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Proton stability in grand unified theories, in strings and in branes

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Abstract

A broad overview of the current status of proton stability in unified models of particle interactions is given which includes non-supersymmetric unification, SUSY and SUGRA unified models, unification based on extra dimensions, and string-M-theory models. The extra dimensional unification includes 5D and 6D and universal extra dimensional (UED) models, and models based on warped geometry. Proton stability in a wide array of string theory and M theory models is reviewed. These include Calabi–Yau models, grand unified models with Kac–Moody levels $k > 1$, a new class of heterotic string models, models based on intersecting D branes, and string landscape models. The destabilizing effect of quantum gravity on the proton is discussed. The possibility of testing grand unified models, models based on extra dimensions and string-M-theory models via their distinctive modes is investigated. The proposed next generation proton decay experiments, HyperK, UNO, MEMPHYS, ICARUS, LANNDD (DUSEL), and LENA would shed significant light on the nature of unification complementary to the physics at the LHC. Mathematical tools for the computation of proton lifetime are given in the appendices. Prospects for the future are discussed.

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Contents

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1. Introduction

The Standard Model of strong, and the electro-weak interactions, given by the gauge group $SU(3)_C \times SU(2)_L \times U(1)_Y$, is a highly successful model of particle interactions [1,2] which has been tested with great accuracy by the LEP, SLC and Tevatron data. The electro-weak sector of this theory [1], i.e., the $SU(2)_L \times U(1)_Y$ sector, provides a fundamental explanation of the Fermi constant and the scale

$$G_{\rm F}^{-1/2} \simeq 292.8\,{\rm GeV} \tag{1}$$