

INELASTIC SCATTERING

QUASIFREE ANALYZING POWERS FOR \bar{n} -p SCATTERING AT 183 MeV

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Inelastic nucleon scattering has recently been used to study the effects of the nuclear medium on the NN interaction. Modifications can arise, for example, from Pauli blocking and binding energy effects and, in a relativistic framework, from the density-dependent effective mass, m^* , of nucleons inside nuclei. Recent interest has been focused on measurements of polarization observables for continuum (\vec{p}, p') reactions, in the region of the inclusive spectrum dominated by quasifree NN collisions.^{1,2} Current calculations suggest that such data should be sensitive to the relativistic m^* effects^{3,4} and to collective aspects of the nuclear spin response,⁵ but not very sensitive to distortions.⁴ However, a comprehensive understanding of the polarization data^{1,2} has not yet been obtained.

More exclusive measurements of polarization observables for quasifree NN scattering can complement the inclusive inelastic scattering measurements in several important ways, most notably by providing a cleaner definition of the contributing process. There is no simple model-independent way to distinguish what fraction of the observed inclusive yield corresponds to quasifree collisions with a single target nucleon, as opposed to more complicated multinucleon interactions. In addition, the inclusive measurements cannot distinguish between p-p and p-n scattering. By detecting the two interacting nucleons in coincidence, we can significantly reduce these sources of ambiguity.

The present experiment, E329, was proposed to measure coincident $A(\bar{n}, np)$ quasifree analyzing powers from deuterium (CD_2 -C), carbon, and tantalum. The experiment was performed at a bombarding energy of $T_n = 183$ MeV in the Polarized Neutron Facility, with the left-right symmetric detector apparatus used previously in the charge symmetry breaking (CSB) experiment spanning a laboratory angular range of 24° to 62° for both the neutron and proton. This setup provides measurements of the nucleon angles with good resolution, thereby constraining the momentum of the recoil nucleus (especially its longitudinal component), but is characterized by poor energy resolution, so that we effectively integrate over a broad range of excitation energy. Thus, the results should be relatively insensitive to details of the shell structure of the target nucleus. Since the measurement and most of the analysis procedures used so far are the same as for the CSB experiment, the reader is referred to previous reports for details.⁶

To date, the quasifree scattering events have been analyzed with the standard CSB free-scattering cuts. These cuts, especially that on the opening angle of the scattered nucleon pair, constrain the surviving quasifree scattering yields to include only events initiated on an essentially stationary target proton. Our experimental detector resolutions suggest that the longitudinal component of the struck nucleon momentum is constrained

to zero to within $\pm 6\%$ of the Fermi momentum (i.e., $-15 \text{ MeV}/c \leq p_z \leq 15 \text{ MeV}/c$).

The average neutron beam polarization was determined by simultaneously measuring asymmetries for free \bar{n} -p scattering from a thin CH_2 target mounted 15.4 cm downstream from the target of interest. For the deuterium, carbon and roughly half of the tantalum data presented here, the average neutron beam polarization was found to be 0.54 ± 0.02 , with the errors representing statistical uncertainties only. The rest of the tantalum data was collected during a later run when the primary proton beam from the cyclotron had an unusually large horizontal polarization component, yielding an average neutron beam polarization of 0.32 ± 0.02 .

The data in Fig. 1, representing typical opening angle (θ_{open}) spectra for carbon, show the fraction ($\sim 60\%$ for deuterium, 10% for carbon, and 4% for tantalum) of the (\bar{n}, np) events over the angular acceptance of the detectors that pass all of the usual CSB free-scattering kinematic cuts, with the exception of the θ_{open} cut itself. The shape of these spectra is determined by detector acceptances and by the Fermi smearing of the sharp angular correlation characteristic of free n-p scattering. The absence of any sharp free-scattering peak (with an experimental resolution of $\sim 3^\circ$ FWHM) sitting atop the broad quasifree spectrum in the right-hand frame (comprising events that have passed free-scattering cuts) indicates that there is no appreciable hydrogen contamination of the C target. The same is true of the CD_2 and Ta targets used.

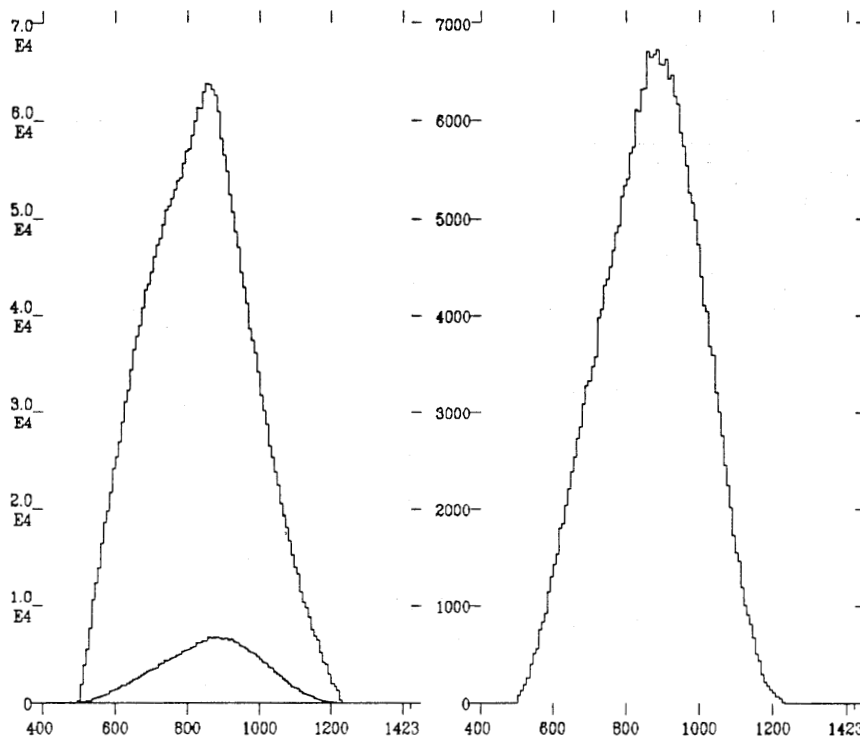


Figure 1. Opening angle spectra (in tenths of a degree) for carbon. The left-hand frame shows all n-p events and, underneath, the data that satisfies all of our free-scattering cuts. The "free" data is shown full scale on the right.

The analyzing power measurements shown in Fig. 2 were extracted after placing a final free-scattering kinematic cut on θ_{open} . Both the deuterium and carbon data are collected into 4° lab angle bins, while the tantalum is collected into 6° bins. The solid line represents Arndt's SM86 global solution⁷ (also used for the beam polarization normalization) for free n-p scattering. The error bars plotted are purely statistical. As Fig. 2 shows, there are small but significant deviations from the free-scattering expectations for deuterium, especially at large scattering angles, while a large change is observed in A_y in going from deuterium to carbon. Also shown in Fig. 2 are data taken during the CSB experiment on a *dummy* target which mocked up the nonhydrogenic contents (mainly C, O, S, and Y) in the polarized proton target. The relatively small differences in the quasifree analyzing powers among the carbon, dummy, and tantalum targets suggest that we are observing essentially some type of *nuclear matter* response.

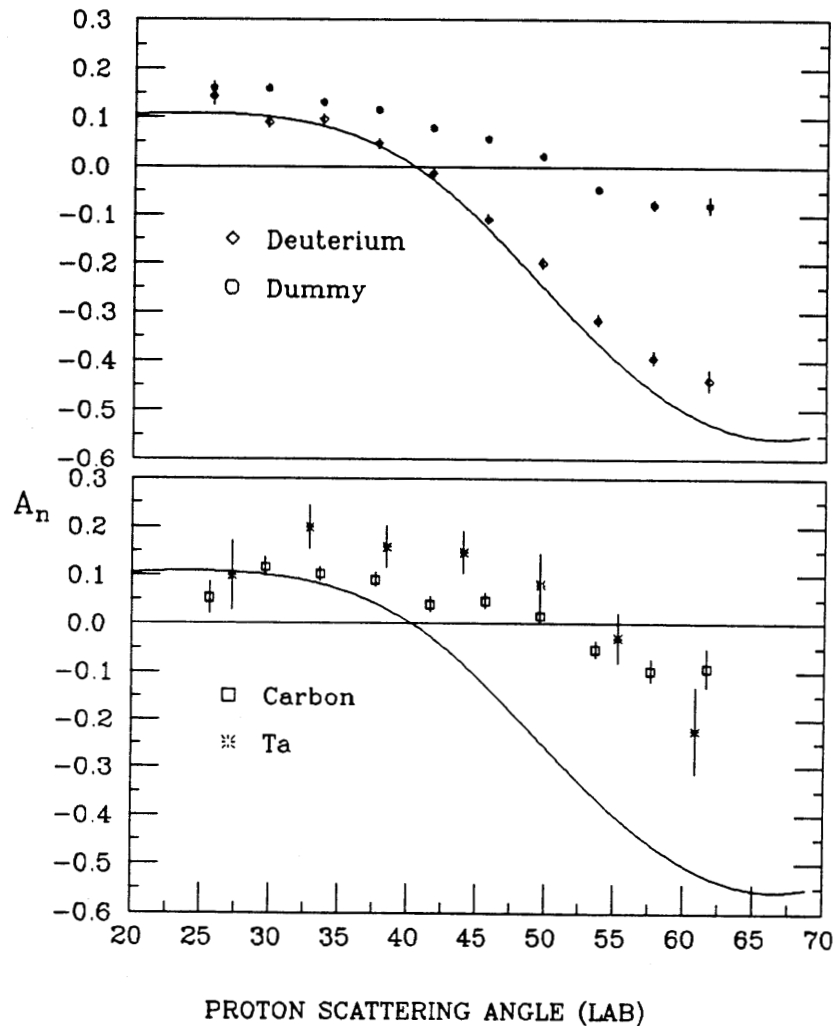


Figure 2. Quasifree n-p analyzing powers. The sign is determined by whether the proton recoils to the left or right of the neutron beam direction. Error bars are statistical only. The solid line represents Arndt's SM86 global solution for free n-p scattering.

Future analysis will focus on trying to understand quantitatively what fraction of the observed deviations from free-scattering analyzing powers may be attributable to kinematic transformations, associated with averaging over finite regions of the Fermi momentum (especially, the transverse momentum component) distribution of the struck proton. To aid in this assessment, we will compare the data obtained for different regions of struck nucleon momentum. Residual, non-kinematic, deviations might arise from distortion effects or from medium modifications (including off-shell behavior of the NN interaction); distinguishing between these sources can only be done within the context of a comparison with specific model (e.g., semi-infinite slab model⁵) calculations.

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σ , A_y , and $D_{NN'}$ MEASUREMENTS OF THE GIANT RESONANCE REGION IN ^{208}Pb USING 200 MeV PROTONS

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The study of isoscalar giant resonances has been an important area of research in nuclear physics. When a new accelerator or detector system become operational, a challenge to such devices is to further extend our knowledge of these collective excitations of the nucleus. Most proton inelastic studies of giant resonances have been carried out with experimental resolutions of 70 to 200 keV and have been aimed primarily at defining global properties. These studies have provided the location, strength and width of the isoscalar $L=2$ giant quadrupole and $L=3$ giant octupole; and in $^{206,208}\text{Pb}$ the $L=4$ giant hexadecapole has been established.

One of the outstanding questions that remains in this field is why hadronic studies have not yet observed the fine structure of the giant quadrupole resonance in ^{208}Pb that is seen in high resolution (40-50 keV) electron scattering studies.¹ To date the "best" attempt to observe this fine structure was an experiment performed at LAMPF using 334 MeV protons detected by the HRS with an energy resolution of 70 keV.² No structure was observed.