Comment on "Test of Charge Symmetry in π^+ and π^- Elastic Scattering on Tritium and ^{3}He"

Nefkens *et al.*[1] have recently measured elastic scattering of 180-MeV π^+ and π^- on ^{3}He and tritium from $\theta_\pi(\text{c.m.}) = 44°$ to 96° and have found the superratio

$$R \equiv \frac{d\sigma(\pi^+ + {}^3\text{H})/d\sigma(\pi^- + {}^3\text{He})}{d\sigma(\pi^+ + {}^3\text{He})/d\sigma(\pi^- + {}^3\text{H})}$$

to vary with angle reaching a maximum of $R_{\text{max}} = 1.31 \pm 0.09$ at $\theta_\pi = 65°$, a large departure from the expected value of $R = 1.0$ on the basis of conventional charge symmetry (CS). As a possible explanation, they suggest that the effect may be less likely due to (i) a "trivial" violation of CS due to Coulomb repulsion of protons in ^{3}He[2-5] or more likely due to (ii) a difference in coupling constants, $f(pp\pi^0) \neq f(nn\pi^0)$.[6] In this note, we point out that the above effect can be explained as the manifestation of multiquark compound resonances (MQCR) in interacting hadronic systems,[7] and suggest a specific experimental test.

The expected value of $R = 1.0$ on the basis of conventional CS is due to the assumption that the hadrons involved in obtaining R can be regarded as elementary particles forming isospin multiplets, (π^+, π^-, π^0) and $(^3\text{He}, {}^3\text{H})$, with distinct isospins and the z component (I_3) of the isospin (I). The above assumption is expected to work well at lower energies even for the $(^3\text{He}, {}^3\text{H})$ isospin multiplet $(I = \frac{1}{2}, I_3 = \pm\frac{1}{2})$ [which are loosely bound three-nucleon $(3N)$ systems], since the effect of Coulomb repulsion of protons in ^{3}He is known to be small, being less than a few percent effect.[2-5] However, if the interacting pion and $3N$ nucleus (^{3}He or ^{3}H) are regarded as a composite multiquark system $(q^{10}\bar{q})$ at higher energies as in the case of the experimental measurements of Nefkens *et al.*,[1] they may manifest a broad MQCR in one or more of the four elastic channels, $(\pi^+ + {}^3\text{H})$, $(\pi^- + {}^3\text{H})$, $(\pi^+ + {}^3\text{He})$, and $(\pi^- + {}^3\text{He})$, and thus can provide an explanation for the breakdown of the conventional CS, $R \neq 1$.

Nefkens *et al.*[1] find that $r_1 \approx 1$ and $r_2 \neq 1$ where r_1 and r_2 are defined as $r_1 \equiv d\sigma(\pi^+ + {}^3\text{H})/d\sigma(\pi^- + {}^3\text{He})$ and $r_2 \equiv d\sigma(\pi^- + {}^3\text{H})/d\sigma(\pi^+ + {}^3\text{He})$. The fact that $r_1 \approx 1$ and $r_2 \neq 1$ implies that the effect of MQCR may be occurring in the channels involving r_2, i.e., $(\pi^- + {}^3\text{H})$ and/or $(\pi^+ + {}^3\text{He})$ elastic channel. Because of our primitive understanding of MQCR involving $(q^{10}\bar{q})$ systems, we cannot provide at present a reliable theoretical estimate of the magnitude of deviation of R from unity, but may be able in the near future to develop a sophisticated model of MQCR along the line recently proposed.[7] However, there is a direct experimental test which can be done to check whether the above MQCR explanation of $R \neq 1$ is consistent or not. If we measure R as a function of pion energy, T_π, we expect $R(T_\pi)$ to exhibit a resonance behavior, with $R \approx 1$ near $T_\pi \approx 0$ and well above $T_\pi = 180$ MeV (used by Nefkens *et al.*[1]). If such a behavior of $R(T_\pi)$ is experimentally confirmed, the effect of $R \neq 1$ observed by Nefken *et al.* may turn out to be an important case of the manifestation of the quark degrees of freedom in nuclei, more convincing than the case of the EMC effect.[8]

The above idea of using the nonconservation of the conventional CS to investigate the quark degrees of freedom in nuclei can be also applied to other experimental situations such as the ratio, $R \equiv \sigma(nd \to {}^3\text{He}\pi^-)/\sigma(nd \to t\pi^0)$,[9,10] of the structure functions of ^{3}H and ^{3}He as measured from the inclusive electron scattering cross sections, and others. A more complete list of these possibilities will be published elsewhere.[11]

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[1]B. M. K. Nefkens *et al.*, Phys. Rev. Lett. **52**, 735 (1984).
[2]R. Brandenburg *et al.*, Nucl. Phys. **A294**, 305 (1978).
[3]T. Sasakawa *et al.*, Phys. Rev. Lett. **45**, 1386 (1980).
[4]G. L. Payne *et al.*, Phys. Rev. C **22**, 832 (1980).
[5]J. Friar *et al.*, Comments Nucl. Part. Phys. **11**, 51 (1983).
[6]A. Thomas *et al.*, Phys. Rev. D **24**, 2539 (1981).
[7]Y. E. Kim and M. Orlowski, in *Hadron Substructure in Nuclear Physics—1983,* edited by W.-Y. P. Hwang and M. H. Macfarlane, AIP Conference Proceedings No. 110 (American Institute of Physics, New York, 1983), and Phys. Lett. **140B**, 275 (1984), and Phys. Rev. C **29**, 2299 (1984).
[8]J. J. Aubert *et al.*, Phys. Lett. **123B**, 275 (1983); A. Bodek *et al.*, Phys. Rev. Lett. **50**, 1431 (1983); R. G. Arnold *et al.*, Phys. Rev. Lett. **52**, 727 (1984).
[9]W. Dutty *et al.*, in *Few Body Problems in Physics Volume II—Contributed Papers,* edited by B. Zeitnitz (Elsevier, New York, 1984), p. 235.
[10]Y. E. Kim, L. Tiator, and C. Y. Cheung, to be published.
[11]Y. E. Kim, to be published.

