

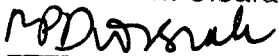
**Final Report on Grant
DE-FG02-94 ER40824
Vernon Hughes
Yale University**

This grant enabled research from 1991 to 2001 on muonium, the bound state of a positive muon and electron. The effort was led by Vernon Hughes, and involved almost 20 physicists from four U.S. and two international institutions.

The experiment E1054 performed under the grant at the Clinton P. Anderson Meson Physics Facility at Los Alamos, was both a continuation and improvement on a series of experiments dating back to the discovery of muonium in 1960. High precision measurements of two Zeeman hyperfine transitions in the ground state of muonium were made, using microwave magnetic resonance spectroscopy and a line-narrowing technique. The experiment yielded the most precise values for the ground state hyperfine interval, $\Delta\nu$, to 12 ppb, and the ratio of muon to proton magnetic moments, μ_μ/μ_p to 120 ppb, representing a threefold (statistics limited) improvement over previous work. The mass of the muon, m_μ , is also determined most precisely from this work.

Comparison between theory and experiment for $\Delta\nu$ constitutes the most precise test of bound-state QED, and also tests μe universality. Using the theoretical predictions for $\Delta\nu$, a value of the fine structure constant α was derived to 58 ppb. Finally, by searching for sidereal variations in the transition frequencies, limits were placed on the muon parameters of theoretical extensions of the standard model allowing CPT and Lorentz violation.

DOE Patent Clearance Granted



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Office of Intellectual Property Law
DOE Chicago Operations Office

5-29-03
Date

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(Previous GC-782)

OMB Control No.
1910-0800

PATENT CERTIFICATION

Yale University
Contractor

☐ Interim Certification

☒ Final Certification

DE-FG02-94ER40824
DOE Prime and/or Subcontract Nos.

Contractor hereby certifies that:

1. All procedures for identifying and disclosing subject inventions as required by the patent clause of the contract have been followed throughout the reporting period.
2. There were no subcontracts or purchase orders involving research, development, and demonstration except as follows: [State none when applicable.]
NONE
3. No inventions or discoveries were made or conceived in the course of or under this contract other than the following

(Certification includes ☒ , does not include ☐ all subordinates):

[State none when applicable.]

TITLE	INVENTOR	DATE REPORTED	DOE "S" NO.*
NONE			

4. The completion date of this contract is as follows: May 31-2001
5. The following period is covered by this certification:

January 15, 1994
Month Day Year

to

May 31, 2001
Month Day Year

Yale University
Contractor

Vernon W Hughes / SD
Signature

Physics Dept., PO Box 208121

New Haven, CT 06520-8121
Address

March 13, 2003
Date of Certification

* Also include Subcontract No. If available