Comments

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Comment on "Microscopic optical-potential analysis of charge-symmetry violation in $\pi^{\pm}$ elastic scattering from ^{3}H and ^{3}He"

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A recent calculation by Kim, Kim, and Landau attributes the charge-symmetry violation seen by Nefkens *et al.* in elastic scattering of $\pi^{\pm}$ from ^{3}H and ^{3}He to direct Coulomb effects. This calculation explains only the most obvious part of the charge-symmetry breaking. We believe that their calculations do not support their conclusion concerning the effect seen in the experimental data.

In a recent brief report Kim, Kim, and Landau[1] (KKL) discuss a possible explanation of the violation of charge symmetry (CS) observed by Nefkens *et al.*[2] in the elastic scattering of $\pi^{\pm}$ from ^{3}H and ^{3}He. The conclusion of KKL is that the violation can be due to "direct" Coulomb effects which arise from adding the interaction of the pion and nucleus charges to a charge-symmetric strong interaction. We comment here on several of the points discussed by KKL.

KKL state that "the Coulomb force is the ultimate source of charge symmetry violation . . . ." It is clear that the Coulomb force leads to a breakdown of CS. However, the most interesting and important question posed by the data is whether the observed violation is, in fact, entirely owing to Coulomb effects, or is a manifestation of a breakdown of CS, at least in part, in the strong interaction. To support the above quote, it must be demonstrated either that Coulomb effects completely explain the CS violation or that it is impossible for the strong interaction to contribute to the CS violation. KKL do neither and explain only the most obvious part of the CS breaking. Other Coulomb and non-Coulomb effects are dismissed as small even in the light of related data. For example, there are indications in related measurements that the ^{3}H-^{3}He form-factor difference is important: the deviation of the ratio

$$r = d\sigma(pd \rightarrow {}^3\mathrm{H}\pi^+)/2d\sigma(pd \rightarrow {}^3\mathrm{He}\pi^0)$$

from unity, in violation of charge independence, is attributed to the effect of the Coulomb repulsion of the two protons in ^{3}He.[4–8] Although pion-production and pion-scattering reactions are not identical, they contain the same π^3H or π^3He vertex and final state; it is reasonable to believe that the effects of the form-factor difference are similar. Recent calculations conclude that 20–30 % changes in the "superratio,"

$$R = d\sigma(\pi^{+\,3}\mathrm{H})d\sigma(\pi^{-\,3}\mathrm{H}/d\sigma(\pi^{+\,3}\mathrm{He})d\sigma(\pi^{-\,3}\mathrm{He}) ,$$

result at $\theta_{\mathrm{c.m.}} > 120°$ owing to this effect.[3] If one considers only the angular region of the data of Ref. 2, contributions of the order of 5–15 % are evident in the figures shown in Ref. 3. Certainly, this contribution should not be dismissed as "small" without demonstration.

KKL have examined other Coulomb effects, which modify the effective π-nucleon energy, the overall energy dependence of the nuclear potential, the nuclear mass, and the wave equation, and also found them to be small. Unfortunately, the references they cite (their Ref. 8) are not directly related to this question; thus it is difficult for the reader to judge the importance of these effects.

In Ref. 1 KKL compare their calculation to the data of Nefkens *et al.* The calculation predicts a peak of roughly the same size (and with the same sign) as that observed. However, the value of R calculated by KKL differs substantially from unity only in the region of the "non-spin-flip" dip. They explain that the existence and position of the peak, in their simple model, is very much dependent on the existence and position of the "non-spin-flip" dip. However, the data show that R is significantly greater than unity even for $\theta_{\mathrm{c.m.}} < 60°$—away from the dip. Thus, the model of KKL does not satisfactory explain the data unless there are other, large, effects. The effect that any modification to their model will have is not evident. Without making the calculations, one cannot assume that the agreement will get better. All that KKL have demonstrated is that the direct Coulomb effect they have considered might produce a large effect. KKL state:

"What is unequivocal is that the difference in character for the cross sections that form the theoretical r_1 and r_2 is caused solely by the direct addition of pion-nucleus, Coulomb, and nuclear potential; more subtle charge-symmetry breaking effects, e.g., at the nuclear structure, or pion-nucleon levels, appear to be a small correction to our macroscopic violation." It would take more than a "small correction" to make up the difference between the calculation and the data. Yet they conclude: "Consequently, we view the charge-symmetry violation reported by Nefkens *et al.* as a real effect, the dominant part of which arises from the addition of the pion-nucleus, Coulomb, and nuclear forces." Their calculated r's and R do not warrant this conclusion.

In conclusion, the central question raised by the data of Nefkens *et al.* is whether the observed violation of CS can be fully explained by direct, projectile-target Coulomb effects, or signals a breakdown of CS of the strong interaction (possibly owing to the Coulomb interaction between the two protons in ^{3}He). The calculation of KKL has only demonstrated that the direct Coulomb effects can produce an effect of the same magnitude as that observed; it still leaves open the question as to whether or not Coulomb effects are the only source of CS violation. The statement that "the Coulomb force is the ultimate source of charge-symmetry violation" must be supported or refuted with complete, realistic calculations that include all reasonable Coulomb effects, and only when these calculations have been tested on a broad range of data will we be able to make progress in addressing the question of a possible CS violation of the strong interaction in pion scattering on ^{3}H and ^{3}He.

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