$T(M^2) \rightarrow T_D(M^2)$ as $M^2 \rightarrow \infty$. This is a manifestation of the polynomial ambiguity of Ref. 8. In the range of parameters necessary to represent the data ($f/g < 0$), this other possibility does not lead to any appreciable change in our results.

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Equality of Analyzing Power and Polarization in the Reaction ^{3}H(p, n)^{3}He

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The quantities A_y and P^y were remeasured for $E_p < 4$ MeV in the reaction ^{3}H(p,n)^{3}He. Although our A_y data confirm previous data, our P^y values are appreciably larger than earlier results and in fact agree well with those for A_y. Elimination of the previously reported A_y-P^y difference has important consequences. Charge-symmetry-breaking effects must be small or nonexistent in this reaction; and the previously required f-wave admixture to the lowest $J^\pi = 2^-$ state of ^{4}He is no longer necessary.

Concern over the inequalities of the analyzing power A_y for an incident polarized beam and the polarization P^y for an incident unpolarized beam for (p, n) reactions began in 1971 with the reaction ^{3}H(p, n)^{3}He. Haight *et al.*[1] compared their A_y data to the then existing P^y data and observed that the two quantities were essentially the same above 4 MeV, but differed appreciably below this energy, by about 20% of the experimental magnitude. This difference was particularly surprising as charge-independent R-matrix calculations[1] showed differences of less than 1%. Since then, several pertinent Letters have appeared. First, Arnold *et al.*[2] showed that the differences in these quantities provided fairly unambiguous evidence for an f-wave admixture to the lowest 2^- state in ^{4}He. Conzett[3] followed by showing that an equality of A_y and P^y is expected in (p, n) reactions connecting mirror nuclei. More significantly, he recognized that differences in these quantities imply a breaking of exact charge symmetry by the Coulomb interaction and hence measures of these differences provide a mechanism for investigating charge-symmetry-breaking terms in the nuclear interaction. Because of the significance of these differences in the reaction ^{3}H(p, n)^{3}He and because of suspected problems in the earlier experiments, we remeasured both quantities and report our results and conclusions in this Letter.

The A_y measurements were carried out using The Ohio State University polarized-ion-source facility[4] which yields beams of 50 nA with about 60% polarization. The neutrons were produced in a 0.23 mg/cm^2 titanium-tritium target and were detected by a pair of symmetrically located NE213 scintillators. Recoil spectra, gated for neutrons using conventional n-γ discrimination electronics, were accumulated, stored on magnetic disk, and subjected to further off-line data reduction. The A_y data were obtained by alternately measuring spectra with the beam polarized and unpolarized for equal total charge. After each A_y measurement, the beam polarization was obtained by inserting a ^{4}He polarimeter in front of the neutron target. Further experimental details will be given by Doyle *et al.*[5]

The results of these A_y measurements at 45° in the center-of-mass frame (c.m.) for $E_p = 1.75$ to 3.9 MeV are shown in Fig. 1(a) along with the earlier data of Haight *et al.*[1] and with a curve to guide the eye. The agreement between the two sets of data is quite good over the entire energy range. Besides confirming the earlier data, this agreement indicates that concerns over beam depolarization effects in the tandem accelerator terminal[1] and differences in experimental techniques are of little consequence. An angular distribution of A_y measured at 2.48 MeV is shown in Fig. 2(a) along with a fit to the data. Our data are in excellent agreement with the earlier data of Brown and Rohrer[6] plotted in this figure. For completeness, the A_y angular distribution of

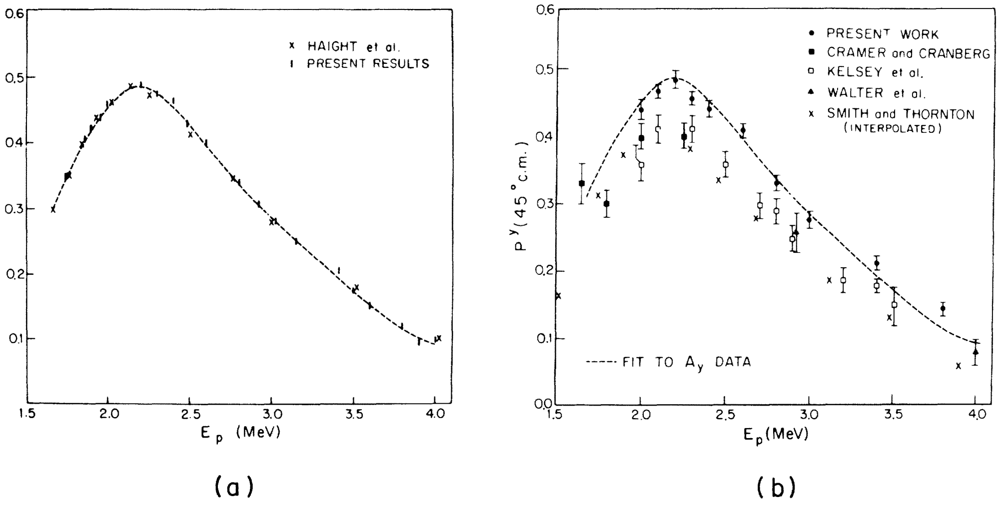

FIG. 1. (a) Analyzing power measurements at $\theta_{\text{c.m.}} = 45°$ are compared with earlier data of Haight *et al.* in Ref. 1. (b) The present P^y data are shown and compared with earlier P^y data of Refs. 9–12. The smooth dashed curve sketched through the A_y data in (a) is also shown in (b) to facilitate comparisons with the P^y data.

Brown and Rohrer at 2.26 MeV is shown in Fig. 2(c) along with a corresponding fit.

The P^y measurements were made using an unpolarized proton beam from the tandem accelerator at Triangle Universities Nuclear Laboratory and a neutron polarimeter facility that includes a spin-precession solenoid and a high-pressure (200 atm) helium gas scintillator. Neutrons produced by bombarding a 1.08 mg/cm^2 titanium-tritium target passed through the solenoid; and the polarization was determined by scattering from helium into one of two symmetrically positioned NE102 detectors. The latter were located at (lab) angles from 90° to 110°, depending on the magnitude of the n-^{4}He analyzing power at various energies. The n-^{4}He analyzing-power values

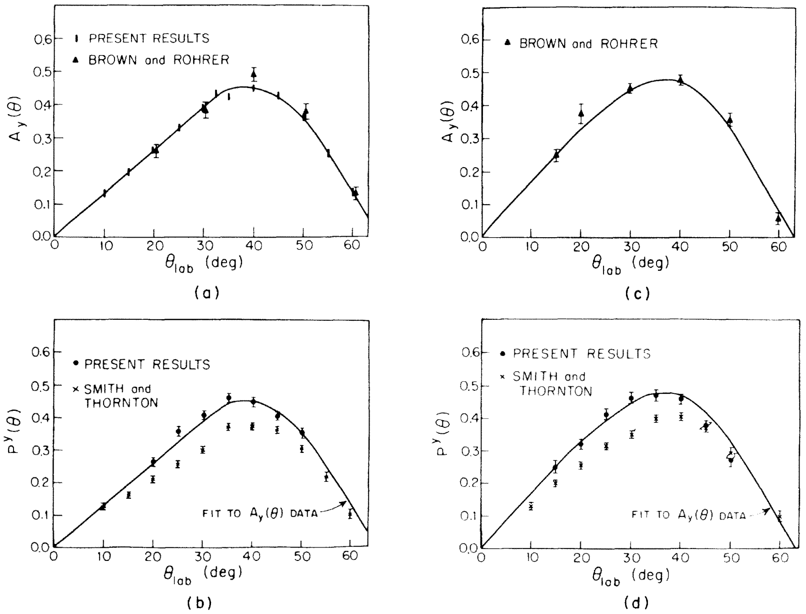

FIG. 2. (a) An angular distribution of A_y at 2.48 MeV is compared with the earlier data of Brown and Rohrer (Ref. 6). (b) Present P^y data at 2.46 MeV are shown along with earlier data of Smith and Thornton (Ref. 9). (c) An A_y angular distribution at 2.26 MeV of Brown and Rohrer (Ref. 6) is shown. (d) Present P^y data at 2.26 MeV are shown along with earlier data of Smith and Thornton (Ref. 9). Fits to the A_y data in (a) and (c) are also shown in (b) and (d), respectively, to facilitate comparison between the two quantities.

were calculated using the Stammbach-Walter[7] phase shifts and were corrected for system-geometry and multiple-scattering effects. Data were recorded on magnetic tapes using an on-line computer and analyzed later off-line. A more complete description of the experimental apparatus and data-reduction procedures will be given by Byrd *et al.*[8] The polarization values measured near 45° (c.m.) at energies between 1.75 and 4.0 MeV are shown in Fig. 1(b) as solid dots and are compared with earlier data.[9-12] Angular distributions of P^y were measured at 2.26 and 2.46 MeV and these are shown in Figs. 2(b) and 2(d) together with the data of Smith and Thornton.[9] The magnitudes of our polarization data are consistently larger than reported in the earlier experiments. This conclusion bears out the recent suspicion of Tornow *et al.*[13] that the P^y data of Smith and Thornton[9] are too low in magnitude.

Because our P^y results differ so appreciably from those reported by several other groups, we examined our data-taking procedures and our spectra quite carefully. We observed that each gated helium recoil spectrum consisted of a peak superimposed on an unpolarized background. Since a proper determination of the value of P^y depends upon the manner in which this background is subtracted, we scrutinized each case on an off-line computer using a fitting code designed especially for this purpose. Such a background may be due to neutrons which scatter first on the helium containment vessel, followed by a helium scattering and subsequent detection in fact coincidence by one of the NE102 detectors. Background contributions to the recoil spectra could also arise by neutrons scattering from ^{4}He after having been scattered from such material as the scintillator end windows. Detailed studies of these effects are given by Tornow, Spiegelhauer, and Mack[14] and Davie and Galloway.[15]

It is difficult to criticize the data reported by other authors because only meager details about the spectra are given in their papers. However, the time-of-flight method as used by Cramer and Cranberg[12] and by Smith and Thornton[9] was not capable of revealing all of the sources of background. Accordingly it is unlikely that all of the corrections could have been determined properly by these authors. In the one case which employed a technique similar to ours, Kelsey, Hoop, and Van der Maat[10] reported making no background correction. It would appear therefore that the old data are too low in magnitude, principally because background effects contribute significantly at the low neutron energies encountered here. In fact, without correction for such backgrounds, the present P^y data would be comparable in magnitude to the previously reported results.

To compare our P^y data with A_y data, we have transferred curves that best fit the A_y angular distributions in Figs. 2(a) and 2(c) to Figs. 2(b) and 2(d), respectively. At both energies, the new P^y data are in close agreement with the A_y fits. Similarly, the dashed curve in Fig. 1(a) sketched through the A_y data has been transferred to Fig. 1(b); and again, the agreement between the new P^y data and the A_y fit is good over the entire energy range. Clearly these quantities are equal within the experimental uncertainties.

In conclusion, our new measurements show clearly that the previously reported difference between A_y and P^y in the reaction ^{3}H(p,n)^{3}He does not exist. This suggests that charge-symmetry-breaking effects are small or nonexistent in this reaction. The inclusion of an f-wave admixture to the lowest 2^- state in ^{4}He proposed to account for the former discrepancy between these two measured quantities is no longer required. Furthermore, because the analysis of the reaction ^{3}H(p,n)^{3}He, including the former sets of P^y data, has been instrumental in determining the present mass-4 level structure,[16] revisions of this structure are now undoubtedly required. Lastly, we now believe that the background effects discussed above imply additional problems in the interpretation of neutron-polarization data for other reactions at low neutron energies.

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Strong Isotope Dependence of K-Vacancy Production in Slow Ne^+-Ne Collisions[*]

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Large isotope effects in the K x-ray yields from collisions of ${}^{A}Ne^+$-${}^{B}Ne$ $(A,B=20,22)$ have been observed. For slow collisions (relative velocities $\sim\frac{1}{3}$ a.u.) the K x-ray yields do not scale well with either relative velocity or center-of-mass energy, whereas at higher collision velocities, the yields appear to scale well with relative velocity.

The dominant mode of production of K-shell vacancies in slow, symmetric ion-atom collisions was originally predicted[1] to be due to the transfer of an initial $2p$ vacancy into the K shell by the rotational coupling of the $2p\sigma$-$2p\pi$ molecular orbitals of the collisionally formed quasimolecule. Quantitative predictions of vacancy production rates in Ne^+-Ne collisions were made[2] by scaling collision trajectories in D^+-D collisions and scaling the molecular energy levels of the $H_2{}^+$ molecule. For Ne^+-Ne collisions the K-vacancy production rate for a given impact parameter was taken as the product of the probability that the initial $2p$ vacancy occupied the $2p\pi$ molecular orbital and the probability of rotational coupling of the $2p\sigma$ and $2p\pi$ orbitals. Isotope effects in the trajectory scaling were considered negligible if the ratio of the nuclear charge to the reduced mass of the collision partners was near unity (i.e., $Z/M_r \approx 1$) and the screened nuclear charge was a constant fraction of the bare nuclear charge.[2]

Within the approximations used in Ref. 2, it was expected[2] that K-vacancy production in symmetric collisions between different isotopes of the same element would be approximately the same in collisions of the same relative velocity. The present experiment provides the first precise test of this prediction using K x-ray production as a measure of the K-vacancy production. For ${}^{A}Ne^+$-${}^{B}Ne$ collision velocities of about $\frac{1}{2}$ a.u. or greater, we have verified the accuracy of this prediction. For velocities $\sim\frac{1}{3}$ a.u., we find a 40% isotope effect in the K-vacancy production rate for equal relative velocities!

A central purpose of this Letter is to describe sensitive means for making quantitative tests[3] of mass-dependent corrections to scaling calculations like those of Briggs and Macek[2] and to illustrate the success of such tests for Ne^+-Ne collisions. It is surprising that such sensitive tests can be obtained from such relatively simple total cross-section measurements.

For $Z_A = Z_B$, and given internuclear separation, isotopic effects on energy levels of the Ne-Ne collision system and on corresponding electronic screening of the nuclei may be neglected. For equal relative velocities, isotopic effects on fluorescent yields are also expected to be small. The dominant isotope effects are due to differences in internuclear trajectory, slight variations in which strongly influence the probability of rotational coupling near the threshold (Figs. 2 and 3 of Ref.