TITLE: ANALYZING POWERS FOR THE THREE-NUCLEON BREAKUP REACTION ^{1}H($\vec{\text{d}}$,p)pn AT 16 MeV

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SUBMITTED TO: 5th International Symposium on Polarization Phenomena in Nuclear Physics, Santa Fe, NM, August 11-15, 1980

MASTER

University of California

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ANALYZING POWERS FOR
THE THREE-NUCLEON BREAKUP REACTION ^{1}H($\vec{\text{d}}$,p)pn
AT 16 MeV[a]

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We have measured the analyzing powers A_y, A_{xx}, A_{yy}, and A_{xz} for the kinematically incomplete three-nucleon breakup reaction ^{1}H($\vec{\text{d}}$,p)pn at a deuteron bombarding energy of 16.0 MeV. Similar data for the elastic scattering ^{1}H($\vec{\text{d}}$,p)^{2}H were obtained at the same time. Data were acquired at laboratory angles between 15.0° and 42.5°. The detected proton continua extended over a range in excitation energy E^* for the residual pn system, which varied with angle from E^* = 0-2.6 MeV at 15.0° to E^* ≈ 0-0.2 MeV at 42.5°.

The experiment was performed at the Los Alamos Scientific Laboratory Van de Graaff facility[1] and made use of the Lamb-shift polarized ion source.[2] A deuteron beam in the intensity range 8-120 nA was incident on a hydrogen gas target located in the "supercube" scattering chamber.[3] The fraction of the total beam that was polarized was determined by the quench-ratio technique,[4] and this fraction typically had values near 0.82. Protons were identified in two ΔE-E detector assemblies placed symmetrically to the left and right of the incident beam direction. The data-taking procedure[5] was a modified version of the three-spin-state method.[6] The proton lab energy resolution was about 140 keV, as inferred from the energy width of the elastic group. Th translates into an E^* resolution in the range 70-90 keV. An energy calibration was carried out for each detector assembly by measuring the position of the elastic proton group in the spectrum as the detector angles were varied over a range large enough to yield proton energies appropriate for analysis of the continuum data. Data tables and an extended discussion of the experiment are given in a Los Alamos report.[7]

The breakup analyzing power that attains the largest magnitude is A_{xz}. In Fig. 1 we show A_{xz} at 27.5° (lab) as a function of excitation energy E^*. Data analyzed using summing widths (bins) ΔE^* of both 0.1 and 0.2 MeV are shown. One readily sees that it is sufficient to use a 0.2-MeV bin to represent the E^* dependence. At
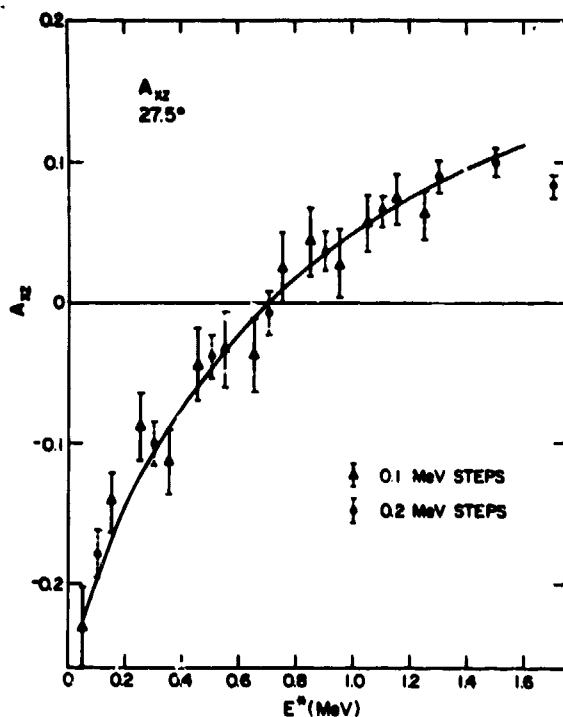
Fig. 1. A_{xz} vs E* at 27.5°(lab) for 0.1-MeV and 0.2-MeV bins. The curve is to guide the eye.
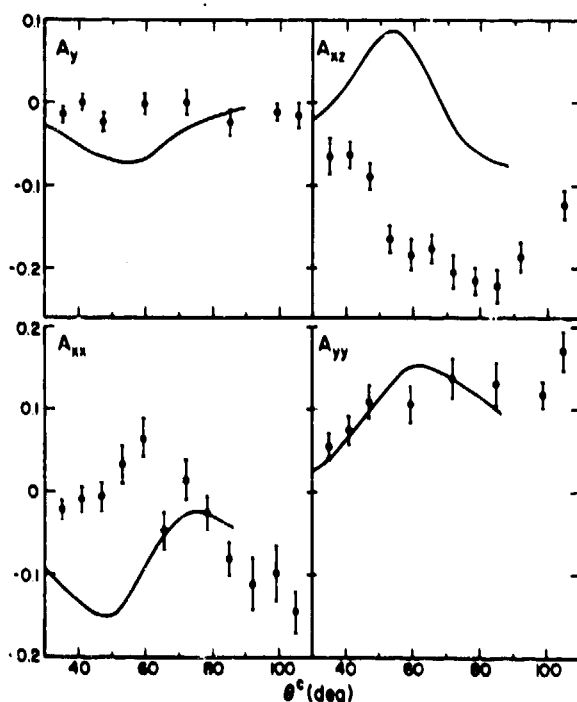

Fig.2.Elastic (curves) and break-up (points) analyzing powers vs proton c.m. angle θ^c. The break-up data are for E*=0-0.2 MeV.

other angles, A_{xz} shows a similar variation with E*. At E* = 0.1 MeV, A_{xz} has values in the range of about -0.1 to -0.2, and for E* > 1.5 MeV A_{xz} tends to reach a plateau at a value of about +0.1. At 25° (lab) A_{xx} also shows a rather rapid variation versus E*, dropping from 0.06 to -0.01 as E* increases; however, this effect is not nearly so striking as that exhibited by A_{xz}. In addition, the variation of A_{xx} with E* changes as a function of lab angle much more than it does for A_{xz}. A_{yy} tends to drop from about 0.1 to about 0.02 as E* increases, and the values for A_y are usually consistent with zero.

In Fig. 2 we compare angular distributions of the elastic analyzing powers (curves) with those of the breakup reaction (points) for the E* interval 0-0.2 MeV. For A_{xx} and A_{xz}, large differences between the elastic and breakup values are observed. Such differences are not particularly surprising, because elastic scattering leads to a pure triplet pn final state, whereas the breakup reaction near threshold should have a significant contribution from the singlet pn state. However, previous p+d results[8] at 22.7 MeV and d+d results[9] at 21 MeV showed that the breakup vector analyzing powers summed over the E* interval 0-1 MeV were smaller in magnitude but similar in angular shape to the corresponding elastic quantities. This seemed to imply

triplet contributions which were unexpectedly more important than indicated by differential cross-section results.[10] Our measurements show that a 1-MeV bin is far too large to use if effects of the singlet state are to be studied. Such a conclusion was also suggested by Faddeev calculations.[11] In addition, because A_{xz} (or T_{21}) varies the most with E^*, we conclude that this analyzing power is more sensitive to singlet-state contributions than are the others.

1. R. Woods, J. L. McKibben, and R. L. Henkel, Nucl. Instrum. Methods 122, 81 (1974).

2. G. P. Lawrence, G. G. Ohlsen, and J. L. McKibben, Phys. Lett. 28B, 594 (1969).

3. P. A. Lovoi, Los Alamos Scientific Laboratory report LA-6041-T (1975).

4. G. G. Ohlsen, J. L. McKibben, G. P. Lawrence, P. W. Keaton, Jr., and D. D. Armstrong, Phys. Rev. Lett. 27, 599 (1971).

5. R. E. Brown, F. D. Correll, R. F. Haglund, Jr., R. A. Hardekopf, N. Jarmie, G. G. Ohlsen, and P. A. Schmelzbach, Phys. Rev. C 20, 892 (1979); W. Grüebler, R. E. Brown, F. D. Correll, R. A. Hardekopf, N. Jarmie, and G. G. Ohlsen, Nucl. Phys. A331, 61 (1979).

6. G. G. Ohlsen and P. W. Keaton, Jr., Nucl. Instrum. Methods 109, 41 (1973).

7. G. G. Ohlsen, F. D. Correll, R. E. Brown, N. Jarmie, and R. A. Hardekopf, Los Alamos Scientific Laboratory report, LA-8401-MS (1980).

8. F. N. Rad, H. E. Conzett, R. Roy, and F. Seiler, Phys. Rev. Lett. 35, 1134 (1975).

9. J. Sanada, S. Seki, T. Tagishi, Y. Takeuchi, M. Sawada, and K. Furono, in Proc. Int. Conf. on Nuclear Structure, Tokyo, 1977 [J. Phys. Soc. Jpn. 44, Suppl. 577 (1978)], p. 8.

10. H. Brückman, W. Kluge, H. Matthäy, L. Schänzler, and K. Wick, Nucl. Phys. A157, 209 (1970).

11. J. Bruinsma and R. van Wageningen, Phys. Lett. 63B, 19 (1976) and Nucl. Phys. A282, 1 (1977); C. Stolk and J. A. Tjon, Phys. Rev. Lett. 39, 395 (1977).