Violation of isospin conservation in two-nucleon pickup reactions?*

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The recently reported differences in the analog reactions $^{16}O(p, {}^3He)^{14}N$ (2.31 MeV) and $^{16}O(p, t)^{14}O$ (g.s.) are correctly predicted by distorted-wave Born-approximation calculations, using standard parameters with no adjustments.

[NUCLEAR REACTIONS $^{16}O(p, t)$ and $^{16}O(p, {}^3He)$, $E = 27$ MeV; calculated $\sigma(\theta)$, ratio.]

In a recent study of the analog reactions ^{16}O-$(p, {}^3He)^{14}N$ (2.31 MeV) and $^{16}O(p, t)^{14}O$ (g.s.), Ingalls claims to have found "the first significant violation of the simple isospin intensity rule for isospin-raising two-nucleon pickup reactions."[1] The reported violation lies in the fact that the ratio $\sigma(p, {}^3He)/\sigma(p, t)$, plotted as a function of θ, varies from the simple prediction

$$\frac{\sigma(p, {}^3He)}{\sigma(p, t)} = \frac{k_{^3He}}{k_t}\frac{2T_i + 1}{2}$$

which arises in the absence of distortion and Coulomb effects.

We have investigated the significance of this violation of isospin conservation by performing distorted-wave Born-approximation (DWBA) calculations for the two reactions, using the code DWUCK.[2]

The calculations employed the two-particle coefficients of fractional parentage of Cohen and Kurath,[3] though the predicted angular distribution shapes [and the $\sigma(p, {}^3He)/\sigma(p, t)$ ratios] are essentially independent of the details of the microscopic configuration. All optical-model parameters used are standard[4-6]; none of the parameters was changed for the purpose of this calculation. The proton parameters are those of Watson, Singh, and Segel,[4] and have been shown[6] to give good fits to a variety of data involving protons and light nuclei. The t and ^3He parameters are the standard set with $r_0 = 1.14$ fm. This set has been extensively used[5] in DWBA calculations of reactions involving ^3He (or t) and light nuclei. All the parameters are listed in Table I.

The angular distributions predicted are in reasonable, though not perfect, agreement with the data of Ref. 1. The predicted ratio $\sigma(p, {}^3He)/\sigma(p, t)$ is plotted in Fig. 1, as a function of laboratory angle. (The individual DWUCK outputs were converted to the lab system before taking the ratio.) Clearly, the major differences observed between the two reactions are predicted by DWBA. The small deviations between experiment and theory could be improved by small changes in the parameters, but such parameter juggling does not seem justified.

Ingalls states that he performed several pairs of $(p, {}^3He)$ and (p, t) DWBA calculations, none of which were able to account for the data. The re-

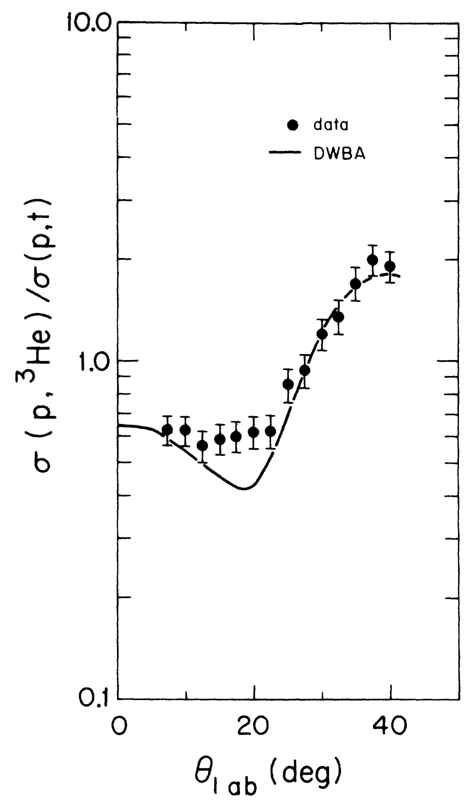

FIG. 1. Ratio $\sigma(p, {}^3He)/\sigma(p, t)$ for the reactions ^{16}O-$(p, {}^3He)^{14}N$ (2.31 MeV) and $^{16}O(p, t)^{14}O$ at $Ep = 27.0$ MeV. The points are from the data of Ref. 1. The curve is the result of the distorted-wave Born-approximation calculations described in the text.

TABLE I. Potential parameters used in DWBA analysis of the $^{16}O(p,{}^3He)^{14}N$ (2.31 MeV) and $^{16}O(p,t)^{14}O$ (g.s.) reactions (Refs. 4 and 5).

	V (MeV)	$r_0 = r_{so}$ (fm)	$a = a_{so}$ (fm)	W (MeV)	$W' = 4W_D$ (MeV)	r'_0 (fm)	a' (fm)	V_{so} (MeV)	r_{0c} (fm)
p	53.6	1.125	0.57	0	32.3	1.125	0.50	5.5	1.40
t (^{3}He)	177	1.138	0.724	12	0	1.602	0.769	5	1.40
b.s.	Varied	1.26	0.60					$\lambda = 25$	1.26

sults of his calculations are not shown, and we are unable to ascertain the reason for the failure. The difficulty may be with the proton optical-model parameters. It appears from Ingalls's article that his calculations used either a proton potential from proton scattering on nuclei with $A > 40$,[7] or a proton potential for much higher energy—43.7 or 54.1 MeV.[8] In both Refs. 7 and 8, one of the mass-3 potentials listed is very similar to that used here, so it is unlikely that his difficulty lies with the ^{3}He and t potentials. We emphasize again that the present fit does not arise from parameter juggling, but rather from a DWBA calculation with parameters that are standard for light nuclei (Refs. 4–6).

It is clear that the present data do not constitute a violation of isospin conservation beyond that expected from Coulomb and distortion effects. Comparisons of such mirror reactions are probably not sensitive enough to reveal isospin violations even if they occur.

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