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Limit on Strangeness Conserving Neutral Current

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LIMIT ON STRANGENESS CONSERVING NEUTRAL CURRENT

In this note we investigate the lower bounds that one obtains in the Weinberg model[1] for neutral currents in the neighborhood of the (3,3) resonance. The main objective is to relax the assumption that the final particles are in a pure I = 3/2 state.

Consider the ratio

$$R \geq \frac{\sigma(\nu+p\rightarrow\nu+p+\pi^0)+\sigma(\nu+n\rightarrow\nu+n+\pi^0)}{2\,\sigma(\nu+n\rightarrow\mu^-+p+\pi^0)} . \qquad (1)$$

The weak neutral current contributing to this process is denoted by

$$J_0^\alpha = A_3^\alpha + V_3^\alpha - y\, J_{em}^\alpha \qquad (2)$$

where $y = +2\sin^2\theta_W$ and $J^\alpha_{em} = V^\alpha_3 + V^\alpha_s$ with V^α_3 and V^α_s being the isovector and isoscalar terms respectively. The Weinberg angle θ_W was bounded by

$$\sin^2\theta_W \lesssim 0.33$$

which arises from, presumably, allowing one standard deviation in the experimental data. To be conservative we shall take

$$\sin^2\theta_W \leq 0.40 , \qquad (3)$$

which corresponds to[2]

$$\frac{\sigma(\bar{\nu}_e + e \rightarrow \bar{\nu}_e + e)_{exp}}{\sigma(\bar{\nu}_e + e \rightarrow \bar{\nu}_e + e)_{F-G}} \leqslant 3$$

where the subscript F-G stands for the prediction of the Feynman-Gell-Mann theory.

A convenient isospin decomposition of the ratio is

$$R = \frac{|X_3 - \frac{1}{2} X_1 + y E_V|^2 + y^2 |E_S|^2}{|X_3 + X_1|^2} \tag{4}$$

where X_3 and X_1 are the $I = 3/2$ and $1/2$ amplitudes, respectively, and E_V and E_S are the contributions of the isovector and isoscalar electromagnetic current. With no dynamical assumptions whatsoever, we have

$$R \geqslant \left[\left| \frac{X_3 - \frac{1}{2} X_1}{X_3 + X_1} \right| - y \left| \frac{E_V}{X_3 + X_1} \right| \right]^2 + y^2 \left| \frac{E_S}{X_3 + X_1} \right|^2 . \tag{5}$$

According to reference 3 and Eq. (3), the second term in the square bracket is

$$y \left| \frac{E_V}{X_3 + X_1} \right| < y \left(\frac{V_{em}}{\sigma_{\nu \rightarrow \mu}} \right)^{1/2} \simeq 0.36 .$$

Available data suggest that the nonresonant background in neutrino- or photon-reactions at the relevant energy interval is at most about

25 ~ 30%. Thus assuming

$$\left|\frac{X_3}{X_3+X_1}\right| \simeq 0.80 \quad ,$$

we have

$$R \geq \left[\frac{3}{2}\left|\frac{X_3}{X_3+X_1}\right| - \frac{1}{2} - y\left(\frac{V_{em}}{\sigma_{\nu\to\mu}}\right)^{1/2}\right]^2 = 0.11. \qquad (6)$$

This lower limit is physically unrealistic since it assumes a destructive interference of the I = 3/2 and 1/2 amplitudes. A more realistic bound is obtained if we assume X_1 and X_3 to be 90° out of phase, and allow $|X_1|^2 / (|X_1|^2 + |X_3|^2)$ to be as big as 0.30. In this way we have

$$R \geq \left[\left(1 - \frac{3}{4}\frac{|X_1|^2}{|X_1|^2+|X_3|^2}\right)^{1/2} - y\left(\frac{V_{em}}{\sigma_{\nu\to\mu}}\right)^{1/2}\right]^2 \simeq 0.27 \qquad (7)$$

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This is to be compared with $R \lesssim 0.14$ (90% confidence level).[4] Note that both Eqs. (6) and (7) reduce to the result of Paschos and Wolfenstein in the limit $X_1 / X_3 \to 0$.

REFERENCES

[1] S. Weinberg, Phys. Rev. Letters 19, 1264 (1967); Phys. Rev. D5, 1412 (1972). See also A. Salam, "Elementary Particle Theory" edited by N. Svartholm (Almquist and Forlag A. B., Stockholm, 1968).

[2] H. H. Chen and B. W. Lee, Phys. Rev. D5, 1874 (1972); the number here is deduced from Fig. 1 of this paper.

[3] E. A. Paschos and L. Wolfenstein, to be published.

[4] W. Lee, Phys. Letters, 40B, 423 (1972).