COMPOSITE FERMIONS: CONSTRAINTS AND TESTS

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ABSTRACT

We review the substantial constraints and tests of models of composite leptons and quarks set by experiment and theory. New limits on the anomalous magnetic moment of the tau and of the quarks are presented.

INTRODUCTION

There have been many recent papers in which leptons and quarks are considered to be composites of more fundamental constituents. Perhaps the main motivation for this large effort, and the only present indication for compositeness, is the large number of "elementary" fermions (three $SO_{10}$ 16's). In this paper, we review a number of possible indications or tests for compositeness. Some of these place very strong constraints on such composite models, e.g., the phenomenal agreement between experiment and present theory...
GORDON L. SHAW AND DENNIS J. SILVERMAN

(QED plus hadronic) for both the electron\textsuperscript{1} and muon\textsuperscript{2} anomalous magnetic moments $F_2$: a part in $10^{10}$ for $F_2^e$ and a part in $10^8$ for $F_2^\mu$. In addition there are theoretical constraints such as those of 't Hooft\textsuperscript{3} which are discussed in detail elsewhere in this Session.\textsuperscript{4} The topic of composite fermions has thus developed to a stage such that all serious model builders should take all these constraints into account in a substantive manner and/or have some novel testable predictions.

Most efforts have naturally been directed toward the symmetry aspects of composite models. The very difficult aspect of the necessary dynamics has been largely neglected. The above mentioned constraints on $F_2$ indicate that if the $e$ and $\mu$ are indeed composite, a "new" type of dynamics with $mR \ll 1$ (where $m$ and $R$ are the composite mass and size) is involved as compared to, e.g., that of hadrons composed of quarks with $mR > 1$. We review some recent relativistic calculations\textsuperscript{5} for a "point-like" composite fermion in which a composite mass of approximately one tenth of the sum of the constituent masses was achieved. This work illustrates the difficulties in obtaining a dynamical calculation with heavy constituents of a composite $e$ or $\mu$. Perhaps models with light constituents with approximate chiral symmetry are a better approach. However, in this case we have no full dynamical calculation.\textsuperscript{6}

Although nowhere in the same ballpark, useful limits have been set\textsuperscript{7} on $F_2$ for the $\tau$ and for the quarks from PETRA data on $e^+e^-$ annihilation. These limits as well as a new low-energy test\textsuperscript{7} are presented. To illustrate the usefulness of these tests, we discuss a unified $SO_{14}$ model\textsuperscript{8} in which the $SO_{10}$ electron and muon families are elementary and the tau family is composite.

POSSIBLE INDICATIONS FOR COMPOSITENESS: TESTS AND CONSTRAINTS

Here we list a number of possible indications for composite fermions and briefly comment on associated tests and constraints.

1. Families: The observed left-handed fermions (along with