Those who would not make any pretense at circumventing the law of gravity seem to forget the definition of "law" when trying to dance around universal entropy; the measure of increasing randomness or disorder; the decrease in the amount of energy available for useful work.* Yet, such wishful thinkers have awarded the highest plaudits for speculative effort:

> Illya Prigogine, 60, has not actually worked in a chemistry lab for decades. But his research in thermodynamics at the Free University of Brussels has earned him both the Nobel Prize and the promise of fame far outside his own field. . . . Prigogine's insights will give biologists new grounds for learning how the first random molecules organized themselves into life forms (Anon., 1977, p. 87).

Still, for all the accolades, the master himself seemingly has burst the evolutionary bubble for those who will grasp at any straw. Furthermore, he did so in the context of his own research:

> . . . in a nonisolated system there exists a possibility for formation of ordered, low-entropy structures at sufficiently low temperatures. This ordering principle is responsible for the appearance of ordered structures as crystals as well as for the phenomena of phase transitions.
>
> Unfortunately this principle cannot explain the formation of biological structures (Prigogine, et al., 1972, p. 23).

*Editor's Note: For several articles on creation, evolution and thermodynamics see Williams, E. L., editor. 1981. Thermodynamics and the development of order. Creation Research Society Books. Terre Haute, IN.

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MINISYMPOSIUM ON VARIABLE CONSTANTS—VI*

CHANGING CONSTANTS AND THE COSMOS

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Abstract

Four different theories of variable fundamental physical constants are reviewed and compared. Special emphasis is placed on problems of interest to the creationist. The number of explanations for difficult and diverse diluvial problems available from these types of theories, as well as their application to the problems of light from distant galaxies and radioactivity, makes this field a most interesting one from the creationist perspective.

Introduction

Uniformitarianism as envisioned by Charles Lyell would exclude any possibility that any of the physical constants could ever have changed over time. Lyell viewed uniformitarianism as a methodology in which not only were the laws of nature the same throughout all time but even the rates of the processes were identical to the rates occurring today. In order to explain any observational data Lyell would only admit explanations which excluded any reference to the supernatural and used only present rates of processes. Any appeal to a change in a physical constant would be excluded on two counts. First, a change in a physical constant alters the form of natural law. As will be discussed below, a change in the gravitational constant requires either that energy not be conserved over time, or a radically different law of force than the one in use today, or that new energy fields be discovered or postulated (Bishop and Landsberg, 1976). Lyell would secondly reject a change of a physical constant on the grounds that it would alter the rates of processes in the past.

Modern views of uniformitarianism are much more relaxed about the issue. Requiring that the rates of all processes in the past be the same as those seen today is equivalent to having the earth be a perpetual motion machine in which the average rates of rainfall would be the same even billions of years ago when the sun was less luminous than today. This objection was pointedly raised by Lord Kelvin and it was because of his efforts that the constant rate aspect of uniformitarianism was dropped. Today modern uniformitarianism requires only that the laws of physics be the same today as the were billions of years ago. Changing any of the physical constants violates even this weaker form o uniformitarianism since the present would no longer be the key to the past. Thus even modern science has been reluctant to embrace the idea of a change in the physical constants.

Definitions

What are the universal fundamental physical constants? Basically they are values which are claimed to be fundamental to the structure of the universe. They are called universal constants because they are presumed to have the same value from place to place

*Parts I-V are in *CRSQ* 26:121-31; 27:6-15

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throughout the universe and throughout all time. The mass of the pendulum bob on my grandfather clock is constant. Ignoring such processes as oxidation, that mass will remain the same through all time. If I were to move my clock from here to another planet or star, the mass would still be the same. The mass of my pendulum bob however is not a fundamental constant because I have the power to change its mass by any of several expedients. I can cut it in half, dip it in acid or weld more mass on to it. It is not universal since various environments can alter its value.

The same thing cannot be said for the rest mass of the proton or electron which are two of the universal fundamental constants. The rest mass of every electron throughout the entire universe is identical to every other electron and thus the mass of the electron is said to be universal. Is it fundamental? We cannot alter the rest mass of the electron. But if we were able to alter that value or alternatively, if the value of the electron rest mass were different during different epochs of history, or if it were different in other galaxies, radical changes in the structure of the universe would be observed. Thus the rest mass of the electron is a universal fundamental constant of nature.

Davies (1982, p. 39) lists 13 fundamental physical constants. In addition to the rest mass of the proton and electron these are: electric charge on the proton, Planck's constant, speed of light, gravitational constant, weak force constant, strong force constant, Hubble constant, cosmological constant, cosmic photon-proton ratio permittivity of free space and Boltzmann's constant. In this article I will only discuss the effect of changing the gravitational constant, and permittivity. I will also discuss the effect of changing one nonfundamental constant, the permeability offree space, since it has been proposed as the cause of a change of radioactive decay rates by Setterfield (1981, p. 56). Finally I will discuss a theory of changing constants put forward by Barry Setterfield. This theory deserves special attention because it involves a change in six fundamental constants.

Are the constants constant? Uniformitarianism would answer in the affirmative. If the constants are not constant, then the laws of physics were different in the past. This ipso facto violates the premise of modern uniformitarianism that the laws of physics are the same. However, as has been pointed out many times, uniformitarianism is a self-imposed restraint upon how the geologic astronomic and biologic data is to be interpret. One does not prove that uniformitarianism is correct; one merely assumes that is and eliminates certain explanations and theories from consideration. However, merely assuming constant constants does not guarantee that in reality they are constant.

The values of the constants that we measure today are generally called constant. But in point of fact, we cannot directly measure the value of the constants for past time in the same fashion that present values are obtained; Because of this it is necessary to use indirect measurements and observations of the effects of a changed constant in order to determine whether the value was different. In many cases, the value of a given constant has only been directly measured for less than 100 years and one should ask if that is long enough for any change to manifest itself.

Change in the Permeability of Free Space

The first notable effect of a change in the permeability is an alteration of the speed of light. The speed of light is proportional to the inverse square root of the permeability. This relationship, which follows directly from Maxwell's equations, was derived by Maxwell (Barnes, 1977) without any assumption concerning the constancy of the speed of light. This relation is assumed to hold whether the speed of light is constant or not. Thus if the permeability was less by a factor of four in the past, then the speed of light would have been twice as fast as it is today. This implies that if creationists accept a variable permeability, then the light from distant stars can be explained.

A change in the permeability also would have some effect on the problem of radioactivity . There are two aspects of radioactivity which need solution. First, why do the ratios of parent to daughter isotopes occur in ratios which appear to indicate great age, assuming the constancy of decay rates. Second, the problem of missing isotopes needs a creationist explanation. The missing isotopes are radioactive nuclides which should exist on earth, assuming they had been originally created and assuming the earth is as young as creationists generally believe. For instance, silicon 32 has a half life of 650 years and should exist in detectable quantities if the earth is only 7,000-10,000 years old. In fact this isotope does not exist naturally on earth (Morton, 1982, p. 228). An obvious creationist explanation is that the rates of radioactivity decay were faster in the past. A change in the permeability would alter the rates of beta decay. The rate of beta decay is proportional to the fourth power of the speed of light (Segre, 1963, p. 355). If the speed of light were twice as fast due to permeability only and ***nothing else changed,*** then the rate of beta decay would be 32 times faster. Interestingly, without changing some other fundamental constant as well as the permeability, alpha decay would remain constant (Segre, 1963, p. 278). However, the change of permeability alone is not a very satisfactory solution to the problem of radioactive decay.

If radioactive decay occurs too rapidly, then one must consider another problem. Radioactivity produces considerable heat. The amount of heat given off by rapidly occuring radioactivity is most clearly seen in the explosion of a nuclear bomb. In a nuclear bomb, exceptional amounts of energy are emitted instantly. The conversion of this energy to heat produces the vaporization of materials as well as a damaging shockwave. Even though radioactive nuclides are not as concentrated in nature as they are in a bomb, if their rate of radioactive decay increases, then the extra heat generated will heat up the crust of the earth. Too fast of a rate of heat production could melt the earth. * If the decay curve postulated by Setterfield is extrapolated to the first week of creation, the amount of heat generated by such a rapid rate of decay would vaporize the earth. (Morton ***et al.,*** 1983, p. 65).

A change in the permeability also would have the immediate effect of altering the earth's magnetic field.

***Editor's Note: See Williams, E. L. 1990. Variables or constants? An introduction. *CRSQ* 26:124, footnote, first column for a different view of rapid radioactive decay.**

The field is directly proportional to the permeability and thus is inversely proportional to the square of the speed of light. Thus if the permeability were smaller in the past, the earth's magnetic field was also smaller.

A change in the value of the permeability is incompatible with energy conservation, if nothing else was altered. The energy density of a magnetic field is

$$\text{Energy Density} = \frac{B^2}{2\mu_0} \propto \frac{\mu_0^2}{2\mu_0} \propto \mu_0 \qquad (1)$$

where B is the magnetic induction and μ_0 is the permeability. B is proportional to μ_0 so the energy density is proportional to μ_0. Thus if μ_0 increases , then the energy density increases and if μ_0 decreases, the energy density decreases. When the total energy in the magnetic field is calculated, the total energy of the field is still proportional to μ_0. This means that a change in the permeability does not conserve energy. However this should not necessarily be considered a reason to reject changes in the fundamental constants since any change in any constant seems to violate conservation laws.*

There is a good possibility that any change in the speed of light, whether caused by permeability or by permittivity, would have the effect of altering the phenomena of the rainbow. This author has done some preliminary calculations which indicate that a change in the speed of light would cause a change in the dispersion of light passing through a water droplet. If this were the case then a change in the permeability would certainly have the potential for preventing the formation of a rainbow.

From the foregoing one can conclude that a change in the permeability can explain light from distant stars, the problem of radioactive dating and the missing isotopes, and may explain the rainbow. The difficulty with a change in permeability itself is that it cannot explain an alteration of alpha decay which is one of the primary processes of radioactive decay.

Change in the Gravitational Constant

The gravitational constant was one of the first fundamental constants to have been suggested as being variable (Dirac, 1939). He made the suggestion based upon some coincidences among certain physical relationships. Probably because of Dirac's credentials and the simple elegance of his reasoning, the gravitational constant has been a favorite candidate for variability. Dirac showed that the ratio of the electrical force to the gravitational force between an electron and proton in a hydrogen atom was approximately 10^{40}. He also noticed that the generally accepted age of the universe expressed in atomic units of time (the time necessary for light to traverse an electron) was also approximately 10^{40}. Dirac proposed that these two quantities were proportional. This would then require the gravitational strength to decrease inversely proportional to t, and would predict that G is currently decreasing at a rate of -6.6×10^{-9}%/yr.

The effects of a change in the gravitational constant are very dependent upon which theory of gravitational change one uses. If one assumes that only G changes and no other constants are involved, known as the primitive theory, then the effects are as follows:

1. The period and radius of an orbit will increase if G is decreasing with time. This means that the earth is further from the sun now than in the past and the moon is further from the earth. This obviously has implications for the temperature of the earth in the past. Another implication is that lunar occultations of stars will not occur quite as soon as predicted. Analysis of lunar occultation data has yielded the only positive evidence of change in G with estimates ranging from -7.2×10^{-9}%/yr to -8×10^{-9}/yr (Van Flandern, 1976; Wesson, 1980). When compared with the theoretical value, the agreement is remarkable. However other experiments have yielded negative results. *
2. The radius of the earth would expand. This would largely be due to relaxation of the gravitational compression of the earth.
3. If one requires energy to be conserved, then the Newtonian inverse square law of gravitation would have to be substantially altered (Bishop and Landsberg, 1976).
4. One topic which has received insufficient attention is that, if the gravitational constant was greater in the past and energy is not conserved, then the red shifts seen in distant stars could be due to gravitational redshift** rather than velocity redshift. Within the General Theory, the equations governing each phenomenon are identical (Misner, Thorne and Wheeler, 1973, pp. 187, 779).
5. The shape of galaxies should be altered with distance, due to the different gravitational force in effect when the light we see now left the galaxy (Wesson, 1980).

Several objections have been raised regarding a change in the gravitational constant. From a creationist perspective, the amount of increase in the gravitational constant necessary to compress the earth to the radii which expansionists suggest would make it difficult to understand how the bones of dinosaurs could have withstood the gravitational pull. On an earth half the present radius in size, every object would weigh more than three times what they weigh on the present earth. One must explain how a dinosaur weighing 70 tons on the present earth could have lived if it actually weighed over 200 tons. It does little good for creationist to advance a hypothesis which destroys all life.

Another objection is that G is really a non-entity within the General Theory of Relativity. Gravity is merely curvature of spacetime and is not a force in the usually understood sense of the term. Changing G requires that the curvature of spacetime everywhere change. As Dirac (1978, p. 78) aptly stated, ". . . there is no room in Einstein's theory for variation of G." That not withstanding, several attempts have been made to modify Einstein's work to allow a variable

***Editor's Note: There is a situation where conservation laws could vary as well as the constants involved without a loss of energy conservation. See Williams, E. L. 1990. Variables or constants? An introduction. CRSQ 26:127.**

***Editor's Note: See DeYoung, D. B. 1990. Changing constants and gravitation. CRSQ 26:130-31 for a discussion of the nonvariation of G.**

****Editor's Note: See Ettari, V. A. 1988. Critical thoughts and conjectures concerning the Doppler effect and the concept of an expanding universe. CRSQ 25:140-46 for a brief discussion of gravitation redshifts.**

G, some with quite bizarre implications (Van Flandern, 1981; Canuto and Hsieh, 1980). Canuto and Hsieh (1980) correctly note that Einstein's equations do not require a constant G, but only a constant product of G x M. They use this lesser constraint to answer the next objection to a variable G.

At one time it was felt that the solar luminosity would increase with increasing G to the extent that the earth would be roasted (Teller, 1948). In order for a changing G to be compatible with general relativity, one must assume that the product GM is constant. With that assumption the luminosity is approximately constant (Canuto and Hsieh, 1980). This item will become important when discussing Setterfield's views.

As for creationist problems, there are not many that a change in G would solve. Gravity is the most unique of the four forces known to physics. Grand unification theories have had more success in uniting the other three forces than they have had in including gravity.

Change in Permittivity

Morton (1979, 1980, **1981, 1982, 1983, 1986, 1987)** has investigated the effects and implications of a change in the value of the permittivity of free space. I postulated that at the time of the Flood the permittivity increased. Since that time the value has remained constant, and also prior to the Flood the value was constant. The permittivity is the mediator of all electrical interaction. As such it plays a very critical role in the affairs of nature. The effects of changing the permittivity are more widespread than the effects of changing the permeability. This is probably because the permittivity is more fundamental to the natural order. In the literature one often finds discussion of a change of the ratio of e/m where e is the electronic charge and m is the electron mass. In some situations this is equivalent to discussing a change in the permittivity.

The effects of changing the permittivity are as follows:

1. As in the case of the permeability, the speed of light would be faster in the past if the permittivity were smaller. The speed of light is proportional to the inverse square root of the permittivity. Thus if the permittivity was less by a factor of four in the past, then the speed of light would have been twice as fast as it is today. This holds promise of explaining how light from distant galaxies arrived on earth in creationist time frame, depending on how much the permittivity is postulated to have changed during the period of the Flood (with constant values before and after). The speed of light would have been faster before the Flood and slower after the Flood, but only having a variable value during the Flood.

2. A change in the permittivity would have a major impact on the problem of radioactive decay and the missing isotope problem mentioned above. Unlike the permeability which would also require changes in other constants to explain both types of radioactivity , a decrease in the value of the permittivity would increase the decay rate of both beta and alpha decay. Morton (1982) showed that a decrease in the value of the permittivity by a factor of 1648 prior to the Flood would explain why silicon 32 with a half life of only 650 years does not exist naturally today. A change in only one constant to explain both types of radioactivity seems simpler than having to change more than one fundamental constant.

A change in the value of the permittivity by only 2000 times would not have any associated heat problems. As mentioned above when discussing the change in the permeability, too drastic a change in the value of either permittivity or permeability would quickly melt the earth's crust. Thus any change in either constant must be moderate to avoid this problem.

3. As with the change in the permeability, a decrease in the permittivity might alter the dispersion of light in a water droplet. Thus the permittivity also might alter the rainbow. Thus the pre-Flood world may not have known the beauty of the rainbow.

4. Energy is not conserved. A change in the permittivity would affect the energy density of the electric field just like a change of the permeability affected the energy density of the magnetic field. It is this author's opinion that since only God can change a fundamental constant, energy conservation is not necessary unless the implications of the change require it. Also, a change in a fundamental constant can only be accounted for miraculously and therefore it is not a naturalistic phenomena.

These four alterations in nature are the only four effects that are shared by changes in the permeability and the permittivity. The next effects are those peculiar to the permittivity.

5. An atom emitting electromagnetic radiation would emit a more energetic photon if the permittivity were smaller in the past. At first glance this might appear to be detrimental to the theory. If elements emitting visible light today were in the past emitting gamma rays would it not seem reasonable that life would be killed? The answer surprisingly is no. If an atom were emitting a more energetic photon it would also absorb the more energetic photon and thus the effect would be negated. Also heat capacities of materials would be greater. The heat capacity is the quantity of energy per gram that a material must absorb for each degree rise in temperature. These factors should ameliorate any problem with a change in the wavelength of light due to a change in permittivity.

6. An increase in the permittivity would provide an explanation for the problem of explaining the heat released by condensing water vapor at the time of the Flood. Each gram of water (approximately 200 raindrops) releases 600 calories of heat when the water vapor condenses to form those drops. Dillow **(1981,** p. **269-72)** calculated the amount of heat given off by the vapor canopy when it condensed to water and found that if all the heat from a canopy (50 feet in thickness) were to be placed into the atmosphere at one time the temperature would rise 2100°C. Those who postulate a canopy should account for this heat. An increase in the permittivity would cause a huge absorption of heat as the electrons around each and every atom adjusted to its new radius. Quantum mechanics requires that energy be absorbed when an electron moves away from the nucleus. The increase in the permittivity would cause the electrons to be further from the nucleus and thus they would absorb much heat. The permittivity hypothesis is the only creationist theory which can account for the absorption of enough heat at a rapid enough rate to allow for 40 days and nights of rain.

7. Using an equation for the luminosity given in Davies (1982, p. 54) one can determine that if the permittivity were smaller in the past, the sun would undergo a 40 fold increase in luminosity. This is a problem but less of one than that predicted by Setterfield's theory.

8. A change in the permittivity would cause the earth to expand via a different mechanism than the expansion caused by a change in the gravitational constant. The distance between the orbit of the electrons and the nucleus in an atom is directly proportional to the strength of the electric field. The stronger the electric field, the smaller would be the radius of the electron's orbit. Thus if the permittivity were smaller before the Flood, then each atom would have been smaller and thus the earth's radius would have been smaller. As the permittivity changed, the earth's radius gradually expanded.

An expanding earth explains many of the features of the earth's geology which are not explained by other creationist theories. These include the following facts:

1. The fit of the continental shapes into a solid outer covering for the earth if the earth's radius were smaller.
2. The expansion theory allows for the only numerical explanation for the thicknesses of the sediments observed on the earth (Morton, 1980). Since the sediment thicknesses apparently can only be numerically explained by a deluge, this fact presents tremendous support for our view of earth history.
3. Continental drift would present a serious heat problem if it occurred within the creationist time frame (Morton, 1981; Baumgardner, 1986). Baumgardner's estimate of the temperature rise is more realistic than Morton's but still it presents a serious thermal problem. The expansion of the earth would largely negate any large heat problem caused by the separation of the continents.
4. Expansion of the cart caused by a change in the permittivity would solve one of the most serious objections to secular theories of expansion, namely how compressive features formed on an expanding earth where only extensional forces should be found. Due to the differential expansion of different atoms and molecules, some regions of the crust might expand faster than the earth's average rate of expansion and thus produce, compressive forces (Morton, 1983). This is the most important feature of an expansion due to permittivity since this objection has generally caused people to reject expansion.
5. A decrease in the permittivity would strengthen chemical bonds. This would have two implications. The leg bones of dinosaurs would have been stronger, which would improve their chances of surviving on a smaller, more gravitating earth. As noted above, this is one possible objection to the expanding earth hypothesis. The second implication would be that thin overthrusts, which creationists have correctly pointed out as being too mechanically weak to exist, are explained. The basic objection has been that rocks are not strong enough to have been thrusted the distances observed. A decrease in the permittivity would make the rocks much stronger.
6. Dillow (1981) analyzed the flight characteristics of the Pteranodon and concluded that in order for the larger pteranodons to fly they needed a denser atmosphere. Dillow appealed to the vapor canopy as the cause of the denser atmosphere. A smaller earth would also have a much denser atmosphere.

Several other creationists have considered earth expansion as a solution to creationist problems. These include Baumgardner (1978), Unfred (1986), and Mundy (1988). Baumgardner and Unfred considered a change in permittivity as a cause of the change in earth radius, but Mundy did not mention it.

Setterfield's Views

Setterfield (1981) proposed a theory in which the permeability of free space changed, combined with an attempt to conserve energy. The decay of the speed of light is presented in a totally naturalistic manner in which the speed of light apparently had a built-in decline throughout earth's history. There is no divine intervention to cause this decline. A day and half after creation the speed of light is postulated to have been 150 quadrillion km/s, Morton *et al.* (1983); Akridge (1983); Aardsma (1988); Humphreys (1988); Brown (1988) and Holt (1988) have all detected major problems in this theory.

Setterfield postulated that since creation, the speed of light decayed in a log sine fashion and only in the past 30 years has the speed of light become constant. The permeability change is postulated as being the cause of the decay in the speed of light. If that were all that was postulated to have changed, the results would be as outlined above but the implications of a change in permeability alone are not very interesting to the creationist. It only solves the problem of light from distant stars and galaxies.

Setterfield added one other postulate to his theory which not only made the theorys implications interesting to the creationist, but also was the ultimate cause of criticism. He required that energy be conserved. This second postulate allowed him to advance an explanation of radioactive decay in a creationist framework but it also raised many inconsistencies whose solutions seem to require more and more constants to be variable. To date he has postulated that six fundamental constants are changing. These are the speed of light, mass, Planck's constant, gyromagnetic ratio, permeability and gravitation. Amazingly with all this variability in the universe the theory still only explains two creationist problems: radioactivity and the speed of light.

The inconsistencies published so far can be found in the above referenced articles. There is one inconsistency which has not been discussed in the literature and that concerns Setterfield's contention that the constant of gravitation has changed.

In a response to a criticism of the theory that a decrease in the mass of the earth would cause the past earth's rotation rate to increase to such an extent that the earth would break apart, he suggested that the gravitational constant was proportional to c^4 (Setterfield, 1983). If true, then the orbital radius of the planets would remain constant. But due to a mathematical error he made in deriving this relationship the correct dependency is one of G on c^2. This would then require that the earth's orbit grow smaller as G changed, causing the earth to become hotter. A further probem arises because the luminosity of the sun can be shown to depend directly upon c. (See Appendix.) A four-fold increase in the speed of light results in a four-fold increase in the solar luminosity, or the amount of light emitted. According to Setterfield (1981), in 2,384 B.C. the velocity of light was five times faster, resulting in five times more light reaching the earth. At creation the sun would have been emitting 500 billion times more energy, thus scorching the earth and all its newly created life.

As is shown in the Appendix, to be consistent with Setterfield's view and to be physically correct, G must be assumed proportional to c^2. But that would violate Setterfield's assumption of energy conservation and would require a major revision of his theory. It would also mean that the force of gravity was proportional to the inverse of c^2. This would imply that on the day of creation the force of gravity was so low that the atmosphere would have escaped from the earth. Adam and Eve would have been able to jump from the surface of the earth, never to return. Thus one is faced with two horns of a dilemma: Either the earth is too hot or the earth has no gravity in Setterfield's view. Until these inconsistencies are solved, this hypothesis cannot be accepted.

Conclusion

The possibility that some of the fundamental constants have varied throughout earth's history should be given serious consideration by creationists. A change in a physical constant is more palatable to the creationist than to the actualist or uniformitarianist since possible changing constants are certainly non-uniform. As is evidenced, these changes appear fruitful in answering problems that previous creationist viewpoints have only been able to explain in an *ad hoc* fashion. Over the long term, it is difficult to argue with successful explanations.

How should we justify a change in a physical constant? We should not consider it simply as a naturalistic change. When one examines the history of science, one finds that gradually as more physical phenomena were explained by naturalistic means, God was more and more relegated to an irrelevant role in the affairs of nature. No longer was the Creator of the universe seen as an important part of that universe. This trend in science was a major factor in the secularization of society which we have seen in the 20th century. It seems very incongruous for the creationist who should be defending God's role in the universe, to also propose theories in which God is irrelevant. If we creationists wish to have science take a more open-minded position on the place of God in nature, then it is incumbent upon us to put God back into science. Our adversaries certainly will not.

Finally, since the changing of fundamental universal constants is fraught with potential perils, it would seem prudent to apply Ockham's Razor. This is basically a philosophical rule in science that the theory which uses the fewest assumptions and explains the most phenomena is the better theory. Table I shows the effects of changing various constants and the phenomena which would be explained by the changes. The reader can judge for himself.

Appendix

Setterfield uses a form of the gravitational potential which appears in the General Theory of Gravitation. It is,

$$\text{Potential} = \frac{G\,M}{c^2 r} \qquad (2)$$

Table I. Possible Effects of "Variable" Constants

If the postulated change provides an explanation for the phenomena, then the box will contain ayes or the direction of the altered value. If the postulate has no explanatory power for the phenomena, the box will contain a "no."

Phenomena	Permeability	Gravitation	Permittivity	Setterfield
number of constants altered	1	1	1	6
energy conserved	no	?	no	yes
speed of light	faster	constant	faster	much faster
radioactive decay	faster	?	faster	much faster
planetary orbital radius	constant	G > smaller G < larger	constant	depends
luminosity of sun	constant	constant	slightly larger	much larger
galactic shape	constant	altered	constant	depends on G
emitted wavelength	constant	constant	greater	constant
heat from 40 days rain	no	no	yes	no
earth expansion	no	yes	yes	no
shape of continents	no	yes	yes	no
sediment thickness	no	yes	yes	no
continental drift heat	no	no	yes	no
rainbow	maybe altered	constant	maybe altered	constant
overthrusts	no	no	yes	no
magnetic field	altered	constant	constant	altered

where G is the gravitational constant, M is the mass of the potential producing body i.e. the sun, c is the speed of light and r is the distance from the center of the sun to the point at which the potential is evaluated. This equation is only valid for the gravitational potential when the units of time used are geometricized units (Misner, Thorne and Wheeler, 1973, pp. 29-30). Time is represented in centimeters of light travel, not seconds. It is the square of the velocity of light which acts as the constant of proportionality. In this equation one inputs mass in conventional units and the potential is given in geometricized units. This equation is identical to the more familiar form of the equation in which the potential is not given in geometricized units, but in conventional units. The more familiar form is

$$\text{Potential} = \frac{GM}{r} \qquad (3)$$

where the potential is given in conventional units.

Setterfield claims that in order for energy to be conserved, mass must be divided by the square of the velocity of light, and the potential must be constant. Thus following through the reasoning on both equations, albeit only equation (5) will be correct, we find that the potential in geometricized units is

$$\text{Potential} = \frac{G \times M_0}{c^4 r} = \text{Constant} = v^2 \qquad (4)$$

and in conventional units of time (seconds) it is

$$\text{Potential} = \frac{G \times M_0}{c^2 r} = \text{Constant} \qquad (5)$$

where in each case the dependence of M on c has been made explicit. M_0 is the present value of the solar mass. From equation (4) Setterfield concludes that G is proportional to c^4 and that the velocity of the orbiting planet is also constant under such a change (Setterfield, 1983, p. 67-68). The v^2 part of equation (4) is published in the reference article.

Setterfield makes a mathematical error in going from equation (4) to what he calls the Neo-Newtonian formulation. He multiplies both sides of equation 4 by m, and claims that

$$\frac{G \times M_0 \times m_0}{r} = \text{Constant} = (mc^2)v^2 = m_0 \times v^2 \qquad (6)$$

where the dependence on c from (4) has been canceled. If equation (4) is equal to a constant then (6) cannot be constant since (6) is equivalent to:
Constant of equation (4) x m = Constant of equation (6). Since

$$m = \frac{m_0}{c^2}$$

then

$$\text{Constant of (6)} = \frac{G \times M_0 \times m_0}{r} = \frac{\text{Constant of (4)} \times m_0}{c^2}$$

Thus since the constant of (6) depends upon c, it is not constant. One has a choice: either the constant of (6) is constant or the constant of (4) is constant but both cannot be constant.
The force can be shown to be

$$\frac{G \times M \times m_0}{r^2} = \frac{\text{Constant of (6)} \times m_0}{c^2}$$

The force between the sun and the earth is inversely proportional to c^2 if G is proportional to c^4 and the constant of (4) is the true constant. From this it can be shown that the distance from the earth to the sun is also inversely proportional to c^2. Thus in Setterfield's view of gravity, since the speed of light was faster in the past, the distance from the earth to the sun must have also been much smaller.

Following the same line of reasoning from equation (5) which is the mathematically and physically correct equation, the only way for the radius of the earth's orbit to remain constant under Setterfield's views is for the gravitational constant to be inversely proportional to c^6 in geometricized units (or equivalently to the inverse fourth power in conventional units) with equation (6) equal to a constant. If (4) and (5) are constant then the force of interaction cannot be constant and hence the radius of orbits will change.

The latest thinking on the dependency of the luminosity with G starts with the relativistic assumption that

$$G \times M = \text{constant}.$$

Canuto and Hsieh (Equation 12, 1980) derive this relation from the standard relativistic equations. The radiant emittance (R_b) of a blackbody like the sun is

$$R_b = \sigma T^4. \qquad (8)$$

where T is the temperature of the sun's interior and σ is the Stefan-Boltzmann constant. Zemansky (1968) gives the dependence of σ on other constants. Thus

$$R_b = \frac{2\pi^5 k^4 T^4}{15 c^2 h^3}. \qquad (9)$$

where k is the Boltzmann constant and h is Planck's constant. The energy density of radiation in the sun is related to the emittance by (Zemansky, 1968)

$$u = \frac{4}{c} R_b. \qquad (10)$$

Thus

$$u = \frac{8\pi^5 k^4 T^4}{15 c^3 h^3}. \qquad (11)$$

According to Setterfield (Table 10, p. 64, 1981), k and the product of h and c are constant. Thus Setterfield's views would lead to the conclusion that the energy density within a star is constant.

Canuto and Hsieh (Equation 15, 1980) assume that the luminosity of the sun is equal to

$$L = \frac{1.33\pi R^3 u}{\tau}, \qquad (12)$$

where τ is the photon diffusion time and R is the radius of the sun. Canuto and Hsieh (Equation 16, 1980) define τ as

$$\tau = \frac{R^2}{cl}, \qquad (13)$$

where l is the mean free path of the photon. Defining the opacity of the sun as $K = 1/(l\rho_0)$ where ρ_0 is the density of the sun and substituting this into equation

(13) we find

$$\tau = \frac{R^2 K\rho_0}{c}. \quad (14)$$

Substituting this into equation (12) we find

$$L = \frac{1.33\pi Ruc}{(K\rho_0)}. \quad (15)$$

Now the product of K and ρ_0 within Setterfield's view must be constant. The reason for this is that ρ_0, the sun's density is merely the solar mass divided by the volume. Under Setterfield's assumptions the mass is proportional to the inverse of c squared. Since these two are inversely related to each other their product is constant. This follows from the constancy of the mean free path. Thus their product is put in parentheses. Canuto and Hsieh (Equation 18, 1980) show that:

$$kT \sim \frac{GM\rho_0}{R} \quad (16)$$

but within Setterfield's view where G is proportional to c^4, and M and ρ_0 are proportional to c^2, it is obvious that kT is constant. This confirms that u is constant and that there is no hidden dependency upon c.

Thus we are left with equation (15) as the dependency of the solar luminosity upon c. Even if the earth's orbit does not change its distance from the sun, the sun's emission of energy would quickly burn the earth if the speed of light increased as much as Setterfield has claimed. However, when one uses the correct variation of the earth's orbit with a change in the speed of light, it would imply that as the earth approached the sun, the sun would be intrinsically more luminous and therefore hotter.

There does not appear to be a consistent assumption which can change c and solve both of these problems. The dependency of solar luminosity on c is due to the photon diffusion time being less and is not due in any way to a change of G within Setterfield's theory. However, a correct view of the dependence of G on c implies that the pull of gravity felt by an object on earth would be inversely proportional to c^2.

If G is proportional to c^2 and mass proportional to the inverse of c^2 then the force of gravity

$$F = \frac{G_0 \times M_e \times m}{c^2 r^2}. \quad (17)$$

Where M_e is the mass of the earth and m the mass of an object on earth. This dependence of the force of gravity on c implies that the force of gravity was 150 quadrillion squared times smaller during the first week of creation. This is hardly compatible with a stable creation.

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QUOTE

Ideology emerged as a strong force in the seventeenth century, with the separation of religion and moral philosophy from science, in the attempt of Hobbes and Descartes to place all things, including ethics and politics, on a scientific basis. As scientific rationalism went its separate way from religion, ethics, politics, and humanistic subjects, the traditional distinction between values and facts was greatly eroded.

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