Comment on "Total Cross Section for Photon Absorption by Two Protons in ^{3}He"

In a recent Letter [1], absorption of intermediate energy photons on a diproton pair in ^{3}He is interpreted as an electric quadrupole transition. Because the initial state $^1S_0(pp)$ does not carry angular momentum and the 1^+ final states are absent in the two-proton system, the $M1$ multipole transitions, dominant in photodisintegration of the deuteron in the Δ region, do not contribute. Also, due to the absence of an electric dipole moment, the convection part cannot contribute to $E1$ transitions. However, the dominance of $E2$ is not guaranteed, since this argument ignores the spin degrees of freedom. Contrary to $M1$, the $E1$ multipole is not really forbidden, as assumed in Ref. [1], because the $^3P_1$ final state is accessible by the spin-flip part of the $E1$ operator and turns out to be important.

Further arguments for the $E2$ dominance in Ref. [1] are based on the qualitative similarity of the measured $^3\mathrm{He}(\gamma, pp)n_{\mathrm{spec}}$ total cross section to the $E2$ strength calculated for deuteron photodisintegration [2]. On the other hand, also other multipoles have a similar energy dependence. Perhaps a more convincing feature in that comparison was the size of the cross section, which was 4.7 times the $E2$ strength of the free deuteron case. Naively from the charge difference one would, indeed, expect a factor of 4. However, the more compressed quasideuteron wave function in ^{3}He gives already an enhancement factor of 5 in the $E2$ strength [3], so that also this evidence appears circumstantial. Furthermore, the $E2$ strength in deuteron disintegration is shared by many partial waves. Their contributions to the total $E2$ cross section $\sigma(E2; \gamma + d)$ together with the contributing currents are listed in Table I for a typical photon energy of 300 MeV. There, $\sigma(E2; \gamma + d)$ is essentially given by isospin $T = 0$ channels, while the $T = 1$ partial wave $^1D_2$ contributes to 8% only. So the most important final partial waves for $\sigma(E2; \gamma + d)$ are different from the one ($^1D_2$) in case of a pp pair and are subject to different final state interactions. Moreover, contrary to $\sigma(E2; \gamma + {}^1S_0(pp))$, the cross section $\sigma(E2; \gamma + d)$ contains coherent contributions from the spin-dependent one-body current, which also have not been taken into account in Ref. [1]. Switching them off leads to the values in the last column of Table I. It results in a nearly 30% reduction of the cross section, changing the factor 4.7 above to 6.5. Clearly, a calculation with a realistic $^1S_0(pp)$-pair wave function and the correct spin-isospin structure is needed.

TABLE I. Contributions from possible final states to the $E2$ cross section in free deuteron photodisintegration for 300 MeV photon energy. The contributing currents are the one-body convection current C, spin plus spin-orbit current S, and the two-body current SI covered by the Siegert operator.

np	Current	$\sigma(E2)\,(\mu b)$	$\sigma(E2;$ without $S)\,(\mu b)$
$^3S_1$, $^3D_1$	C, SI, S	0.084	0.061
$^1D_2$	S	0.022	0
$^3D_2$	C, SI, S	0.001	0.000
$^3D_3$, $^3G_3$	C, SI, S	0.163	0.133
Total		0.270	0.194

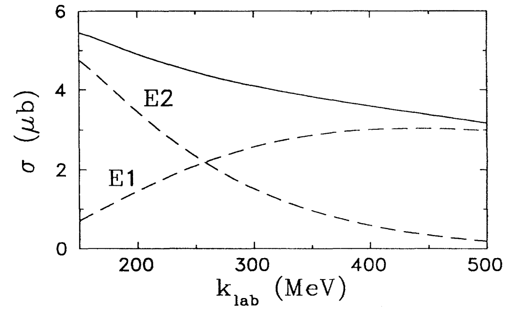

FIG. 1. $E1$ and $E2$ multipole strengths (dashed) and their sum (solid) for $\gamma + {}^1S_0(pp) \to p + p$ multiplied with a statistical factor $\frac{1}{3}$ for comparison with $\sigma({}^3\mathrm{He}(\gamma, pp)\,n_{\mathrm{spec}})$.

Our results for the lowest multipoles shown in Fig. 1 include the one-body and two-body currents contained in the Siegert operators [2]. The initial wave function of the pp pair is taken to be the square root of the two-body density correlation function in ^{3}He as in Ref. [3]. The final state pp wave function is obtained from the Bonn OBEPR potential. One can clearly see that the $E1$ multipole contribution cannot be neglected in comparison with $E2$. Preliminary results of a more realistic study including Δ degrees of freedom do not change this conclusion.

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[1] T. Emura *et al.*, Phys. Rev. Lett. **73**, 404 (1994).
[2] H. Arenhövel and M. Sanzone, Few-Body Systems, Suppl. **3**, 1 (1991).
[3] J. A. Niskanen, P. Wilhelm, and H. Arenhövel, Univ. of Mainz Report No. MKPH-T-94-10 (to be published).

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