Photodisintegration of $He^3$ by Polarized Gamma Rays

Kirk McDonald

August 7, 1970

We have received a preprint with the above title from Frascati by Fabbri, Picozza and Schaerf (LNF-69/82). They report an asymmetry in the cross-section for $\gamma + He^3 \dashrightarrow p + d$ for $E_\gamma = 260$ MeV, and $\theta_{c.m.} = 90^\circ$:

$$A = \frac{\sigma_\parallel - \sigma_\perp}{\sigma_\parallel + \sigma_\perp} = 0.36 \pm 0.08$$

I have used the partial wave analysis of my previous note to give a form for the asymmetry. Again I consider only the transitions

| | | |
|---|---|---|
| E1 --> $^2P_{1/2}$ | labelled | $P_1$ |
| E1 --> $^2P_{3/2}$ | | $P_3$ |
| M1 --> $^4S_{3/2}$ | | $S_3$ |
| E2 --> $^2D_{3/2}$ | | $D_3$ |
| E2 --> $^2D_{5/2}$ | | $D_5$ |

In this case, all three cross-sections $\sigma_\parallel$, $\sigma_\perp$ and $\sigma_T$ have the form

$$A + B\cos\theta + \sin^2\theta(C + D\cos\theta + E\cos^2\theta)$$

where

| | $\sigma_T$ | $\sigma_\parallel$ | $\sigma_\perp$ |
|---|---|---|---|
| A | $S_3^2 + (2/3)(P_3 - P_1)^2 + 4(D_5 - D_3)^2$ | $A_{\sigma_T}$ | $A_{\sigma_T}$ |
| B | $4\sqrt{2/3}\,\mathrm{Re}(P_3 - P_1)^*(D_5 - D_3)$ | $B_{\sigma_T}$ | $B_{\sigma_T}$ |
| C | $P_3^2 + 2\mathrm{Re}P_3^*P_1 - 2(D_5 - D_3)^2$ | $2P_3^2 + 4\mathrm{Re}P_3^*P_1$ | $-4(D_5 - D_3)^2$ |
| D | $2\sqrt{2/3}(5\mathrm{Re}P_1^*D_5 + 2\mathrm{Re}P_3^*(3D_3 + 2D_5))$ | $2D_{\sigma_T}$ | 0 |
| E | $10(D_5^2 + 4\mathrm{Re}D_3^*D_5)$ | $2E_{\sigma_T}$ | 0 |

Note that $\sigma_\parallel + \sigma_\perp = 2\sigma_T$

Using these expressions, the asymmetry at $90^\circ$ is

$$A = \frac{P_3^2 + 2\mathrm{Re}P_3^*P_1 + 2(D_5 - D_3)^2}{S_3^2 + (2/3)(P_3 - P_1)^2 + P_3^2 + 2\mathrm{Re}P_3^*P_1 + 2(D_5 - D_3)^2}$$

From the experimental value of $A \sim 1/3$ we conclude that

$$S_3^2 + (2/3)(P_3 - P_1)^2 \cong 2P_3^2 + 4\mathrm{Re}P_3^*P_1 + 4(D_5 - D_3)^2$$

Which tends to indicate that the contribution from $S_3$ is the largest of all at this energy. If this is true it is good news since the $\Delta(1236)$ would appear in this amplitude around this energy.

---------------

In the Frascati paper reference is made to transitions from the $^4D_{1/2}$ part of the $He^3$ ground state. I have not included any of these in my analysis. They are discussed by Bailey, Griffiths and Donnelly in Phys. Letters 24B, 222 (1967). An experiment at $E_\gamma$ = 15 Mev to look for these transitions is reported by Belt, Bingham, Halbert and van der Woude in P.R.L. 24, 1120 (1970).