

## STUDIES OF FEW-NUCLEON SYSTEMS AT INTERMEDIATE ENERGIES

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This short review emphasizes some recently investigated aspects of few-nucleon systems suitable for the methods of intermediate-energy physics. The following topics are included:  $\Delta$ - $\Delta$  components in the deuteron wave function,  $\mu^-$  capture in deuterium, possible use of quasi-free reactions and the proton-induced deuteron breakup. Certain features of  $\pi^-$  absorption in light nuclei are described in a separate contribution to this meeting.

The existence of the  $\Delta$ - $\Delta$  component in the deuteron wave function. Internal nucleon degrees of freedom are expected to be important at small nucleon-nucleon distances<sup>1)</sup>.  $N^*$ 's and  $\Delta$ 's may exist within nuclei for short periods of time. The  $\Delta$ - $\Delta$  component is one of the simplest structures that satisfies the deuteron spin-isospin quantum numbers. Theoretical calculations performed to estimate the probability of the  $\Delta$ - $\Delta$  component within the deuteron mainly followed the impulse approximation approach<sup>2)</sup> or coupled-channel calculations.<sup>3)</sup> Early works which included only the  $\pi$ -exchange component of the nucleon-nucleon interaction were forced to introduce the cut off in order to avoid the singular behaviour of the interaction. Since the  $\rho$  exchange potential is of the opposite sign to the  $\pi$  contribution, it provides a natural cut off at about 0.4 fm. This inclusion has stabilized the theoretical predictions at approximately 0.5-1.0% for the probability of the  $\Delta$ - $\Delta$  component within the deuteron.<sup>4,5)</sup> A number of experiments have been performed to check these predictions. The possibilities of producing  $\Delta$  during the interaction of the probe with the target nucleons present considerable difficulties for proper interpretation. Therefore, the observation of the spectator  $\Delta$ , especially in the backward direction, is regarded as a reliable method for determining the  $\Delta$ - $\Delta$  component. In this way, 0.7% was extracted as the upper limit of the strength for this component.<sup>6)</sup>

The capture of  $\mu^-$  in the deuterium exhibits several interesting features. The hope of extracting neutron-neutron scattering parameters from this process was stated<sup>7)</sup> and questioned.<sup>8)</sup> The importance of the induced pseudoscalar constant  $g_p$  for the absolute transition rate was stressed.<sup>9)</sup> The frequently quoted conclusion<sup>8)</sup> that  $g_p$  influences the differential capture rates more strongly than neutron-neutron parameters is not quite correct.<sup>10)</sup>

Quasi-free reactions at intermediate energies. The quasifree scattering picture was generalized to include the possibility of

performing the nuclear reaction on a cluster of nucleons within the nucleus, while the rest acts as a spectator.<sup>11)</sup> The cross section for the  $a(A, yb)B$  reaction factorizes in the kinematical part, off-shell cross-section for the  $a+x \rightarrow b+y$ :  $\sigma_{a+x \rightarrow b+y}^{\text{off-shell}}$  reaction and the square of the wave function for the target nucleus in the momentum space  $|\phi(p_x)|^2$ . In this notation  $x$  represents a cluster of nucleons on which the quasifree reaction occurs and  $B$  is the spectating part of the target. The examination of the quantity  $\sigma_{a+x \rightarrow b+y}^{\text{off-shell}}$  was proposed as a tool for the investigation of multinucleon correlations within nuclei.<sup>12)</sup> The conditions necessary for this correlation examination should be fulfilled for intermediate-energy projectiles.

Proton-induced deuteron breakup at intermediate energies. From the kinematically complete experimental studies<sup>13,14)</sup> of this reaction several conclusions have emerged. The differential cross-section for the reaction is dominated by quasifree-scattering (QFS) and final-state-interaction (FSI) mechanisms. From the data accumulated in the geometry favourable for the QFS mechanism, the momentum distribution within the deuteron has been extracted. A surprisingly large amount of the high-momentum components has been found. In the geometry favourable for the FSI contribution, the experimental spectra can be qualitatively explained by FSI theories, provided a constant is added to the matrix element.

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