Critique of Some New Setterfield Material

G. P. Jellison

A few years ago, I became aware of Barry Setterfield's claims that fundamental physical constants such as the speed of light *c*, Planck's constant *h*, and the electron's mass *m* and charge *e* have undergone major changes during historical times. This "*c*-decay" theory formed the basis of a creationist "explanation" of our ability to observe distant galaxies in a Universe with a putative age of only 6,000 years or so.

I found the critical analysis of astrophysicist Dr. Tom Bridgman invaluable in helping me understand what Setterfield was saying. Before long, I had written up some of my own criticisms of *c*-decay, and this material was posted on Tom's "Dealing with Creationism in Astronomy" website.[1]

I also participated in discussions on a creationist Internet discussion site,[2] and was especially pleased to have the opportunity to debate at least some of my findings with Setterfield himself. (Actually, only two of my criticisms were addressed by Setterfield. His attempts to defend his work demonstrated an inability to understand elementary calculus and atomic physics. After much resistance, he finally admitted that I was right in both cases.)

Now, two years later, a "Response Concerning Jellison's Criticisms"[3] and two new articles, "Quantum Redshifts and the Zero Point Energy"[4] and "Data and Creation: The ZPE-Plasma Model,"[5] have appeared on Setterfield's website. In what follows, I provide a critique of this new material.

The Basics

Setterfield has always claimed that *c*, the speed of light, was much higher in the past than it is now. Because of coordinated variations in other constants, such as Planck's constant, electron mass, etc., as well as changes in as the fundamental rate of radioactive decay and other basic atomic processes, these time variations supposedly cancel each other out in geological and astronomical observations. Thus, looking at light from the distant Universe is not expected to reveal direct evidence of *c* decay (in Setterfield's speculative framework).

Not surprisingly, Setterfield doesn't accept the Big Bang theory, and has devoted much of his recent effort to development of eccentric cosmological notions. He is committed to the concept of a "quantized redshift." Along with a tiny minority of

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[1] Jellison, G. P. and Bridgman, W. T., "Analysis of the Variable Lightspeed (c-Decay) Theory of Barry Setterfield," http://homepage.mac.com/cygnusx1/cdecay/cdecay_2007Jellison3.pdf.

[2] www.youngcosmos.com.

[3] Setterfield, B., "Response Concerning Jellison's Criticisms," http://www.setterfield.org/Jellison/html.

[4] Setterfield, B., "Quantized Redshifts and the Zero Point Energy," *Journal of Vectorial Relativity* vol. 3, no. 4, December 2008, pp. 1-32, http://jvr.freewebpage.org/TableOfContents/Volume3/Issue4/QuantizedRedshiftsAndTheZeroPointEnergy .pdf. Many of Setterfield's recent papers have been posted in the *Journal of Vectorial Relativity*. This is not a mainstream science journal. It appears to be a strictly online entity, devoted to presentation of certain eccentric physics concepts. The *JVR* home page includes information for referees, but based on the issues discussed in this report, the *JVR* peer-review process clearly leaves much to be desired!

[5] Setterfield, B., "Data and Creation: The ZPE-Plasma Model," http://www.setterfield.org/ZPE-Plasma_model.html.

astronomers, he thinks that the wavelength changes we see as we look deeper into space are not continuous, but vary in a stepwise manner, allegedly disproving the model of an expanding Universe. Setterfield believes the Universe is essentially static, and is stabilized against contraction or expansion by variations in the fundamental constants. The astronomical redshift is allegedly due to changes in intrinsic atomic properties, the quantization reflecting some sort of atomic quantum effect.

Setterfield believes the cosmos is permeated with "zero point energy" (ZPE). The amount of ZPE allegedly increased dramatically during much of the Universe's history, and this variation caused continuous changes in the fundamental constants. Prior to 2007 Setterfield also claimed that atoms suddenly and universally increased in size during sporadic "quantum jumps." This change in atomic dimensions was allegedly caused by changes in electron mass. During the jumps, he said, electrons get less massive by a factor of 1.00000878256, causing atoms to get larger, and giving the observed astronomical redshift as we look out into the cosmos.

But this argument was wrong. I demonstrated during the youngcosmos.com interactions with Setterfield that increases in electron mass would actually give an astronomical *blue*shift. Setterfield got it wrong because, among other things, he didn't understand basic atomic theory (e.g. the Bohr atomic model), as taught in any freshman physics course.

In a significant reversal, Setterfield then announced that, in fact, electrons get *more* massive during quantum jumps. This causes atoms to get smaller at the jumps, resulting in the "quantized" redshift.

This was Setterfield's understanding until recently. The fundamental constants change smoothly and continuously as ZPE increases, but these changes cancel out and are generally unobservable. In addition, elementary particle masses undergo discontinuous changes at rare intervals, resulting in the observed "quantized" redshift.

But more recently, Setterfield has discarded this scenario and has replaced it with a potpourri of new cosmological ideas. In two recent posted items – "Quantized Redshifts and the Zero Point Energy" (which I'll refer to as "Redshifts") and "Response Containing Jellison's Criticisms," – he said that there are *no* mass changes at quantum jumps. In these reports from 2007 and 2008, he proclaimed that the redshift is derived from atomic changes that are derived solely from the continuously varying constants he has always believed in. However, in a more recent Appendix[6] to "Data and Creation" he reverses himself yet again, declaring that, at the quantum jumps, "there is a small quantum increase in *m*."

This recent work by Setterfield is enormously confusing; one might fairly categorize it as "chaos theory." As I see it, Setterfield is flailing about, trying to rearrange his basic concepts in a way that fits the subset of astronomical facts he knows about and accepts. In addition, his new work, like the older material, contains a number of outright errors. This report will discuss some of the reasons that his new claims are invalid.

"Statistical Trends in Atomic Constants"

Section II of "Redshifts" ("Statistical Trends in Atomic Constants") reviews Setterfield's claim that the fundamental constants changed radically in the past. The "*c*-decay phase lasted only until 2992 BC. After that, the fundamental constants allegedly

[6]Setterfield, B., "Technical Appendix: The ZPE Model and Quantized Redshifts," http://www.setterfield.org/ZPE_Plasma_technical_appendix.html. Setterfield produced this new material when critical analysis by Mark Kluge revealed a mathematical error in "Redshifts."

"oscillated" in such a complex way that the oscillation cannot be clearly characterized. Setterfield says these oscillations caused measurable changes even in the 20th century, but they unfortunately leveled off around 1970 (hence our current inability to observe them).

Actually, since *c* in 2992 BC was allegedly 53,400,000,000,000,000 cm/s, the maximum"oscillation" we could have today would be negligible compared to the enormous decrease in the constants since then (a factor of 1.78 million!). In fact, to within an incredibly fine tolerance, measurements today show no significant variations, oscillations or otherwise, in the constants. What's happened, of course, is that technology has caught up with Setterfield. The constants can now be measured to many decimal places, and within these tolerances their values are as steady as can be. All of this is discussed in detail in my 2007 critique (which Setterfield has never taken any notice of), and so will not be presented at length in this report.

Setterfield has unearthed, and consistently refers to, a number of obscure research papers that allegedly support his convictions. He may be less prone to quote-mining than many other creationists, but he cannot be exonerated of this charge completely. For example, in "Redshifts" we find the claim,

> In 1965, Sanders [in his book *The Fundamental Atomic Constants*] noted that the increasing value of *h* could only partly be accounted for by improvements in instrumental resolution and changes in listed values of other constants. Thus, it is quantitatively inadequate to blame the increase in *h* on these factors. ("Redshifts," p. 15).

But this misrepresents what Sanders actually wrote:

> Improvements in instrumental resolution and in the understanding of the form of the limit* resulted in a steady decrease of the deduced value of *h*/*e* from 1.3749 x 10^{-17} erg sec esu^{-1} in 1921…, to (1.37928 ± 0.0004) x 10^{-17} erg sec esu^{-1}...in 1951. Part of the discrepancy of these figures is due to the change in the accepted values of *c* and Λ** between 1921 and 1951.[7]

Regardless of what Setterfield implies, nothing in this passage suggests that the fundamental constants have undergone genuine variations. Actually, Sanders stated clearly that claims of variation in the speed of light (and, presumably, the other constants) have no foundation in any measurements prior to 1965 (when his book was written).[8]

"ZPE and the Redshift"

Setterfield's mathematical difficulties begin in Section II.B ("ZPE and the Redshift") of the "Redshifts" paper. He wants to establish the quantized redshift as a

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* That is, the lower wavelength limit of the X-ray spectrum generated when electrons strike a solid target. Measuring this limit allows one to derive a value for *h*/*e*.

** Λ is a conversion factor between X-units (a formerly used measure of x-ray wavelengths) and cm.

[7] Sanders. J. H., *The Fundamental Atomic Constants*, Oxford University Press, Oxford, 1965, pp. 12-13.

[8] Ibid., p. 20.

result of changes in the intrinsic properties of atoms during the past history of the (young) Universe.

In "Jellison's Criticisms" he states that "there is now NO quantum change in sub-atomic particle masses. Everything depends on the behavior of Planck's constant, *h*, and the conservation of orbital angular momentum." As already noted, in the more recent "Technical Appendix" document he admits to an erroneous derivation and reverts back to his original position on this matter. After reading the Appendix I cannot ascertain how many errors he acknowledges, or exactly what they are. Therefore, some of my arguments below may be directed at claims that are now inoperative. Nevertheless, my criticisms reflect things that he did say quite recently. Demonstrating these errors makes an essential point about his lack of scientific competence.

In the "ZPE and the Redshift" section he restates his long-standing claims that fundamental constants have undergone gradual, coordinated changes due to changes in Zero Point Energy (ZPE) in the past. Planck's constant *h* increases as time goes on, and (at times not corresponding to "jumps") electron mass *m* increases as the square of *h*:

$$m \propto h^2$$

He accepts conservation of kinetic energy. Therefore mv^2 must be constant, requiring *v*, the electron velocity, to vary as 1/*h*. Thus, *mv* is proportional to *h*. As time goes on and *h* increases, *mv* increases. But the angular momentum of an orbiting electron must be conserved,[*] and so *mvr* is a constant, requiring the orbit radius *r* to decrease. Atoms therefore were larger, and emitted redder light, in the past:

> …the orbit radius and the wavelength of the electron de Broglie wave are directly related. This implies that, in order to conserve angular momentum as the ZPE increases and *h* increases, the de Broglie wavelength shortens and can therefore be accommodated in an orbit of a smaller radius. Since the wavelength of emitted light from a given orbit is related to both of these factors, the emitted wavelengths of light will become successively shorter, and more energetic, with increasing ZPE strength and so will be bluer with time.
> ("Redshifts," p. 18)

But the de Broglie wavelength is $\lambda = h/mv$. If *mv* is proportional to *h*, the de Broglie wavelength doesn't change! As Setterfield acknowledges, the circumference of the electron orbit, and therefore the size of an atom, is governed by the size of de Broglie standing waves. If the de Broglie wavelength is constant, so is the atomic size

However, Setterfield says the de Broglie wavelength gets shorter as time goes on, and, incredibly, derives the redshift by equating an atom's de Broglie wavelength to the wavelength of emitted light ("Redshifts," Eq. (22)). In reality, these two quantities typically differ by a factor of about 1,000!

This is not Setterfield's worst error, since he is correct in his conclusion - that smaller atoms would emit bluer light. Since he flubbed this in his online debate with me a few years ago, it's gratifying to see that he's gotten things at least partially straightened

[*] *Linear* momentum is not conserved, but for some reason this doesn't seem to bother Setterfield.

out. But my approval is nullified by the absurd details of his atomic claims. In the Technical Appendix we read

> …as time moves forward, the radius of each orbit decreases in a series of steps. Each step has the effect of making the orbits further apart. Calculation shows that this occurs because the outermost orbit has essentially no change in its radius, or at most a very minor change, while the innermost orbit moves the most. All other orbits move inwards in proportion.

Setterfield doesn't show the calculations that allegedly show the inner orbits changing, but not the outer ones. Therefore, one can't prove him wrong, despite the difficulty in imagining a believable physics model that would behave in this way. But he seems to have forgotten why he is going through all this. He wants a model that will reproduce the redshift observed in light from the distant Universe. But the light emitted by atoms comes from the "optically active" electrons in the *outer* parts of the atom. His claim

> When an outside force excites an electron, forcing it out of its normal position relative to the nucleus, it will release the energy from that force as a photon of light when it snaps back into position. However, because the orbits are now further apart, there is a greater energy difference between them.

makes no sense because the inner electrons don't get forced out of their normal positions. In a multi-electron atom, it is the ones in the *biggest* orbits that make transitions between quantum states and emit light. Since Setterfield says these orbits haven't changed size significantly, his model for the redshift doesn't work.

Setterfield suggests that, as Planck's constant changes, atoms get "stuck" at their current sizes and only shrink in discrete jumps. There is no justification for this. It certainly is not derived from quantum theory. Legitimate scientific advances are achieved by reasoning, not proclamation.

"Recombination and Turbulence"

In "Redshifts" Section IV.B., Setterfield writes a population equation for Planck Particle Pairs (PPPs), which are an essential feature of his cosmology. The equation is

$$\frac{dN}{dt} = q - RN^2 \qquad \text{(S.27)}^*$$

where N is the number of PPPs, q is their creation rate, and R is a recombination coefficient. So far so good (although that's not saying much, since this is just the first step in his derivation). An equation of this type is correct for expressing the evolution of electron and ion populations in plasma (such as the interstellar medium) and it would be expected that the last term should go as N^2, since recombination is a two-body process. The recombination coefficient R is a function of temperature, but of course is not a function of N. Unfortunately, in the derivation to follow, Setterfield needs the last term to

* I designate Equation (27) in Setterfield's "Redshifts" paper as (S.27).

go as N, rather than N^2 (otherwise he wouldn't be able to derive the redshift equation he's trying to get). He achieves this in a way that can charitably be described as creative.

He cites a scientific reference that contains the equation for τ, the recombination time:

$$\tau = \frac{1}{NR}$$

This makes sense: if either the recombination coefficient or particle density is large, the time needed for a particle pair to recombine will be small. Setterfield, however, inverts this equation to get

$$R = \frac{1}{N\tau}$$

Although formally correct, this equation gives the misleading impression that R is proportional to $1/N$. This is not true, of course, because τ is a function of N. Much worse, however, is what comes next: he uses a ridiculous dimensional argument to drop the τ, getting

$$R = \frac{1}{N}$$

and substitutes this back into (S.27), getting rid of the unwanted factor of N!

$$\frac{dN}{dt} = q - RN \qquad \text{(S.29)}$$

I wish real physics were this easy!

A few equations further along, he has

$$3N = N_1$$

where N is the density of PPP available for recombination at any time, and N_1 is the original number of PPP (presumably at the Creation). Clearly, N_1 can't change, and so it can't be equal (except at one time in history) to a time-varying quantity. The absurdity of this is made clear when he derives

$$N = \frac{N_1 - N}{2}$$

Since N_1 is constant, if N increases, the left side of this equation gets bigger, but the right side gets smaller! Not good.

This section of "Redshifts" continues by means of some invented equations. Setterfield rather arbitrarily chooses an exponent of 0.5 in his Equation (S.32) and announces that "our purposes here are satisfied" by an exponent $n = 2$ in the equation

$$(N_1 - N)^n \propto t$$

His key equations are chosen, not derived.

"Deriving the Redshift Equations"

The mathematical shenanigans continue in Section IV.C., "Deriving the Redshift Equations." Setterfield gets the equation

$$\frac{dM}{dT} = \frac{k_2}{M} - k_1 M$$

where $k_1 = 0.5$ and k_2 is a coefficient related to the q term in (S.29). Setterfield doesn't like the k_1 and k_2 factors, and as usual, finds an elegant solution. He just drops them!

Later on (S.46), Setterfield uses the absurd substitution

$$\sqrt{1-T} = -\sqrt{T-1}$$

Of course, it should be

$$\sqrt{1-T} = i\sqrt{T-1}$$

Because of this error, in (S.46) and (S.47) he has the terms $\sqrt{T-1}$ and $\sqrt{T^2-1}$ which, since T is between zero and one, are imaginary numbers! Setterfield doesn't notice this, but fortunately makes the same error a second time, canceling out the first one.

Fundamental Inconsistencies

Setterfield's new claims about atoms are riddled with internal inconsistencies. For example, note that by invoking the equality of the nucleus-electron electrostatic force and the product of m and the centripetal acceleration (that is, by applying $F = ma$), we can write

$$\frac{e^2}{4\pi\varepsilon_o r^2} = \frac{mv^2}{r}$$

Setterfield says the angular momentum $L = mvr$ is a constant. We can write the above equation as

$$\frac{e^2}{4\pi\varepsilon_o r^2} = \frac{Lv}{r^2}$$

Therefore

$$\frac{e^2}{4\pi\varepsilon_o} = Lv$$

and so

$$v = \frac{e^2}{4\pi\varepsilon_o L}$$

So, for any given (constant) value of angular momentum, only one value of velocity is possible. This contradicts Setterfield's claim that the electron orbital velocity is proportional to the (allegedly) time-varying speed of light (he needs this so that kinetic energy will be constant). Setterfield's scenario cannot maintain simultaneous validity of energy conservation, angular momentum conservation, and $F = ma$.

Furthermore, the alleged variation of electron orbital velocity v is

$$v \propto h^{-1} \propto c \qquad \text{(S.18)}$$

The atomic orbital radius varies in the same way:

$$r \propto h^{-1} \propto c \qquad \text{(S.19)}$$

Viewed classically (as Setterfield does), the electron will make an orbit about the nucleus in a time

$$t = \frac{2\pi r}{v}$$

Hence we can write

$$t \propto \frac{h^{-1}}{h^{-1}}$$

Hence, t is constant. There is no variation in the orbital period t because, as time passes, the orbit gets smaller and the velocity decreases. These two variations cancel out, leaving the period constant.

This leads to a fatal problem. Setterfield has always claimed (and reiterates in another very recent paper[9]) that the atomic orbital period t varies with time; in fact, it is proportional to h (and therefore inversely proportional to c). Setterfield *needs* t to be

[9] Setterfield, B., "Reviewing a Plasma Universe with Zero Point Energy," *Journal of Vectorial Relativity* vol. 3, no. 3, September 2008, p. 18, http://jvr.freewebpage.org/TableOfContents/Volume3/Issue3/APlasmaUniverse.pdf.

time-varying. The frequency of light emitted by atoms should be inversely proportional to t.* But if t is constant, atomic processes are invariant, and there is nothing to compensate for the postulated changes in the speed of light, which would cause distant galaxies to be enormously red-shifted (much more than the cosmological redshift we observe). He has always invoked compensatory changes in atomic frequencies to explain our inability to detect c-decay by observation of distant galaxies. Without $t \propto c^{-1}$ his ideas are exposed to falsification by routine astronomical measurements.

"Data and Creation: The ZPE-Plasma Model"

Setterfield's most recent posted paper is largely concerned with claims about the Earth's geological history, and with presenting a historical timeline relating c-decay to the geological column and human history. I'll have little to say about much of this, since it's outside the domain of physics and is almost impossible to comment on in a rational fashion (e.g. his claim that the Mesozoic Era, the age of dinosaurs, lasted only 127 years). I'll limit myself to Setterfield's discussion of blackbody radiation, since this is physics-related, and as far as I can tell, new.

Space is permeated with microwave photons – relics of the era when the Universe was a ball of plasma at high temperature. The existence of this "blackbody" radiation was *predicted* by the Big Bang theory, and its characteristics are explained, with great accuracy, by standard Big Bang cosmology. The radiation dates back to the time when the Big Bang fireball became transparent to photons. This happened when matter dropped to a temperature of about 3000 K, allowing ions and electrons to combine into neutral atoms. The blackbody radiation now exists in the form of microwave photons, with wavelength corresponding to a temperature of 2.725 K – over a thousand times less than what prevailed when the radiation originated. This wavelength shift is readily explained by the ongoing expansion of the Universe. The photons act like a gas that cools as it expands, causing their energy and wavelength to decrease.

Setterfield has adopted some of these concepts. However, since he doesn't think the Universe is expanding, he tries to explain the redshift by changes in zero point energy (ZPE):

> With a low ZPE, atoms were less energetic, and so their emitted temperature radiation had longer wavelengths than the same temperature has today. In other words, the temperature radiation coming to us from that time has been redshifted…

Setterfield tries to explain the shift in the radiation's blackbody spectrum by invoking changes in the spectra of the emitting atoms. However, he forgets that he is talking about plasma. As Setterfield knows, atoms and ions emit *line radiation*; at certain

* In classical mechanics, the frequency of the emitted light would be exactly equal to the orbital period. The situation is not so simple in quantum mechanics, since the frequency of an emitted photon is determined by the energy difference between the initial and final atomic levels. But we still find the frequency of the emitted light to be of the same order of magnitude as the classical orbital frequency: for the lowest transition of the hydrogen atom, the difference is about 67%. According to the correspondence principle, this difference should go to zero for large quantum numbers (highly excited states). And indeed, when we get to n =10, the difference is only 14%. Even in quantum mechanics, the frequency of emitted light would change if and only if the classically-computed orbital frequency changes.

well-defined, discrete wavelengths that are characteristic of the atomic species in question. But blackbody radiation from a plasma is *continuum radiation*. Its spectral characteristics depend on the temperature of the plasma, but not on the spectra of the constituent atoms and ions. It originates largely from the free electrons, which undergo acceleration and emit light when they interact with ions. These free electrons radiate differently from electrons bound to atoms because their energy is not quantized; it can have any value. Changes in atomic energy levels would not change the wavelength of blackbody radiation from an optically thick plasma. Setterfield's explanation of the cosmic microwave radiation is invalid.

But let's imagine Setterfield is right. He claims that blackbody plasma radiation was redshifted in the past. The redshift factor was 1,981 halfway through the first day of Creation Week. Since a considerable redshift must have persisted for some time after that, we can conclude that during early human history there was a redshift of at least a thousand. Since the Sun is a dense plasma emitting blackbody radiation, we must conclude that solar radiation was also redshifted during early prehistory by at least three orders of magnitude. This would shift most of the Sun's energy emission (in the infrared/visible today) into the microwave part of the spectrum. The Earth would be dark, with almost no visible-wavelength photons available to support photosynthesis. Once again, Setterfield is in conflict with elementary science.

Conclusion

Setterfield says that the arguments I gave in 2007 are "out of date" and "invalid." In fact, they are: I demonstrated that his cosmology was riddled with obvious errors, and he has replaced it with a new version (at least his third, by my counting). Unfortunately, as shown above, his new work is even less coherent than what it replaced. And I stand by my assertion, documented in my 2007 report, that the non-cosmological aspects of the *c*-decay theory are just as invalid.

Unfortunately, he has consistently ignored these criticisms. He has never cited my 2007 report, and his web page has never acknowledged the existence of Bridgman's "Dealing with Creationism in Astronomy" website. He refers to Bridgman and me by name, but generally doesn't let his admirers know where they can learn what we have to say, in our own words.

I really haven't spent much time poring over his new work. I think the criticisms I give here are valid, but they are just the tip of the iceberg, so to speak. I'm sure that someone with more time (and expertise) would find many more problems with Setterfield's claims.

I am frustrated and saddened by my continuing engagement (and lack of reciprocal engagement) with Setterfield. I have no reason to doubt the impression I get from the non-science-oriented material on his web page: that he is a person of deep and sincere religious conviction and high personal standards. Unfortunately, he is also instinctively drawn to crank science. He assumes that astronomers and other mainstream scientists are so self-deluded that they ignore all evidence against their pet theories. And he seems never to doubt that he, virtually alone, has the ability to see clearly what so many others have ignored.

If even some of Setterfield's ideas are correct, he is the greatest scientist in the history of the world. If he is wrong, he has wasted much of his life twisting science into

bizarre forms, motivated by his need for a Universe that will accommodate his Biblical literalism. It's a shame that a man of considerable intelligence and genuine, if quirky, integrity should be in this position.

Whenever he comes up with something new, I try to understand what he's saying. Unraveling his strange derivations can be entertaining, and in the process of evaluating his claims I sometimes learn some interesting new science. But mostly, I'm frustrated by the self-constructed intellectual prisons that he and other creationists live in. Despite the thrill of the chase, in the end it gives me little pleasure to spend my time trying to decipher Setterfield's strange ideas, and telling anyone who will listen how wrong he is.

Acknowldgements

I'm grateful to Tom Bridgman and Mark Kluge for reviewing this document. I also sent a copy to Barry Setterfield, who thanked me respectfully but regretted that he has insufficient time to make any substantial comments on it for the foreseeable future. Therefore, I must post it without knowing whether he accepts any of these criticisms.