Simulation of dC and dCH$_2$ reactions from 300 MeV to 500 MeV of deuteron energy

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Content

- Motivation
- Introduction
- Simulation
- Comparison
- Conclusion
The goal of the simulations is to find a method by means of which the signal from the dp non-mesonic breakup can be separated from the background.

The obtained results will be used in the experimental spin program that will be realized in Nuclotron in Dubna.

The aim of this experimental investigation is to contribute to the elucidation of the structure of the spin dependent parts of the nucleon-nucleon and three-nucleon forces acting in the dp non-mesonic breakup.

The deuteron energies will be ranging from 300 MeV up to 500 MeV.
Deuterons and nucleons can be considered to be few body systems for the description of which the non-relativistic Schrödinger equation that includes only the NN potentials as a starting point can be used.

It has been shown that the data obtained from the NN scattering at low and intermediate energies can be described with high precision using the NN potentials only (e.g. CD-Bonn).

These modern NN potentials, however, underestimate the binding energies of the three-nucleon systems $^3$H and $^3$He by about 0.5-1 MeV and don’t reproduce the dp breakup and dp elastic scattering data.
Introduction: 

nd scattering under 30 MeV

- Description based on NN potentials
  - Cross section - OK
  - Tensor analyzing powers - OK
  - Vector analyzing power $A_y$ - X

- Description based on NN potentials with inclusion 3NF leading to $A_y$ puzzle
Introduction: pd and dp elastic scattering at intermediate energies

- pd elastic at 250 MeV → Faddeev equations (3NF) unable to describe cross section → new type of 3NF?
- dp elastic at intermediate energies → Sagara region → cross section up to 30% comes from 3NF
Cross section of $Nd$ elastic scattering at energy 140 MeV and 270 MeV

$AV18$, CD-Bonn, Nijm I, II, 93
$AV18 + TM$ 3NF

K. Sekiguchi et al.,

3NF manifestation in the vicinity of Sagara discrepancy.
Introduction: dp breakup

Fields of investigation:

- 3NF
- relativistic effects
- Coulomb effects

dp breakup 130 MeV → desc. included 3NF don’t describe data. dp breakup reaction data can be described by $\chi PT$, but only under 100 MeV/nucl.
Internal Target Station is very well suited for the experiment on the measurement of the \textit{dp}- breakup reaction.

\(\Delta E - E\) scintillation detectors based on FEU85 and FEU65 PMTs
dp- breakup reaction 300-500 MeV

<table>
<thead>
<tr>
<th>configuration</th>
<th>$\Theta_1$</th>
<th>$\Theta_2$</th>
<th>$\Phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>31.7° – 36.3°</td>
<td>27.0° – 31.6°</td>
<td>180°</td>
</tr>
<tr>
<td>14</td>
<td>31.7° – 36.3°</td>
<td>44.1° – 48.7°</td>
<td>180°</td>
</tr>
<tr>
<td>23</td>
<td>27.0° – 31.6°</td>
<td>43.4° – 48.0°</td>
<td>180°</td>
</tr>
</tbody>
</table>
dp- breakup reaction at 500 MeV

- Red and blue curves surround two selections of events named “cut1” and “cut2”.
- Selection was done for the CH$_2$ target, 500 MeV deuterons and the detector configuration $14$-$\Theta_1$ - $31.7^\circ$ – $36.3^\circ$, $\Theta_2$ - $44.1^\circ$ – $48.7^\circ$, $\Phi$ - $180^\circ$. 
The area designated as “cut1” includes events in which the detected particles pass through the detector basically along its longitudinal direction and stay in it, i.e. they deposit there “all” of their kinetic energy.

The part of the plot designated as “cut2” contains events in which the detected particles pass through the detector basically along its longitudinal direction but after depositing some part of their kinetic energy there leave it.
dp- breakup reaction at 300 MeV

\[ \Theta_1 \ 31.7^\circ - 36.3^\circ \\
\Theta_2 \ 27.0^\circ - 31.6^\circ \\
\Phi \ 180^\circ \]

\[ \Theta_1 \ 31.7^\circ - 36.3^\circ \\
\Theta_2 \ 44.1^\circ - 48.7^\circ \\
\Phi \ 180^\circ \]

CH$_2$ - non shaded spectra, carbon - shaded spectra
first column: cut1, second column: cut1 + cut2

14/17
dp- breakup reaction at 500 MeV

CH₂ - non shaded spectra, carbon - shaded spectra
first column: cut1, second column: cut1 + cut2

15/17
Simulated (shaded) and experimental (non shaded) plots of the invariant mass distribution obtained using the CH$_2$ target for the detector configurations 12. ($\Theta_1$ - 31.7° – 36.3°, $\Theta_2$ - 27.0° – 31.6°, $\Phi$ - 180°.) The cuts used are 5 MeV < $\Delta E$ < 35 MeV and 0 < $E$ < 178 MeV.
We perform GEANT4 simulations of the $dp \rightarrow ppn$ reaction at deuteron energies of 300 MeV, 400 MeV and 500 MeV for various detector configurations. To simulate the signal events, we used a CH$_2$ target. To separate the signal from the background we calculated the invariant mass distributions. GEANT4 modeling suggests that the subtraction procedure may be a useful tool for separating the dp breakup events from the rest of the events originating in the deuteron collisions with the CH$_2$ target. Discrepancy between the modeled and experimentally obtained data that may be partly caused by the particles scattered on the detectors and the construction, partly by the fact that the Binary Cascade model is probably not completely suitable for simulating the dC collisions.