COMMENT

Equivalence of Charge Isospin Symmetry Breaking and Asymmetric Spin-Flip Probability in (p,n) Reactions between Analog States of Mirror Nuclei

The purpose of this paper is to remove a widespread misconception in interpretation of the difference between polarization and analyzing power in (p,n) reactions connecting isobaric analog states of mirror nuclei. Conzett[1] has shown that in such reactions the proton analyzing power A is equal to the neutron polarization P when the ingoing proton is unpolarized, provided that time-reversal invariance and isospin symmetry hold. On the other hand, Arnold[2,3] has expressed the difference $P-A$ in terms of the transition probabilities T_{fi}, where the subscripts refer to the polarization of the initial proton and the final neutron (subscripts "↑" and "↓" denote spin up and spin down, respectively):

$$P-A=2(T_{\uparrow\downarrow}-T_{\downarrow\uparrow}).$$

This leads to the idea of a nonzero $P-A$ arising from "asymmetric spin flip." Indeed an observed difference between P and A is ascribed to two distinct causes[3-5] in that "a nonvanishing $P-A$ difference in these reactions requires the presence of both an isospin-symmetry breaking component in the interactions responsible for the reaction and a transverse spin-flip mechanism which yields a spin-flip asymmetry."[5] It is, however, the intention of this Letter to suggest that asymmetry of the spin flip is, in fact, a consequence of breaking of charge symmetry or time-reversal invariance.

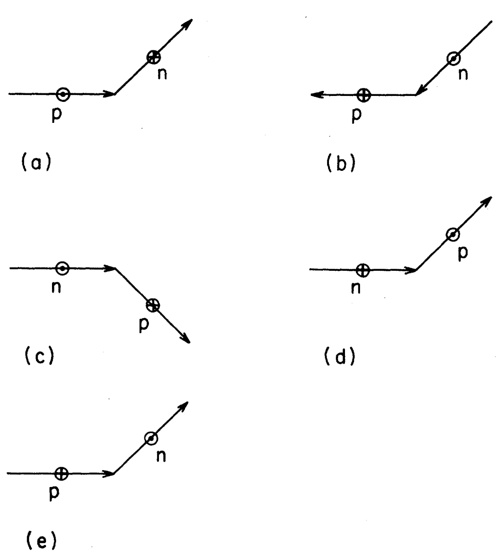

FIG. 1. Schematic diagram suggesting the equivalence of the Conzett and Arnold statements concerning quantities P and A as defined in the text. Circles with dots indicate "spin-up"; crosses, "spin-down" configurations.

Fig. 1(a) shows a reaction process for which the transition probability is $T_{\downarrow\uparrow}$. Fig. 1(b) shows the inverse reaction, for which the cross section is equal to that of Fig. 1(a) by detailed balance. Figs. 1(c) and 1(d) result from a rotation about an axis perpendicular to the reaction plane, so that the neutron is incident from the left, followed by a rotation of 180° about the neutron momentum. Fig. 1(e) is the charge symmetric reaction, obtained by exchanging all neutrons and protons. The transition probability for Fig. 1(e) is $T_{\uparrow\downarrow}$, so that by time-reversal invariance and charge symmetry $T_{\downarrow\uparrow}=T_{\uparrow\downarrow}$, i.e., the spin flip is symmetric and $P=A$. Any observed difference between P and A is caused by an asymmetry of the spin flip which can result presumably from a breaking of charge symmetry or time-reversal invariance. Furthermore, a large $T_{\uparrow\downarrow}-T_{\downarrow\uparrow}$ difference will be observed only if the total spin-flip probability $(T_{\uparrow\downarrow}+T_{\downarrow\uparrow})$ is large, which implies that

$$|P-A|\leq 1-K_y^{y'}=2(T_{\uparrow\downarrow}+T_{\downarrow\uparrow}),$$

$K_y^{y'}$ being the transverse polarization transfer coefficient. Further study of this problem and, in particular, the mechanism by which charge-symmetry breaking leads to asymmetric spin-flip probability should now be undertaken.

J. Birchall
J. S. C. McKee
Department of Physics, University of Manitoba
Winnipeg, Manitoba R3T 2N2, Canada

Received 16 September 1980
PACS numbers: 24.30.Eb, 25.40.Ep

[1] H. E. Conzett, Phys. Lett. 51B, 445 (1974).
[2] L. G. Arnold, Bull. Am. Phys. Soc. 22, 588 (1977).
[3] R. C. Byrd and R. L. Walter, in Proceedings of the Fifth International Symposium on Polarization Phenomena in Nuclear Physics, Santa Fe, 1980 (to be published).
[4] R. C. Boyd, Ph.D. thesis, Duke University, 1978 (unpublished); R. J. Philpott, in Proceedings of the Fifth International Symposium on Polarization Phenomena in Nuclear Physics, Santa Fe, 1980 (to be published).
[5] R. J. Philpott and Dean Halderson, Phys. Rev. Lett. 43, 1785 (1979).