2p-1h state (assumed to have a $1d_{5/2}(1p_{3/2}{}^{-1},p_{1/2})2^+$ configuration). The differential cross section is decomposed into several components from the different diagrams, which are added coherently for the cross section. At E_p = 185 MeV, the P-wave contribution overwhelms the S-wave contribution. Among the four different P-wave diagrams, the operator and final-state exchange terms determine the overall shape of the angular distribution, while the direct term tends to fill in the deep minimum around 90 degrees.

We stress that these results are preliminary and represent only a first step toward understanding the complicated interplay between the (p,π) reaction mechanism and the associated nuclear structure.

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