Global Analysis of Muon Decay Measurements

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We have performed a new global analysis of muon decay measurements to establish model-independent limits on the space-time structure of the muon decay matrix element [1]. The most recent previous global analysis had been performed in 1988 [2]. Our analysis included new measurements of the Michel parameters ρ [3] and δ [4] by the TWIST Collaboration, as well as new measurements of the transverse polarization parameters η, η″, α′, and β′ [5]. We find new limits on the scalar, vector, and tensor couplings of right- and left-handed muons to right- and left-handed electrons. These couplings are given by $g^{\gamma}_{\varepsilon\mu}$, where ε and μ represent the chiralities of the electron and muon, respectively. In the standard model, $g^{V}_{LL} = 1$, and all the other coupling constants are zero.

Table I shows the results. The limits on those terms that involve the decay of right-handed muons to left-handed electrons are more restrictive than in previous analyses, primarily due to the inclusion of the new ρ and δ measurements. The limits on other possible non-standard model interactions are comparable to those in previous analyses. The value of the Michel parameter η found in the global analysis is -0.0036 ± 0.0069. This is slightly more precise than the value found in a more restrictive analysis of the transverse polarization parameters [5], and nearly a factor of two more precise than the previous accepted value [6]. All three of the recent measurements [3-5] play important roles in reducing the uncertainty in η. This reduces the contribution of η to the uncertainty in the Fermi coupling constant G_F to $\Delta G_F/G_F = 6.7 \times 10^{-5}$.

Table I. 90% confidence limits on the muon decay coupling constants.

	Ref. [2]	Present Work
$\lvert g^{S}_{RR}\rvert$	<0.066	<0.067
$\lvert g^{V}_{RR}\rvert$	<0.033	<0.034
$\lvert g^{S}_{LR}\rvert$	<0.125	<0.088
$\lvert g^{V}_{LR}\rvert$	<0.060	<0.036
$\lvert g^{T}_{LR}\rvert$	<0.036	<0.025
$\lvert g^{S}_{RL}\rvert$	<0.424	<0.417
$\lvert g^{V}_{RL}\rvert$	<0.110	<0.104
$\lvert g^{T}_{RL}\rvert$	<0.122	<0.104
$\lvert g^{S}_{LL}\rvert$	<0.550	<0.550
$\lvert g^{V}_{LL}\rvert$	>0.960	>0.960

[1] C.A. Gagliardi *et al*., Phys. Rev. D **72**, 073002 (2005)

[2] B. Balke *et al*., Phys. Rev. D **37**, 587 (1988); W. Fetscher and H.-J. Gerber, in S. Eidelman *et al*., Phys. Lett. B **592**, 1 (2004).

[3] J.R. Musser *et al*. (TWIST Collaboration), Phys. Rev. Lett. **94**, 101805 (2005).

[4] A. Gaponenko *et al*. (TWIST Collaboration), Phys. Rev. D **71**, 071101R (2005).

[5] N. Danneberg *et al*., Phys. Rev. Lett. **94**, 021802 (2005).

[6] S. Eidelman *et al*. (Particle Data Group), Phys. Lett. B **592**, 1 (2004).