## Editor's Comments

The minisymposium on variable constants continues. Please read the first three articles in this series in the March 1990 Quarterly. The Quarterly should be in every college and university library in the United States. Possibly some of our members would encourage acquisitions librarians in schools near them to subscribe to the Quarterly. The interest of the librarian may be increased if the subscription is donated by the member. It is often necessary to discuss the matter with the acquisitions librarian to see if the individual will cooperate. Help the Society any way you can. It is hoped that you will find many articles and notes of interest in this issue. Please send me material to be considered for publication.

Don DeYoung, Editor

**MINISYMPOSIUM ON VARIABLE CONSTANTS—IV***

# THE DIFFICULTY IN OBTAINING REALISTIC CONCLUSIONS ABOUT VARIABLE "CONSTANTS"

EUGENE F. CHAFFIN**

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### Abstract

***A scale covariant modification of Newton's second law is combined with Bohr's model of the atom. If we suppose that physical "constants" have varied in a way consistent with this theory, then it leads naturally to an explanation of the red shifts in the light from distant galaxies. The model is offered as an example of how not only the "constants," but also the equations themselves are suspect in any endeavor to find the true laws of physics. In the second part of the paper, some limits on the variability of "constants" based on data from the Oklo reactor are examined. It is found that limits which have been published in the technical literature are more imaginary than real.***


## Introduction

The possibility that physical "constants" have changed should cause us to question whether the basic equations, Schrodinger's equation, etc. should be "corrected" to properly treat those changes (Chaffin 1986; Dirac 1973; Canuto 1981; Will 1984; Bishop and Landsberg 1976; Troitskii 1987). The anthropic principle is the fact that intelligent human life does exist, and that the universe is fashioned in such a way that this life is possible. The evolutionist, who starts with the Big Bang and traces evolution from elementary particles to man, claims that life exists because if it did not then we would not be around to observe the universe. To the creationist this argument seems rather weak since it leaves out God's creative design. But the creationist also wonders whether changes in the physical "constants" are possible without upsetting the balance that allows life to exist. It is easy to assume that the laws of physics should be written in the usual form, then to allow the constants to vary in these equations, and to do various derivations to show that inconsistencies result. But the larger question is whether the laws and equations may be altered in a way that is consistent with observation and experiment. For example, one might mention the way that the expression for kinetic energy changes when we change from classical physics to relativistic physics. As long as particle speeds are small compared to the speed of light, one hardly notices the difference. It may be that physical "constants" are really variables when referred to the true laws of physics, and that 20th century physics just has not succeeded in measuring the changes as yet. From this point of view, the theoretical physicist must strive to find new theories which are consistent with the facts. Since the possible new theories are difficult to compartmentalize and examine, it is difficult to say when this investigation might end. But the success of just one theory of this type would illustrate my point. The term "scale covariant" refers to an equation maintaining the same form when the size of the space-time units is changed. A specific theory which breaks this scale covariance in a special way is offered as an example.

## A Specific Theory

Let us examine a scale covariant modification of Newton's second law for a charged particle, q, attracted to a mass M and charge Q. Chaffin (1986) previously discussed the dynamical equation:

$$\frac{dp_r}{d\lambda} = -\beta\frac{\bar{G}Mm}{r^2} + \beta\frac{p_\phi^2}{mr^3} \qquad \textbf{(1)}$$

involving the angular and radial momenta:

$$p_\phi = \frac{1}{\beta}mr^2\frac{d\phi}{d\lambda}, \qquad \textbf{(2)}$$

$$p_r = \frac{1}{\beta}m\frac{dr}{d\lambda}. \qquad (3)$$

where $d\lambda$ is "proper time" with $d\bar{\lambda} = \beta d\lambda$. Here $\beta$ is a scale changing factor which in essence changed the G of Newton's Law of Gravitation. The equation (1) was shown to be scale covariant, i.e. it maintains the same form when $\beta$ is replaced by $\theta\beta'$. To take into account electrical forces, one must add the equivalent of Coulomb's Law to the right side of equation (l). But we are only guessing when we decide whether to add it without a factor of or with to the nth power for n = 1,2,3, or whatever, since for = 1 the

*Parts I-III are in CRSQ 26:121-31.

**Eugene F. Chaffin, Ph. D., 715 Tazewell Ave., Bluefield, VA 24605.

result would be the same as the usual Newton's second law. If we take n = 1, we get a scale covariant theory which basically gives the same results as the usual theory. But for n = 0, i.e. no factor of w e obtain:

$$\frac{dp_r}{d\lambda} = -\beta \frac{GMm}{r^2} + \beta \frac{p_\phi^2}{mr^3} - \frac{qQ}{4\pi\epsilon_o r^2} \tag{4}$$

To interface this equation with experiment, we might let q be the electronic charge, and Q the proton charge, i.e. the hydrogen atom. We could then use the Bohr model of the atom, suitably modified to allow $\beta$ to vary. As usual, the gravitational force would be too weak to be of any consequence as far as atomic spectra are concerned. For circular orbits, we have:

$$\frac{dr}{d\lambda} = 0 \quad \text{so that} \quad p_r = 0, \tag{5}$$

hence

$$\beta\frac{p_\phi^2}{mr^3} = \frac{e^2}{4\pi\epsilon_o r^2}, \tag{6}$$

$$p_\phi^2 = \frac{e^2}{4\pi\epsilon_o}\frac{m_o r}{\beta}. \tag{7}$$

From Bohr's quantization of angular momentum we then have:

$$p_\phi = n\hbar \tag{8}$$

where $\hbar = h/2\pi$ = the usual Planck's constant divided by $2\pi$ and n = 1,2,3,... This gives the electron-proton separation as:

$$r = n^2 \frac{4\pi\epsilon_o\hbar^2}{e^2 m}\beta \tag{9}$$

so that this changes with $\beta$. (But the size of the atom also depends on the center of mass motion.) From equation 7 for the angular momentum it follows that:

$$\frac{1}{2\beta} mr^2 \left(\frac{d\phi}{d\lambda}\right)^2 = \frac{1}{2}\frac{e^2}{4\pi\epsilon_o r} \tag{10}$$

Since r is constant for a circular orbit, then the left-hand side of equation (10) is also constant for such an orbit. Hence it also follows that the following expression, which we likewise call the "energy," is also a constant of the motion:

$$E = \frac{1}{2}\beta\frac{p_\phi^2}{2mr^2} - \frac{e^2}{4\pi\epsilon_o r}, \tag{11}$$

and that:

$$E = -\frac{1}{2}\frac{e^2}{4\pi\epsilon_o r} \tag{12}$$

Substituting equation (9) for the electron-proton separation gives:

$$E = -\frac{1}{2}\frac{me^4}{n^2(4\pi\epsilon_o)^2\hbar^2}\frac{1}{\beta} \tag{13}$$

Hence, the quantify usually called "energy" will change with $\beta$. This means that atomic spectra will change. To compare with observation, we recall that light from distant galaxies is shifted toward the red end of the spectrum. This light corresponds not only to great distances, but also to past epochs in time. Hence, if $\beta$ were different in the past, which amounts to a different ratio of electrical to gravitational force strengths, then this might account for the red shifts of extragalactic spectra.

Rust (1974) studied the curves of photometric magnitudes versus time for 36 Type I supernovae in various distant galaxies. These were essentially all the supernovae at great distance for which accurate data were known and published. He found that the results did not agree very closely with the expansion of the universe hypotheses based on general relativity. He also examined some rather bizarre theories to see with what the results did agree. The question of the best theory remains open, awaiting better data and better analyses. The improved analysis of de Vaucouleurs and Pence (1976) failed to change Rust's basic conclusion. Hence, whether equation (13) is at variance with theory also seems to remain an open question.

The above theory is incomplete in that it provides no way to theoretically determine the function $\beta$. This function controls essentially the size of the Coulomb constant $k = 1/4\pi\epsilon_o$ with respect to the gravitational constant G. It has nothing to do with whether these laws are inverse square laws, at present. One aspect of Mach's principle states that the mass of particles may depend on the distribution of distant galaxies in the universe (Hoyle and Narlikar, 1971 and Canuto and Narlikar, 1980). One might speculate that the function $\beta$ may be determined similarly.

In summary, it might be asked whether this incomplete theory offered here results in a change in the speed of light. James Clerk Maxwell (1954) [actually Maxwell wrote this some time before 1891 since the book cited is a reprint] showed that the speed of light depends on the ratio of electrostatic units to electromagnetic units, that the dimensions of this ratio are L/T, i.e. length over time, the mass canceling out. The scale change of the type introduced here may be viewed as a change of the mass units (see Fulton, Rohrlich and Witten, 1962). It is essentially for this reason that this model leaves the speed of light unchanged, provided the length and time units are defined in a way that does not depend on any masses. However the modern atomic clocks depend on the frequency of light emitted by cesium atoms, and the meter is now defined (since 1983) so that the speed of light is exactly $2.99792458 \times 10^8$ m/s (Sears, Zemansky and Young, 1987). Because of equation (13) it may be inferred that the frequencies of cesium light, and thus the second, will change with $\beta$ according to the modern definitions. Hence the meter will also change in order to keep the *defined* value of the speed of light constant. Thus these definitions seem to require the speed of light to remain the same while the length and time scales change.

**The Oklo Data are Inconclusive**

Will, 1984; Irvine, 1983a, b; Shlyakhter, 1976 have cited evidence provided by the Oklo natural uranium reactor that purportedly shows that the strong and weak nuclear forces have not varied relative to the Coulomb force. Shlyakhter's approach starts with the Breit-Wigner formula for a capture cross section:

$$\sigma_c = \frac{A/v}{(E - E_0)^2 + \Gamma^2/4} \quad (14)$$

where v = velocity of incident particle,
A = a constant,
E = energy of incident particle,
$\Gamma$ = level width,
$E_0$ = resonance energy.

Samarium 149 is produced as a result of fission and has a very large resonance peak at $E_0$ = .0976 electron volts (Mughabghab and Garber, 1973). Shlyakhter assumed that, in order to reproduce the measured Samarium isotopic concentrations from Oklo samples, the above capture cross section had to be within three standard deviations of the present day value. From this he deduced that $E_0$ could not be shifted more than .05 electron volts relative to a nuclear potential well of depth 50 MeV. Assuming a linear variation of the strong coupling constant $g_s$, between the Oklo reactions two billion years ago and today, he derived a limit:

$$\frac{1}{g_s}\left|\frac{dg_s}{dt}\right| \leq 5 \times 10^{-19} \text{ year}^{-1}. \quad (15)$$

This approach suffers from four weaknesses:
1) The age of the reactor is assumed to be two billion ears. If the age is only a few thousand years, the limit on the variability of $g_s$, drops by half a dozen orders of magnitude.
2) The variation of $g_s$, is assumed to be linear, and no possibility of episodic or transient variations is taken into account.
3) As is shown in Figure 1, variations in temperature cause shifts in the neutron energy distribution. This causes the effective capture cross section to vary due to the change in overlap of the resonance curve with the neutron energy distribution.
4) The data were never matched to the actual Samarium data, at least if they were, the results were not reported in Shlyakhter's paper. Apparently, it was just ***assumed*** that the data showed that the resonance could not have shifted.

Irvine (1983a, b) also studied the Samarium isotopes, concluding:

> A shift of less than 0.01 eV in the position of a neutron resonance in a potential well 50 MeV deep over 2 x $10^9$ years, represents a variation of less than one part in $10^{19}$ per year.

It is interesting that, although Shlyakhter's paper appeared some seven years before, and reached almost the same exact conclusion quoted above, neither of Irvine's papers contains reference to Shlyakhter's work. In addition, Irvine stated that:

> With the integrated flux fixed at $10^{21}$ neutrons $cm^{-2}$ the Sm-149 / Sm-147 abundance ratio requires that the Sm-149 thermal neutron capture cross section during the operation of the Oklo reactor must have been within 10% of the present day value.

On August 6, 1985 I sent a letter to Professor Irvine outlining my own calculations which showed no such stringent requirements. (I was at the time unaware of Shlyakhter's paper.) My letter has never been answered.

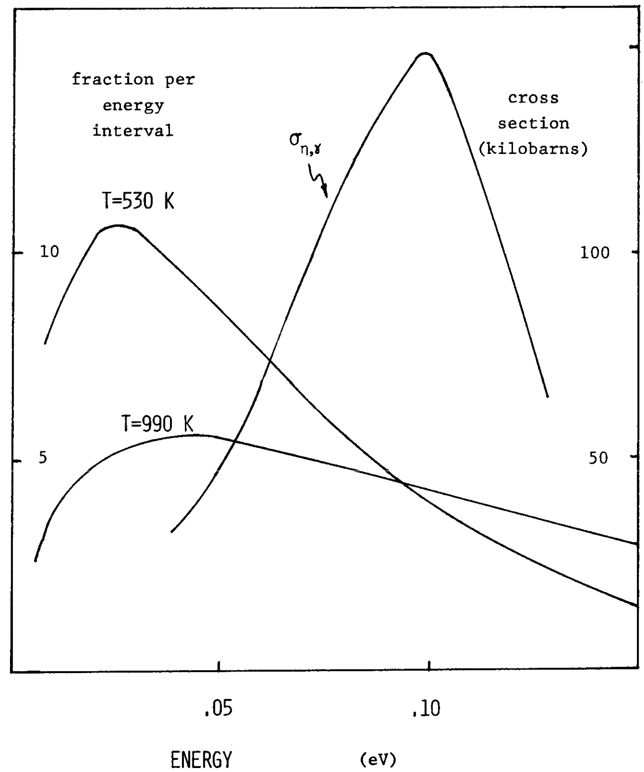


**Figure 1. The neutron energy distribution is shown for two different temperatures together with the Samarium-149 capture cross section versus energy. Since the Oklo reactor's temperature would have varied and the exact values are unknown, it is difficult or impossible to find the exact amount of absorption Sm-149.**

My calculations show that the measured Sm-149, U-235 and U-238 concentrations (data for Echantillon SC52 1472 near the center of reaction zone 2 taken from Holliger, Devillers and Retali, 1978) are consistent with 1. a young (six thousand year) age for the Earth, and 2. a value of the capture cross section equal to the modern value under certain assumptions consistent with the data.

Let me outline the procedure for my calculations. Since Sm-149 is 13.8% of naturally occurring Samarium (Knolls Atomic Power Company Chart of the Nuclides, 12th revision, 1977), we must assume that the initial Sm-149 concentration was not zero. It happens that for the small neutron flux levels and small reaction duration times which are consistent with the young Earth model of Chaffin (1982; 1985) an appreciable fraction of the initial Sm-149 concentration would probably survive the nuclear reactions and still be present in the ore today. Hence we must not make the mistake of assuming that the production rate of Sm-149 through fission would equal its loss rate through neutron capture. In a reactor, most of the Sm-149 formed is produced by the beta decay of Pm-149, which is in turn a fission fragment produced in 1.04% of all U-235 fissions. In the following I will ignore the possibility of diffusion, which is not a good assumption (Chaffin, 1985; Naudet, 1978), but the implication of this section that the Oklo data are inconclusive can only be strengthened if diffusion is a factor. Hence, the rate of change of Pm-149 concentration is the difference between the production rate via fission and the decay rate via beta-minus decay:

$$\frac{dN^{Pm\text{-}149}}{dt} = \gamma^{149}\epsilon N^{25}\sigma_f^{25}\phi_{th} - \lambda_{pm}N^{Pm\text{-}149} \quad (16)$$

where $N^{Pm\text{-}149}$ = Pm-149 concentration
$\gamma^{149}$ = .0104
$\epsilon$ = fast fission factor
$N^{25}$ = uranium 235 concentration
$\sigma_f^{25}$ = thermal fission cross section in **U-235**
$\phi_{th}$ = thermal neutron flux
$\lambda_{pm}$ = decay constant of Pm-149

The rate of change of the Sm-149 concentration is the difference between production via decay of Pm-149 and loss via neutron capture:

$$\frac{dN^{Sm\text{-}149}}{dt} = \lambda_{pm}N^{Pm\text{-}149} - N^{Sm\text{-}149}\sigma_\gamma^{Sm\text{-}149}\phi_{th} \quad (17)$$

where $N^{Sm\text{-}149}$ = Sm-149 concentration
$\sigma_\gamma^{Sm\text{-}149}$ = thermal neutron radiative capture cross section for Sm-149

Under the assumptions outlined above, these equations may be solved for the Sm-149 cross section, giving:

$$\sigma_\gamma^{Sm\text{-}149} = \gamma^{149}\frac{\sigma_f^{25}N^{25}}{N_f^{Sm\text{-}149} - N_i^{Sm\text{-}149}EXP(-\sigma_\gamma^{Sm\text{-}149}\sigma_{th}d)} \times \frac{1}{1-\left(\frac{\gamma^{149}\sigma_f^{25}N^{25}\phi_{th}/\lambda_{pm}}{N_f^{Sm\text{-}149} - N_i^{Sm\text{-}149}EXP(-\sigma_\gamma^{Sm\text{-}149}\sigma_{th}d)}\right)} \quad (18)$$

where $N_i^{Sm\text{-}149}$ = the initial Sm-149 concentration
d = duration time of the nuclear reactions
$N_f^{Sm\text{-}149}$ = final Sm-149 concentration.

Since the initial Sm-149 concentration is unknown, we might ask whether there are any values of this, the thermal neutron flux, and d which are self consistent with the equation above, and the modern answer of 41000 barns at 68°F. The answer is that reasonable values will satisfy the equation: duration time, d, equal to a fraction of a year, the thermal neutron flux near $10^{13}$ neutrons/$cm^2$ sec, and Sm-149 concentration near $10^{17}$ atoms per gram of ore. However, from the fact that various assumptions satisfy the data, we must conclude that the Oklo data are insufficient to decide whether the Sm-149 cross section has varied, and therefore whether the strength of the nuclear force has varied with respect to the Coulomb force.

**Summary**

A specific theory has been offered which allows the strength of the Coulomb force to vary relative to the gravitational force. It shows no contradiction with observation thus far, but shows promise in possibly explaining the red shifts of distant galaxies. Claimed limits on the variability of the nuclear force coupling constant, derived from Oklo data, have been examined and rejected.

## References

***CRSQ—Creation Research Society Quarterly.***

Bishop, N. T. and P. T. Landsberg. 1976. Time varying Newtonian gravity and universal motion. ***Nature*** **264:346-47.**

Canuto, V. M. 1981. Time variability of G. ***Physics Today*** 34(7):12-13.

———— and J. V. Narlikar. 1980. Cosmological tests of the Hoyle-Narlikar conformal gravity. ***Astrophysical Journal*** 236:6-23.

Chaffin, E. F. 1986. Article review of Herman Weyl and the unity of knowledge by John A. Wheeler. ***CRSQ*** 23:118-20.

———— 1982. The Oklo natural uranium reactor examined from a creationist's viewpoint. ***CRSQ*** 19:32-35.

———— 1985. The Oklo natural uranium reactor: evidence for a young earth. ***CRSQ*** 22:10-16.

Dirac, P. A. M. 1973. Long range forces and broken symmetries. ***Proceeding of the Royal Society of London*** **A333:403-18.**

de Vaucouleurs, G. and W. D. Pence. 1976. Type I supernovae as cosmological clocks. ***Astrophysical Journal*** 209:687-92.

Fulton, T., F. Rohrlich and L. Witten. 1962. Conformal invariance in physics. ***Reviews of Modern Physics*** 34:442-57.

Holliger, P., C. Devillers and G. Retali. 1978. Evaluation of the neutron temperatures in the Oklo reaction zones, based on a study of Lu-176/Lu-175, and Gd-156/Gd-155 isotope ratios. Natural Fission Reactors. International Atomic Energy Agency, Vienna. paper IAEA-TC-119/20. pp. 553-65.

Hoyle, F. and J. V. Narlikar. 1971. On the nature of mass. ***Nature*** 233:41-44.

Irvine, J. M. 1983a. The constancy of the laws of physics in the light of prehistoric nuclear reactors. ***Contemporary Physics*** 24:427-37.

———— 1983b. Limits on the variability of coupling constants from the Oklo natural reactor. ***Philosophical Transactions of the Royal Society of London.*** **A310:239-43.**

Maxwell, J. C. 1954. A treatise on electricity and magnetism. Volumes 1 and 2. Dover. New York.

Mughabghab, S. F. and D. I. Garber. 1973. Neutron cross sections. Volume L Resonance parameters. Brookhaven National Laboratory, New York.

Naudet, R. 1978. Summary of the data on the stability and the remobilization of uranium and the rare earths. Natural Fission Reactors. International Atomic Energy Agency, Vienna. paper IAEA-TC-119/25. pp. 643-73.

Rust, B. W. 1974. The use of supernovae light curves for testing the expansion hypothesis and other cosmological relations. Ph.D. thesis, University of Illinois in cooperation with the Computer Science Division of Oak Ridge National Laboratory-publication ORNL 4953.

Sears, F. W., M. W. Zemansky and H. D. Young. 1987. University physics. (seventh edition). Addison Wesley. Reading , MA. p. 4.

Shlyakhter, A. I. 1976. Direct test of the constancy of the fundamental nuclear constants. ***Nature*** 264:340.

Troitskii, V. S. 1987. Physical constants and the evolution of the universe. Astrophysics and Space Science 139:389-411.

Will, C. M. 1984. The confrontation between general relativity and experiment: an update. ***Physics Reports*** 113:345-422.

## QUOTE

**Thus Augustine's conversion must have had not only that deeply liberating personal effect of which he tells us in the** *Confessions,* **but also the effect of supplying for his philosophy "the other half," hitherto missing. Beginning with Aristotle's prime mover, he now sees further that God is creator of everything, the origin of all existence because he** *is* **existence itself, the maker of all essences, a good God whose created things are all good, a God who annihilates nothing but cares for, and saves, being. Thus to the total ancient philosophy, Augustine adds (a) the personal God, (b) the goodness of God and of all created natures, (c) the Christian faith in the recovery of the original goodness of creation by grace, beyond temporal-spatial existence.**

**Niemeyer, Gerhart. 1984. Reason and faith in Carey, G. W. and J. V. Schall, editors.** *Essays on Christianity and Political Philosophy.* University Press of America. Lanham, MD p. 16.