The Velocity of Light: Constant Yesterday, Today and Tomorrow

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ABSTRACT

The results of a correctly weighted regression analysis applied to the historic measurements of c, the velocity of light, indicate that c *has not undergone a statistically significant variation in the last 300 years. An examination of Montgomery's latest analysis indicates that due to the application of inappropriate tests and mishandling of the data the results presented are statistically and scientifically unsound.*

What has happened to Barry Setterfield's 'decay in the speed of light' hypothesis? It is now over 13 years since the hypothesis was first proposed[1] and the further developments, that were promised by the original author,[2] have not been forthcoming. It would seem that here the cause has been publicly abandoned. Perhaps this is just as well as the hypothesis has been statistically and scientifically discredited in both creationist and non-creationist literature.[3-8]

A FURTHER WEIGHTED REGRESSION ANALYSIS

Recently an opportunity was presented to subject Montgomery's complete and edited versions[9] of the historic measurements of c to further weighted regression analysis. Each value of c was weighted according to the reciprocal of the square of the standard error. This is the recommended method of dealing with data with such diverse degrees of precision.[10] The importance of this fact cannot be overemphasised. This analysis was performed according to standard statistical procedure using a programme developed by Dr Mark Evered, lecturer in computer science at the University of Ulm, Germany. The application of a weighted degree one, two or three polynomial equation or a weighted exponential equation always resulted in an *F* statistic that did not even approach significance. The *F* statistic is the result of an analysis of variance of the regression and residual sums of squares of each equation. Clearly these results indicate no significant change in c. There is little point in applying polynomial equations of higher degree. These simply result in multiple turning points through the data. While statistically very interesting the results are scientific nonsense if it is suggested that they describe the behaviour of c. The conclusions drawn from this analysis apply whether the analysis is applied to the unedited or edited selection of c measurements. The removal of the 'laser values' from the analysis does not result in statistical significance being obtained. The same remarks apply whether the aberration values are used with or without Montgomery's 95 km/sec 'correction'.

The equations resulting from this analysis were subjected to tests for any autocorrelation of the resulting residuals. All the coefficients of correlation were close to zero, indicating that autocorrelation was not a problem.[11]

Dr Mark Evered was able to provide computer generated graphs of the data complete with error bars. It can be seen from Figures 1A and 1B that for the vast majority of the data points the error bars cross the true value of c, 299792.5 km/sec, indicating no significant difference from that value. **This fact alone casts severe doubt on the Setterfield hypothesis** and the result of the analysis reported here confirms **absolutely** that there has not been a significant variation in *c* during the time over which it has been measured.

MONTGOMERY'S *PIECE DE RESISTANCE*

Montgomery has submitted the edited version of the

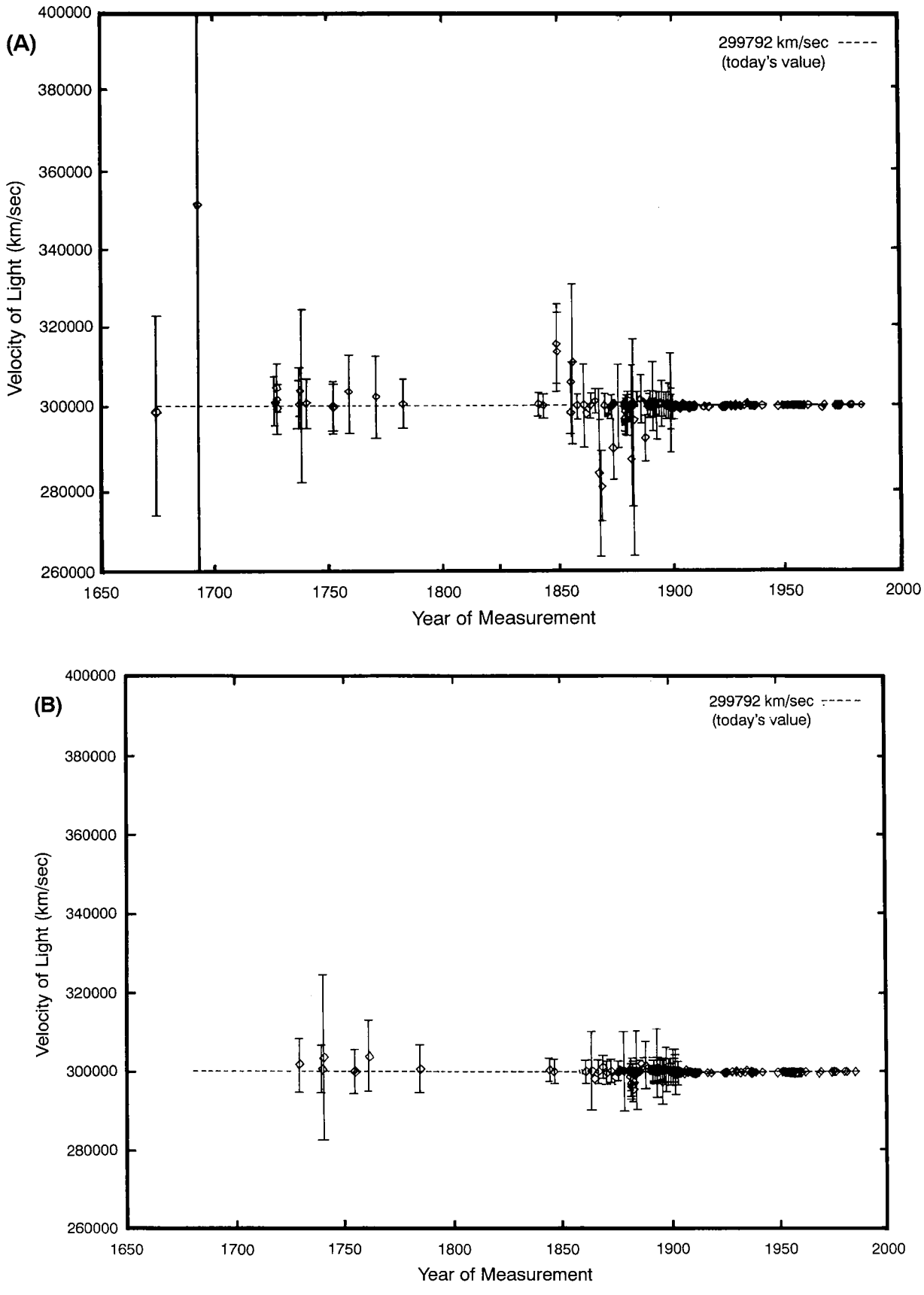

Figure 1. *Unedited* (A) *and edited* (B) *values of* c *versus time of measurement. Note that in both figures the vast majority of error bars cross the true value of* c, *299792.5 km/sec, indicating no significant difference from that value.*

historic measurements of c to regression analysis and to yet another series of *t* tests.[12] Again his results and conclusions are invalid and may be ignored, because the *t* tests utilise unweighted means and are biased by the values of c that have the highest standard errors, and by some measurements to which unjustified corrections have been made. Why, for example, must 95 km/sec be added to values of c estimated by the aberration method? Aberrated starlight reaches the earth via the near perfect vacuum of space with relatively little travel through the atmosphere.[13,14] The section of **Froome and Essen** referenced by Montgomery refers **specifically** to values of *c* measured by the **waves on wires** method. It has nothing to do with aberration. The weighted mean of the historic measurements of c is 299792.5 km/sec whether the edited or unedited list is used and whether or not the laser values of c are included.

As with the *t* tests, so it is with the regression analysis. The method of transforming the data used by Montgomery weights the values of c according to the residual error, not the standard error of measurement, and the latter is the particular component of the total error term that must be used with this type of data.[15] This is made abundantly clear in many statistical texts. There is another consequence when the method of regression advocated by Montgomery is applied to this type of data. The coefficients of the resulting equations are influenced by the points of origin of the X and/or Y axes. Change the point of origin and you can manipulate the predictions of the resulting equation. This method of regression also produces exaggerated estimates of the significance of regression when applied to this sort of data. Any reader with access to a statistical or scientific calculator can easily verify these effects.

The residuals resulting from Montgomery's equation are not randomly distributed; they are in fact significantly skewed, a condition which he has previously not tolerated in the work of others.[16] The regression technique he has used is intended to correct heteroscedasticity, not autocorrelation of residuals which is an altogether different problem. One thing must be made clear. It is customary when discussing autocorrelation of residuals in a time series to refer only to values that are a fixed number of time units apart. Indeed, many text-books actually define autocorrelation thus.[17] The varying time periods between the measurements of c mean that any resulting autocorrelation is very vaguely defined. There is a technique called **generalised least squares** that can correct both heteroscedasticity and autocorrelation.[18] If this is applied to Montgomery's edited listing of the values of *c* the result is a line that has a slight **positive** slope with respect to time (that is, to the year AD) and whose equation is statistically non-significant.

There remains but to make a few miscellaneous comments regarding Montgomery's paper.

(1) Montgomery (and others) have rejected values of *c* measured by the laser method from analysis because the frequency of atomic clocks would vary with changing *c*. Do they not realise that according to Setterfield physics[19] the frequency of the crystal oscillators used in the electronic measurements of *c* would do likewise? This would apply to all oscillators, including the standards against which comparisons are made. How then would you measure a **change** in frequency and hence in c? Time and frequency may have been **defined** in dynamical terms, but they have been **measured** electronically since pre 1947.

(2) Attention has already been drawn to the very high percentage of values of *c*, in both the edited and unedited selections of Montgomery, whose error bars cross the true value of c, 299792.5 km/sec. In Montgomery's regression analysis these values have a profound effect. In an unweighted linear regression performed only on those values of c whose error bars do **not** cross 299792.5 km/sec the slope is 0.45 ±1.15 km/sec/year, not statistically significant. If the method of regression recommended by Montgomery is applied to these values the result is virtually a horizontal straight line through the data, and again statistical significance is not reached. Other writers too[20] have noted the fact that Setterfield and his supporters appear to be unaware of the significance of the errors associated with measurements.

(3) Montgomery has again used the grossly imprecise values of c obtained by the Roemer and aberration methods, despite the fact that

'they (c values obtained by the two aforementioned methods) *are indications that the speed of light is not finite but are far too imprecise to be considered as actual determinations of* c. '[21]

If these grossly imprecise values are used in regression analysis without proper weighting (by the reciprocal of the square of the standard error) they exercise an enormous effect on the resulting equation.

(4) Montgomery continues to include glaring outliers in the data for analysis. This would at least partly account for the non-random residuals. In this case, of course, it does not matter as Montgomery's methods are quite inappropriate for the data under consideration.

(5) Montgomery has derived a quadratic equation to describe the historic measurements of *c*. It is difficult to keep pace with the number of equations that have been presented, each purporting to describe the changes of c with time and with the predictions of each equation very different from all the rest. This one has a turning point in 1967 a d and the predicted value of c rises either side of that year. In 1983, a year in which c was actually **measured** to be 299792.4586 km/sec, the **predicted** value of *c* is 299799 km/sec, in 1990 299808 km/sec and in 2000 299825 km/sec. There are two alternatives:

(a) The conservation of energy is violated.

(b) Atomic clocks start to gain on dynamic clocks, resulting in gross problems for the world's time and navigation standards.

Either way there is an insoluble problem. In claiming that this equation actually describes a change in c itself

Montgomery cannot be serious.

CONCLUSIONS

There is no escaping the fact. There is just no worthwhile evidence that will support the hypothesis that *c* has undergone a decrease or a variation of any kind in the last 300 years. This is despite the fact that Setterfield and his supporters have mishandled the data. If there was even a modicum of supporting evidence one would expect the scientific world to buzz with excitement. It is useless adopting the attitude that this deafening silence is because the hypothesis, if correct, would disturb the world of conventional science. Anyone who has worked in the world of science knows that things do not work that way.

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REFERENCES

1. Setterfield, B., 1981. The velocity of light and the age of the universe — Part 1. **Ex Nihilo, 4**(1):38–48.
2. Setterfield, B., 1989. The atomic constants in light of criticism. **Creation Research Society Quarterly, 25**(4): 190–197.
3. Aardsma, G. E., 1988. Has the speed of light decayed recently? — Part 1. **Creation Research Society Quarterly, 25**(l):36–40.
4. Brown, R. H., 1990. Speed of light statistics. **Creation Research Society Quarterly, 26**(4):142–143.
5. Evered, M. G., 1993. The recent decrease in the velocity of light — what decrease? **CEN Tech. J., 7**(1):93–102.
6. Humphreys, D. R., 1988. Has the speed of light decayed recently? — Paper 2. **Creation Research Society Quarterly, 25**(l):40–45.
7. Osborn, J. C., 1990. Comments on the proposal that the speed of light has varied with time. **EN Tech. J.**, 4:181–185.
8. Keay, C. S. L., 1991. An improper defence of an untenable creationist theory. **The Skeptic, 11**(3):8–11.
9. Montgomery, A., 1994. A determination and analysis of appropriate values of the speed of light to test the Setterfield hypothesis. *In:* **Proceedings of the Third International Conference on Creationism**, Creation Science Fellowship, Pittsburgh, Pennsylvania, in press.
10. Sutcliffe, D. and Landgren, W., 1975. **The Theory and Practice of Statistics**, Collier Publishers, London.
11. Sutcliffe, and Landgren, Ref. 10, p. 244.
12. Montgomery, Ref. 9.
13. Noakes, G. R., 1944. **A Textbook of Light**, McMillan and Company, London, p. 244.
14. Drude, P., 1959. **The Theory of Optics**, Dover Publications, New York, p. 116.
15. Sutcliffe, D. and Landgren, W., Ref. 10, p. 250.
16. Montgomery, A., 1990. Statistical analysis of *c* and related atomic constants. **Creation Research Society Quarterly, 26**(4): 138–142.
17. Sutcliffe and Landgren, Ref. 10, p. 252.
18. Harrison, S. R. and Tamaschke, H. U., 1984. **Applied Statistical Analysis**, Prentice-Hall of Australia.
19. Norman, T. and Setterfield, B., 1987. **The Atomic Constants, Light and Time**. Invited Research Paper for Lambert Dolphin, Santa Clara, California USA.
20. Smith, K., 1986. Creation physics and the speed of light. *In:* **Creationism: An Australian Perspective**, M. W. Bridgstock and K. Smith (eds), 2nd edition, Australian Skeptics, Melbourne, pp. 67–71.
21. Jones, B. and Wilson, P., 1967. **The Principles of Optics**, White and Son, Ltd., Glasgow, p. 144.

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