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Observational Determinations of the Proton to Electron Mass Ratio in the Early Universe

Rodger I. Thompson[1]

[1]Steward Observatory, University of Arizona
Tucson, AZ 85721
USA
email: rit@email.arizona.edu

Abstract. The values of the fundamental physical constants determine the nature of our universe from the height of mountains on earth to the evolution of the universe over its history. One of these constants is $\mu = M_P/M_e$ the ratio of the proton to electron mass. Astronomical observations provide a determination of this ratio in the early universe through observations of molecular absorption and emission lines in distant objects. Observations of molecular hydrogen in distant damped Lyman Alpha clouds provide a measurement of μ at a time when the universe was only 20% of its present age. To date there is no evidence for a change in μ at the level of 1 part in 10^5. This limit produces an observational constraint on quintessence theories for the evolution of the universe and Super Symmetric theories of elementary particles.

Keywords. Cosmology: observations

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1. Overview

Speculation on the time stability of the fundamental constants extends back at least to the middle of the previous century. Observational constraints on the time variation of fundamental constants has centered primarily on the fine structure constant α and the ratio of the proton to electron mass μ. This review concentrates on observational constraints on μ. The most recent observations are given by Reinhold *et al.* (2006), Ubachs *et al.* (2007), Wendt and Reimers (2008), King *et al.* (2009) and Thompson *et al.* (2009). Although the first of these studies, Reinhold *et al.* (2006) and Ubachs *et al.* (2007) indicated a possible change in the value of μ the subsequent studies found no change in μ at the 10^{-5} level using the same data.

The constant value of μ at $\Delta\mu/\mu \leqslant 10^{-5}$ for look back times of 11 gigayears puts significant constraints on high energy and cosmological physics. With larger telescopes and new instrumentation, improvement by a factor of 10 should be possible in the next 5 years. This require stricts attention to the sources of systematic errors. This makes the measurement of fundamental constants in the early universe a low cost and powerful tool for the study of cosmology and high energy physics.

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