Erratum: Investigating Neutron Polarizabilities through Compton Scattering on ^3He [Phys. Rev. Lett. **98**, 232303 (2007)]

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(Received 12 April 2018; published 11 June 2018)

DOI: 10.1103/PhysRevLett.120.249901

We provide updated predictions from our $O(Q^3)$ calculation of elastic Compton scattering from ^3He in chiral perturbation theory. These correct erroneous results published in our Letter and in [1].

The analytic formulas for Feynman diagrams in Ref. [1] are correct. However, the computer code that calculated observables for Compton scattering from ^3He contained the following errors in the implementation of the two-nucleon Compton operator that appears at $O(Q^3)$ in the chiral expansion:

(1) It failed to include the isospin dependence of this operator: $(\tau^{(1)} \cdot \tau^{(2)} - \tau_z^{(1)} \tau_z^{(2)})/2$ (see Eq. (59) of Ref. [1]). This factor is 1 for “deuteron”-like pairs with two-body isospin $T = 0$ and -1 for $T = 1$ np pairs. (It is zero for pp and nn pairs).

(2) There was a factor of 2 missed when coding the piece of the operator that produces transitions between pairs where the two-nucleon spin, S , changes from $S = 0$ to $S = 1$.

(3) There was a mistake in the implementation of the $S = 0$ to $S = 1$ piece of diagram E.

None of the errors occur in the earlier code that computes Compton scattering from the deuteron, since there is only a $T = 0$, $S = 1$ np pair.

The first mistake has the largest consequences for elastic $\gamma^3\text{He}$ scattering. The others only affect parts of the elastic matrix elements that involve small components of the ^3He wave function. But rectifying the isospin factor increases the prediction for the $\gamma^3\text{He}$ cross section markedly: see Fig. 1 which replaces Fig. 1 from our Letter and shows the differential cross section at 60 and 120 MeV for an $O(e^2)$ [$\equiv O(Q^2)$] calculation, an impulse-approximation calculation, and the $O(e^2Q)$ [$\equiv O(Q^3)$] calculation. In this, and all the subsequent calculations in this erratum, the χEFT Idaho NN potential at N^3LO [2] combined with an N^2LO χEFT three-nucleon force [3] was used to generate the cross sections. This was also the default choice in our Letter. The $O(e^2)$ and impulse-approximation results in Fig. 1 are the same as in our Letter and in Ref. [1]. The corrected $O(e^2Q)$ result is approximately 10% larger at $\omega_{\text{cm}} = 60$ MeV than the old, incorrect one. It is 50% (at forward angles) to 60% (at backward angles) larger at $\omega_{\text{cm}} = 120$ MeV.

Meanwhile, Fig. 2 shows the corrected results for Fig. 2 of our Letter, which displayed the sensitivity of the $\gamma^3\text{He}$ differential cross section to changes in the neutron’s electric and magnetic static dipole polarizabilities. The pattern and relative size of the effect is very similar to that seen in the original calculation, although the cross section we now obtain is a little larger in absolute size.

FIG. 1. $\gamma^3\text{He}$ cross section at $\omega_{\text{cm}} = 60$ and 120 MeV. The blue dashed line is the $O(e^2)$ result, the red dash-dotted line represents the impulse-approximation cross section, and the green solid line is the full result at $O(e^2Q)$.

FIG. 2. $\gamma^3\text{He}$ cross section at $\omega_{\text{cm}} = 80$ MeV, for various modifications to the static scalar dipole polarizabilities of the neutron. Left: sensitivity to changes in $\alpha^{(n)}$. Right: sensitivity to changes in $\beta^{(n)}$. Curves as shown in the panel legends.

Figure 3 then shows corrected results for the difference of differential cross sections for ^3He nuclei polarized parallel and antiparallel to the beam direction, for a right-circularly polarized photon beam (Δ_z). And Fig. 4 shows a similar cross-section difference but for target polarization in the scattering plane and perpendicular to the photon beam (Δ_x). In each case the sensitivity to particular neutron spin polarizabilities is displayed. These two figures for Δ_x and Δ_z correct Figs. 3 and 4 from our Letter. The trend of the effect is very similar to that seen in the old results, but the cross-section differences are now $\approx 20\%$ larger in Fig. 3 and $\approx 40\%$ larger in Fig. 4.

None of these changes in our results modify the qualitative conclusions of our Letter and Ref. [1]. The following remains true:

(1) The Compton cross section on ^3He is significantly larger than that on deuterium. Indeed, this conclusion is strengthened after the corrections discussed here are made.

(2) The Compton differential cross section on ^3He has a larger (in absolute terms) sensitivity to the neutron electric and magnetic dipole polarizability than does the deuteron Compton differential cross section.

FIG. 3. Differences of polarized $\gamma^3\text{He}$ cross sections at $\omega_{\text{cm}} = 120$ MeV, as obtained under shifts of different static spin dipole polarizabilities of the neutron. Shifts range from $+100\%$ to -100% of the $O(e^2Q)$ values. Shown are sensitivity to changes in $\gamma_1^{(n)}$ (top left), to $\gamma_2^{(n)}$ (top right), and to $\gamma_4^{(n)}$ (bottom left). Curves as shown in the legend.

FIG. 4. Differences of polarized $\gamma^3\text{He}$ cross sections at $\omega_{\text{cm}} = 120$ MeV, as obtained under changes to the neutron spin polarizability $\gamma_1^{(n)}$ (left) and $\gamma_4^{(n)}$ (right). Legend as in Fig. 3.

(3) Elastic Compton scattering on a polarized ^3He target produces cross-section differences whose sensitivity to neutron spin polarizabilities is similar to those for a free neutron.

Lastly, we point out that in defining the asymmetries plotted in Ref. [1] we divided by the sum of the cross sections for different initial-state polarization of the ^3He nucleus, rather than by the average. Although this was clearly defined in Ref. [1] [see Eqs. (69) and (71) therein], it is a possible source of confusion when comparing with other works.

A concurrent publication [4] presents corrected versions of all $O(Q^3)$ [$\equiv O(e^2Q)$] calculations that were presented in Ref. [1]. It also displays the results for the $\gamma^3\text{He}$ observables in an EFT with the $\Delta(1232)$ as an explicit degree of freedom.

We thank Harald Griebhammer for generating the graphs shown here, Arman Margayan for identifying the errors and correcting the code, and Bruno Strandberg for his help running the corrected code. This work was supported by the U.S. DOE under Grant No. DE-FG02-93ER-40756.

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