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Measurement of $P, A_y, D_{LL}, D_{NN}, D_{SS}, D_{LS}, D_{SL}$ and $d\sigma/dt$ in $\vec{p}$-^{3}He Elastic Scattering at 800 MeV:

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Measurements of polarization observables in scattering of protons from light nuclei constitute potentially a very rich source of information on several aspects of few-body problems. The principal reason of the investigation of such processes is to verify to what extent scattering observables can be predicted by assuming that the collision matrix for proton scattering from these nuclei can be built from the two-nucleon interactions. Such a program is very important in view of the fact that there is interest in interpreting some properties of light nuclei (like e.g. the mass difference between ^{3}H and ^{3}He) in terms of signatures of subnucleonic degrees of freedom[1]. Also it is very interesting to test the predictions of the relativistic multiple scattering models in the case of simplest nuclear reactions in the presence of strongly spin dependent interaction.

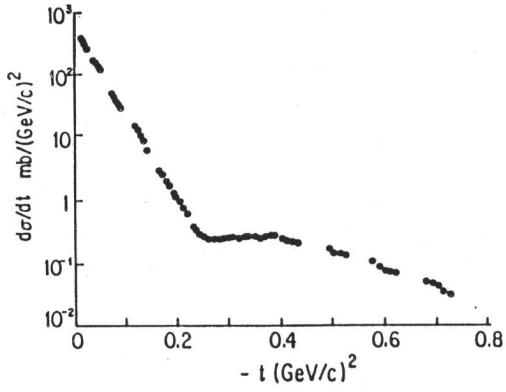
The spin structure of the NN amplitude leads to the dependence of the proton-nucleus amplitude on the combinations of formfactors of matter and spin distribution which, in general do not enter into amplitudes describing electron-nucleus scattering. This important feature makes the proton reactions with these nuclei not only a complementary but rather a unique method of extracting information on the matter and spin-matter distribution in nuclei. In contrast to the elastic scattering of electrons from these three-nucleon systems which involves contribution from only 2 (charge and magnetic) formfactors, proton reactions are sensitive to 6 different formfactors of matter and spin distribution[2]. Extraction of the components of the collision matrix depending on these formfactors can be achieved by making suitable polarization experiments with polarized proton beams and possibly polarized targets.

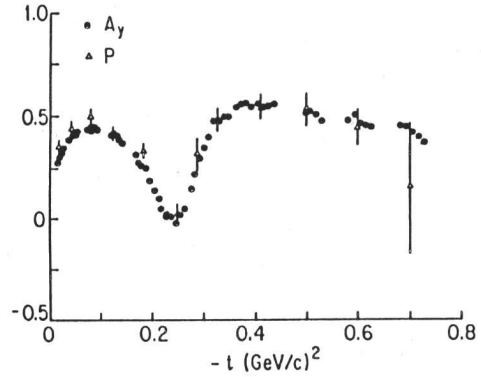
We report here the results of the measurements of the cross section, analyzing powers, and spin-transfer observables (Wolfenstein parameters) for 800 MeV $\vec{p}$ + ^{3}He elastic scattering over a four-momentum transfer squared, -t range of 0.02 - 0.71 $(GeV/c)^2$. These measurements, carried out at the Los Alamos Meson Physics Facility (LAMPF) used proton beams polarized (~90%) in three orthogonal orientations, the LAMPF High Resolution Spectrometer and its associated focal plane polarimeter[1], and a liquid ^{3}He target 1.3 cm (102 mg/cm^2) thick. In this target assembly the ^{3}He, which is stored as a gas in a high pressure tank is cooled and then liquified in three steps: (1) in contact with a liquid nitrogen bath at ~30° K; (2) in contact with a liquid ^{4}He bath at ~4° K; and (3) in contact with a superfluid ^{4}He bath at ~1.5° K. The data are displayed in Fig. 1. Comparison between P and A_y demonstrates the consistency of our data with the invariance of the interaction under the space reflection and time reversal.

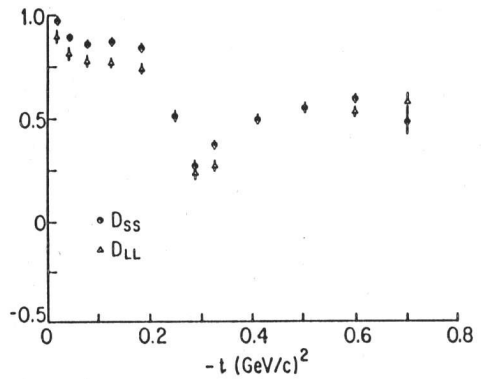
From the general symmetry principles it follows that p-^{3}He scattering matrix is composed of 6 complex subamplitudes and can be written as follows:

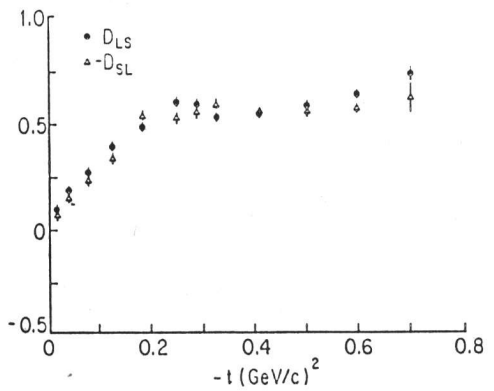
$$F = F_o^o + F_o^n\,(\vec{\sigma}_t\cdot\hat{n}) + F_n^o(\vec{\sigma}_p\cdot\hat{n}) + F_n^n\,(\vec{\sigma}_t\cdot\hat{n})(\vec{\sigma}_p\cdot\hat{n}) + F_q^q(\vec{\sigma}_t\cdot\hat{q})(\vec{\sigma}_p\cdot\hat{q}) + F_k^k(\vec{\sigma}_t\cdot\hat{k})(\vec{\sigma}_p\cdot\hat{k}),$$

where $\vec{\sigma}_p$ and $\vec{\sigma}_t$ are the Pauli spin operators for the projectile and the target respectively and $\hat{q}$, $\hat{n}$, $\hat{k}$ are the 3 unit vectors parallel to $\vec{k}_f - \vec{k}_i$, $\vec{k}_i \times \vec{k}_f$, and $\vec{k}_i + \vec{k}_f$, $\vec{k}_i$, and $\vec{k}_f$ being the initial and final momenta in the center of mass frame.









In general 11 experiments are needed to determine the p-^{3}He collision matrix. Our experiment consists of 6 independent measurements and allows us to determine the following 7 (6 independent) combinations of the amplitudes:

$$I_o = \frac{d\sigma}{d\Omega} = |F_o^o|^2+|F_o^n|^2+|F_q^q|^2+|F_n^o|^2+|F_n^n|^2+|F_k^k|^2\}$$

$$I^oA_y = 2\,\mathrm{Re}(F_o^o F_n^{o*} + F_n^n F_n^{o*}),$$

$$I^oQ = 2\,\mathrm{Im}((F_o^o F_n^{o*} + F_n^n F_n^{o*}),$$

$$I_oD_o = [|F_o|^2 + |F_o^n|^2],$$

$$I_oD_x = |F_q^q|^2,$$

$$I_oD_y = [|F_n^o|^2 + |F_n^n|^2],$$

and

$$I_oD_z = |F_k^k|^2.$$

The theoretical calculations are currently carried out in framework of the relativistic multiple scattering theory[2]. In these calculations the complete spin dependence of the NN interaction, S and D-wave components of the ^{3}He wave functions and the relativistic spin 1/2 propagation effects are included. The preliminary results of this analysis indicate that the relativistic corrections play very important role in this reaction.

References

1. see e.g. G. Miller, to be published in Advances in Nuclear Physics
2. A. Azizi , E. Bleszynski and M. Bleszynski, unpublished
3. J. B. McClelland et al, to be published in Nucl. Instr. and Meth.

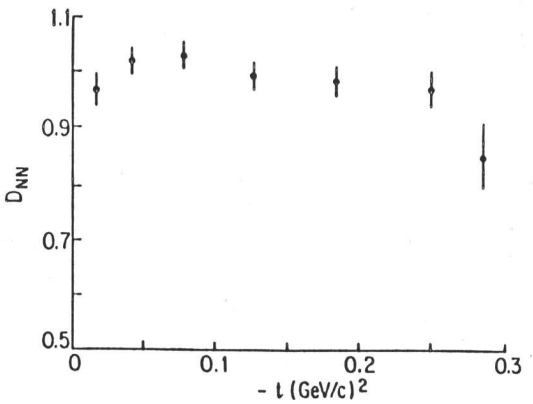


Fig. 1 Spin observables measured for $\vec{p}$-^{3}He elastic scattering at 800 MeV