# NONCONSERVATION OF MUON NUMBER IN A MODEL OF LEPTON STRUCTURE

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We speculate on a possible primary structure for leptons similar to the quark structure for hadrons, and thus propose a new possible approach to the study of these particles. A suppression mechanism is provided for the effects of the new interaction upon the muon anomalous magnetic moment and in the decay amplitude for $\mu \to e\gamma$.

The discovery of weak neutral currents [1] and of the existence of heavy leptons [2] leads to two definite theoretical possibilities for the nonconservation of muon number [3, 4]. One possibility, emphasized by the Strasbourg group nearly two years ago [3], involves a primary neutral current effect which would give rise to the decay $\mu \to 3e$. If the suppression of this effect is associated [3] with the empirical parameter which characterizes *CP* violation, this decay is expected with a branching ratio between about $10^{-8}$ and $10^{-10}$. A second possibility, emphasized by the Strasbourg group about one year ago [4], utilizes the idea of neutrino mixing put forth by Pontecorvo almost twenty years ago [5]. If a single massive neutral lepton mixes with the usual two massless neutrinos in the left-handed weak charged currents, the decay $\mu \to e\gamma$ will occur. Since the branching ratio involves the product of the squares of two mixing parameters times the fourth power of the heavy lepton mass in ratio to the mass of the charged intermediate vector boson, one can get almost any number. For these theoretical reasons, a renewed experimental search for nonconservation of muon number below the present empirical upper limits of about $10^{-8}$ was urged [3].

In this note we suggest another natural theoretical possibility for the nonconservation of muon number, which, if realized, has ultimately many far-reaching experimental consequences. The new possibility is associated with the idea that leptons interact with hadrons at a primary level, i.e. via a Yukawa-type interaction with a dimensionless coupling parameter $g$. The nonobservation of such interactions for leptons at the presently known energies can be viewed as the result of some suppression mechanism. The present evidence for electron-muon symmetry and for the absence of new interactions of leptons with leptons and hadrons need not be raised to the rank of an absolute principle. It is perhaps an unsatisfactory feature of the presently known models of elementary particles that they put on the same theoretical level quarks and leptons as the fundamental constituents of matter. However, leptons share the property of being observable constituents of matter with structured hadrons, not with quarks. If one assumes that matter is formed of fundamental objects and if quarks are considered as these objects, one may give up the point that leptons are without such interactions and boldly assume that they also have a quark structure at some level [6]. One is thus led to postulate the existence of heavy leptons which interact with muons and electrons and with quark structures such as pions [‡1].

As a definite simple example we consider a model with two massive neutral leptons $L_1$ and $L_2$ which interact with muons, electrons and pions via the Lagrangian density

$$\mathcal{L} = \frac{g}{\sqrt{2}}\left\{\bar{e}\left(\frac{1+\gamma_5}{2}\right)L_{1c}\pi^- + \bar{L}_{1c}\left(\frac{1-\gamma_5}{2}\right)e\pi^+ + \bar{\mu}\left(\frac{1+\gamma_5}{2}\right)L_{2c}\pi^- + \bar{L}_{2c}\left(\frac{1-\gamma_5}{2}\right)\mu\pi^+\right\}, \quad (1)$$

[‡1] Atoms have, in general, exchange force interactions which give rise to chemical reactions (we may call these strong interactions), and weak Van der Waals interactions. Some atoms, however, the closed-shell rare gas atoms, although formed of the same constituents as the other atoms, display only Van der Waals forces at the usual energies and have more compact space structure. Do leptons play a kind of similar role in the domain of elementary particles?