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COMPARISON OF BETA-RAY POLARIZATIONS IN FERMI AND GAMOW-TELLER TRANSITIONS AND SU(2)\_L x SU(2)\_R x U(1) MODELS

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ABSTRACT

We analyze the information on SU(2)_L x SU(2)_R x U(1) models provided by measurements of the ratio of beta-ray polarizations in Fermi and Gamow-Teller transitions.

SU(2)_L x SU(2)_R x U(1) models are attractive extensions of the standard model of the electroweak interactions. A characteristic feature of these models is the presence of right-handed charged currents. Among the sensitive probes of right-handed currents are the longitudinal polarizations \( P_e^F, P_e^{\text{GT}} \) of electrons (or positrons) in pure Fermi or Gamow-Teller \( \beta \)-decays. An approach followed in recent and in ongoing experiments involves a comparison of \( P_e^F \) and \( P_e^{\text{GT}} \) for positrons of the same energy. The present experimental result \( P_e^F/P_e^{\text{GT}} = 0.986 \pm 0.038 \) (J. van Klinken et al., Ref. 3) implies the limit

\[
|r|_{\text{expt}} < 10^{-2} \quad (90\% \text{ confidence})
\]

for the quantity \( r = [(P_e^F/P_e^{\text{GT}}) - 1]/8 \). The experiments under way plan to improve the accuracy for \( P_e^F/P_e^{\text{GT}} \) by 1-2 orders of magnitude. The result (1) was interpreted so far only in the framework of manifestly left-right symmetric models. In the investigation reported here we study the implications of (1) for more general SU(2)_L x SU(2)_R x U(1) models, including the most general one which allows for C\( \bar{P} \)-violation, unequal left- and right-handed quark mixing angles, and mixing in the leptonic sector. In each case we compare the corresponding constraints on the parameters with constraints provided on them by other data. Below we give a brief account of our results.

For allowed decay, ignoring recoil-order terms, higher-forbidden contributions and electromagnetic effects, \( r \) is given in SU(2)_L x SU(2)_R x U(1) models by

\[
r \propto -\bar{\nu}_e R e^R \bar{N}^R R \bar{N}^L,
\]
where \( \eta_{ik} \equiv a_{ik}/a_{LL} \) \((i = L,R; k = L,R)\); \( a_{ik} \) are the coupling constants of the \( \Delta S = 0 \) semileptonic Hamiltonian \((a_{RL} \text{ is associated with the term involving the right-handed leptonic and the left-handed quark current, etc.)}\). In terms of the parameters of the most general model

\[
x = \tilde{\nu}_e \theta g \cos(\alpha+\omega),
\]

where \( t_0 = t \cos \theta^R_1/\cos \theta^L_1 \), \( t = \frac{g^R_2}{g^L_2} = \frac{g^L_0}{g^L_0} \), \( \xi = \theta^L_1/\theta^L_1 \), \( \alpha \) and \( \omega \) are CP-violating phases in the right-handed quark mixing matrix and in \( W_L - W_R \) mixing, respectively; \( m_1, m_2 \) are the masses of \( W_1, W_2 \); \( \zeta \) is the \( W_L - W_R \) mixing angle; \( \nu = \nu/e \), \( u_e = u_e = \Sigma_i |U_{ei}|^2 \), \( v_e = \Sigma_i |V_{ei}|^2 \), \( U \) and \( V \) are the left-handed and right-handed leptonic mixing matrices, respectively; the summation in \( u_e \) and \( v_e \) is over the neutrino states produced in the decay (see Ref. 6).

(A) Models with negligible leptonic mixing. Except when the right-handed muon-neutrino is too heavy to be produced in \( \pi \)-decay, in which case the conclusions of case (B) below apply, the best limit on \( t_0 \) comes from measurements of the quantity \( R \) (see Ref. 6), related to the positron momentum spectrum end point in polarized \( \mu \)-decay. Combined with the best limit on \( \xi \), provided by the \( \rho \)-parameter, one obtains \( |r| < 1.3 \times 10^{-3} \). We note that as \( \cos(\alpha+\omega) = 0 \) is not ruled out, an upper limit on \( r \) does not constrain \( t_0 \theta \). In models where \( \theta^R_1 = \theta^L_1 \), the \( K^0 \to \bar{K}^0 \) amplitude, nonleptonic \( K \)-decays and the \( \nu^e \) coefficient in \( \beta \)-decay yield the bound \( |r| \leq 2 \times 10^{-5} \) (see Ref. 6). For the general case the bound \( |r| \leq 2 \times 10^{-4} \) follows from \( \rho \), nonleptonic \( K \)-decays and the \( D \)-coefficient.

(B) Models with leptonic mixing. Except for the case when all the neutrinos can be produced in the decay, muon decay does not provide constraints on \( t_0 \nu^e \) or \( t_0 \tilde{\nu}^e \). The best limit on \( r \) from leptonic and semileptonic processes is obtained combining \( \rho_{\text{expt}} \) and Gamow-Teller \( \beta \)-decay data, yielding \( |r| < 6 \times 10^{-3} \). As \( \nu^e \leq 1 \), in models where \( \theta_{R_1} = \theta_{L_1} \) the limit on \( |r| \) from data involving nonleptonic transitions is the same as in case (A). In the general case only the constraint from nonleptonic \( K \)-decays and the \( D \)-coefficient is applicable, implying only the limit \( |r| < 4 \times 10^{-3} \).

To conclude, in some special versions of \( SU(2)_L \times SU(2)_R \times U(1) \) models either muon-decay data, or constraints which include information from non-leptonic transitions, or both of these, provide an upper limit on \( r \) which is more stringent than the limit from the
present experimental result on $P_e^F/P_e^{GT}$. However in $SU(2)_L \times SU(2)_R \times U(1)$ models where $\theta_i^R$ and $\theta_i^L$ are unrelated and $v_\mu (\equiv \sum_i |V_{\mu i}|^2)$ is arbitrary the limit on $r$ from the direct measurement is comparable to the limit on $r$ implied by other data.

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REFERENCES

5. We assume that the effect of the masses of the neutrinos produced in the decay can be neglected.

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