$E2/M1$ Ratio from the Mainz $p(\vec{\gamma},p)\pi^0$ Data

In a recent Letter [1], Beck *et al.* have determined the $E2/M1$ ratio using differential cross section and photon asymmetry data from the $p(\vec{\gamma},p)\pi^0$ reaction at the Mainz Microtron MAMI. After the correction of a sign error, Eqs. (4) and (6) of [1] read

$$A_{\parallel} = |E_{0+}|^2 + |3E_{1+} - M_{1+} + M_{1-}|^2, \tag{1}$$

$$C_{\parallel} = 12\,\mathrm{Re}[E_{1+}(M_{1+} - M_{1-})^*], \tag{2}$$

for the constant and $\cos^2(\theta)$ terms in the parallel ($\parallel$) component of the differential cross section.

In Eq. (7) of [1], the following association is made:

$$R = \frac{\mathrm{Re}(E_{1+}M_{1+}^*)}{|M_{1+}|^2} \simeq \frac{1}{12}\frac{C_{\parallel}}{A_{\parallel}} \tag{3}$$

between the ratio of $C_{\parallel}$ and $A_{\parallel}$ coefficients, and the ratio of multipoles giving the $E2/M1$ ratio at resonance. At the resonant point, a simplified expression is given,

$$R = \frac{\mathrm{Im}\,E_{1+}^{3/2}}{\mathrm{Im}\,M_{1+}^{3/2}} = R_{\mathrm{EM}}\,. \tag{4}$$

The authors of [1] note that the ratio $C_{\parallel}/(12A_{\parallel})$ has a constant value of -2.5% across the resonance. As a result, they quote $(-2.5 \pm 0.2 \pm 0.2)\%$ for the $E2/M1$ ratio, the systematic error coming from the limited angular efficiency of their detector and ignored isospin $1/2$ contributions.

If we neglect, in our Eqs. (1) and (2), all contributions apart from those involving $|M_{1+}|^2$ and $\mathrm{Re}(E_{1+}M_{1+}^*)$, we actually have

$$\frac{1}{12}\frac{C_{\parallel}}{A_{\parallel}} \simeq \frac{R_{\mathrm{EM}}}{1 - 6R_{\mathrm{EM}}} \tag{5}$$

at the resonant point. Neglect of the R_{EM} term in the denominator results in an error of about 17% for R_{EM}, which is more than double the systematic error quoted in [1].

Using our multipole amplitudes [2], we find this effect is reduced due to a cancellation between $\mathrm{Im}\,M_{1-}$ and $\mathrm{Im}\,E_{1+}$ in Eq. (1). The extent to which this applies to the result of [1] is unclear, as we find [2] a different value, $(-1.5 \pm 0.5)\%$, for the $E2/M1$ ratio. (The error quoted here accounts only for variation within our fitting scheme. A considerably larger variation is found using different models.) We should also note that the correction in Eq. (5) implies an $E2/M1$ ratio which is larger in magnitude. This actually *worsens* the agreement between our value and the value found in [1].

We have compared our fit to an independent fit over the resonance from the RPI group [3]. While both fits describe the Mainz data with a χ^2/data near unity, there are differences in detail. In particular, the RPI group finds a much larger $E2/M1$ ratio (-3.2%). This also supports the view that the associated systematic errors are much larger than those reported in [1].

We thank R. Beck, R. M. Davidson, and N. C. Mukhopadhyay for numerous helpful communications. This work was supported in part by the U.S. Department of Energy Grant No. DE-FG02-97ER41038.

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Received 25 February 1997 [S0031-9007(97)04638-3]
PACS numbers: 13.60.Le, 13.60.Rj, 14.20.Gk, 25.20.Lj

[1] R. Beck *et al.*, Phys. Rev. Lett. **78**, 606 (1997).

[2] Our multipole amplitudes, determined in a fit to low-energy data, are accessible through the SAID program (the solution is W500). Telnet to clsaid.phys.vt.edu with the userid: said. We should note that the W500 analysis fits the Mainz data quite well. The χ^2/data is 193/182. Some earlier fits, prior to the Mainz experiment, accurately predict the Mainz data. For example, solution SM95 gives a χ^2/data of 168/182 for this data set.

[3] R. M. Davidson and N. C. Mukhopadhyay (private communication).

