STATISTICAL ANALYSIS OF C AND RELATED ATOMIC CONSTANTS

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Abstract

The Setterfield thesis that the speed of light (c) has decreased over time is examined from the perspective of Statistical Hypothesis testing. The Student's t test, the Mean Square Successive Difference (MSSD) test and the Run test show strong support for time variance not only for 'c' data but also for c-dependent quantities. No support is found for time variance of c-independent quantities. An examination of statistical work of T. Norman, G. E. Aardsma, D. R. Humphreys, and R. H. Brown reveals some weakness in the statistical supports for their arguments. In addition, some comments are made regarding considerations of Setterfield's theory.

What is Statistical Hypothesis Testing?

Statistical hypothesis testing involves making decisions about a population based on sampling from that population. In particular, it is a technique used to determine the plausibility of some specific statement about the population. The test requires two mutually exclusive hypotheses; H_0: the statement about the population is false (This is the Null Hypothesis) and H_1: the statement is true (This is the Alternative Hypothesis). The null hypothesis is assumed to be true unless the statistics from the sample data force us to accept the alternative hypothesis. This is analogous to a jury who assumes the innocence of the accused until proven guilty. The nature of the hypotheses depends on the nature of the statistic.

As well as hypotheses, a test must also have a critical region for the statistic. If the statistic falls within the critical region, the null hypothesis is considered rejected. The size of this region is determined by the investigator according to his willingness to risk erroneous rejection of the null hypothesis. Typically tabulated are 95%, 99%, 99.9% confidence levels which translate into 5%, 1% and .l% risk of erroneous rejection of the null hypothesis. The values of the statistic associated with these confidence levels for the appropriate size of sample become the critical values beyond which the null hypothesis is rejected. For a more detailed treatment see Bhattacharyya and Johnson, 1977, p. 165. For the purposes of this paper a 95% confidence level is used on a single tail test.

Data Consideration and Statistical Tests

The Setterfield and Norman (1987) report contains nine tables of 'c' data obtained by various methods plus a tenth table of most "reliable" values. It is not within the scope of this paper to examine the credibility of these values as others more competent have done so. Setterfield has reported the results of different reviewers and I am prepared to accept Setterfield's editing of the data until some specific criticism arises.

Aardsma (1988, p. 36) and Humphreys (1988, p. 40) have objected to the earliest values, namely the Roemer and Cassini results. Norman's analysis without these values still shows a significant rate of decrease. My analysis also omits these data.

Aardsma maintains that only analyses using all data should be considered unbiased. However, the elimination of data which is statistically out-of-step with the rest of the data is quite acceptable in making statistical inferences as long as edits are admitted openly. Excluding data which in the opinions of competent authorities is not acceptably accurate is equally valid. While Setterfield edited by the elimination of values rejected by physicists, I have edited the data for 'bad' data (outliers) in a statistical sense. I have removed values which are more than three standard deviations from the sample mean unless there were other similar values nearby. This resulted in eliminating Roemer values 1 and 2 from Setterfield and Norman's Table 1 (1987, p. 12); values 1 and 2 from the tooth wheel method (1987, p. 18); value 1 from the rotating mirror (1987, p. 20) and value 1 from the electrostatic-electromagnetic ratio (1987, p. 30). Four of the six values were higher than 299,792 km/s and so their removal biases against Setterfield's thesis. Also value 1 of the Rydberg table (1987, p. 32) and value 4 of the Gyromagnetic ratio (1987, p. 49) were removed among the c-dependent data. For the Student's t test, the hypotheses are H_0: c is constant at 299,792.458 km/s versus H_1: c is greater than 299,792.458. A rejection of H_0 by this test does not necessarily confirm c time variance as c may be constant but not equal to 299,792.458, or systematic errors may be present. The test does, however, give the opportunity for the data to deny a changing light speed.

The hypotheses for both the MSSD and Run tests are H_0: c is constant versus H_1: c is time dependent. A rejection by the test supports Setterfield directly. Both tests require time sequenced data but only the MSSD requires a normally distributed random variable. Where data is reported in the same year, the values have been averaged into a single value. The data is reasonably close to a normal distribution if one assumes one of the four curves in Table 21 in the Setterfield and Norman report to be valid. More detail about MSSD is available in Lindgren, 1962, p. 330 and Crow, Davis and Maxwell, 1978, p. 63. A description of the Run test can be found in Lindgren, 1962, p. 326 and Draper and Smith, 1966, p. 95.

Discussion of Results

Table I shows the results of all three tests on nine tables of c data. The confidence levels for the Student's t test ranged from 74 to 99%. Only the toothed wheel and the post 1960 results were not rejected at the 95% confidence levels. If one accepts Setterfield's explanation of the post-1960 data is that during the 1960's the experimenters used clocks based on the atomic time standard, then only one table yields results contrary to the Setterfield theory.

The MSSD results ranged from 25% to 99.9%. In fact six of the tables yielded results better than 97.5% confidence level, suggesting trend. The post-1960 results again suggested constancy. The two methods yielding

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Table I. Statistical Test Results for c-Data

	Confidence Level of Test			Agreement with Theory		
Method	T-Test	MSSD	Runs	T-Test	MSSD	Runs
Roemer	98	99.9		Y	Y	—
Bradley	95	99	98	Y	Y	Y
Pulkova		99.8		—	Y	—
Toothed wheel	84	40		N	N	—
Rotating mirror	96	98		Y	Y	—
Kerr cell	2	60		—	N	—
1945-60	99	98		Y	Y	—
1960-83	90	25		Y	Y	
esu/emu ratio	99	99.9	95	Y	Y	Y

Positive Results (Y = Yes, N = No): T-Test 6 of 7; MSSD 7 of 9; Runs 2 of 2; Total 15 of 18.

negative results to the Setterfield theory were the toothed wheel and Kerr Cell methods. The toothed wheel contains the largest percentage of values rejected by the experimenters or other scientific authorities. Kerr Cell has only four data points and contains a systematic error which was later corrected with the geodimeter. The three largest tables—Bradley, EMU/ESU Ratio and 1945-60 all yield strong results in favor of trend. The confidence level of 2% for the Kerr Cell indicates also that c is under the expected value, so much so that the null hypothesis would be rejected under a two tailed test.

The Run test was more limited. In order to obtain reasonable results at least 15 data values should be used. Due to the requirement to average data in the same year only two tables were useful, namely the Bradley and ESU/EMU Ratio tables. The Run statistic on both tables yielded results above 95%. Overall the test statistics rejected c-constancy in 15 of 18 tests and favored trend in 9 of 11. The three statistical tests were also applied to the five c-dependent quantities e/mc, h/e, gyromagnetic ratio, Hall resistance, and m (where e is electron charge, h is Planck's value, m is electron mass) and results are tabulated in Table II. All five confidence levels for the Student's t test were between 93% for electron mass and 99.9% for gyromagnetic ratio. The table for the mass of the electron was obtained from Setterfield's previous work (1983) and appears to be missing all post-1963 values. The confidence level for m should be regarded only as tentative until the post-1963 values are published.

The MSSD test gave results for the five c-dependent quantities from 97.5% to 99.9%, a strong indication of trend for each test. Furthermore each trend is in the direction theoretically predicted by a decline in the value of 'c.' The Run test was applied to four of the five tables. All four tests rejected constancy at the 95% confidence level. The results ranged from 95% to 99.999% for the h/e values, the highest confidence level of any test. The first 10 values of h/e were below the mean and the last 12 values above the mean, a distribution most improbable for a constant with normally distributed error. In total, for c-dependent quantities, 12 of 14 tests reject constancy at the 95% confidence level. Also nine out of nine tests favor time dependent trend in c.

Table II.
Statistical Test Results for c-Dependent Data

	Confidence Level of Test			Agreement with Theory		
Value	T-Test	MSSD	Runs	T-Test	MSSD	Runs
e/mc	99	99	99.9	Y	Y	Y
h/e	99	99.9	99.999	Y	Y	Y
Gyromagnetic Ratio	99.9	97.5	95	Y	Y	Y
Hall Resistance	93	98	—	N	Y	—
Mass of electron	94	99.9	99	N	Y	Y

Positive Results (Y = Yes, N = No): T-Test 3 of 5; MSSD 5 of 5; Runs 4 of 4; Total 12 of 14.

Table III shows the results of the three tests as applied to c-independent constants. The Boltzmann constant and gas constant (R) tables were taken from Setterfield's earlier book (1983). The t test results ranged from 51 to 98% with two values, the Bohr magneton and Boltzmann constant, rejecting constancy at the latest values. These two and the gas constant are tentative until post-1963 data becomes available. The MSSD test ranged from 56 to 89% confidence levels. All five results failed to reject constancy and none of eight indicate a time dependent trend. Out of 45 tests in this paper, 38 or 84% rejected the assumed negation of the Setterfield position. In the MSSD and Run test 18 of 20 tests rejected it. But is this enough? Are some data more important than others?

I consider the Bradley data to be essential because it would be close to impossible to hide a trend with time in such a large amount of data over a period of 150 years. The high accuracy and amount data in the 1945-60 results also make it important. The two c-dependent data sets with the most precise data and longest duration are h/e and e/mc. Without a change in these there is no theory. Of 11 tests conducted on these, all 11 rejected the negation of Setterfield!

Table III.
Statistical Test Results for c-Independent Values

	Confidence Level of Test			Agreement with Theory		
Value	T-Test	MSSD	Runs	T-Test	MSSD	Runs
Charge of electron	56	60	60	Y	Y	Y
Boltzmann Constant	96	56	82	Y	Y	N
Gas Constant	51	89	—	Y	Y	—
Rydberg Constant	65	65	75	Y	Y	Y
Bohr Magneton	98	60	—	N	Y	—

Positive Results (Y = Yes. N = No). T-Test 3 of 5 MSSD 5 of 5. Runs 3 of 3: Total 11 of 13

How important are the seven tests which did not reject the negation of Setterfield? Two of the results in the c-dependent group were within 2% of rejection and therefore are only marginal. Two others are in the c-independent group. But while the t tests cause us to doubt the canonical value of the Boltzmann and Bohr magneton, the MSSD and Run tests do not indicate any trend. The three tests in the 'c' data are the only one's which are of concern. The Kerr cell result is based on only four data points, which is hard to accept in the face of the results in larger data sets. This leaves only the toothed wheel data as counter-indicative of the Setterfield theory. The toothed wheel results are not so easily dismissed. Both the t test and the MSSD are favoring the null hypothesis. In addition the data is not sufficient to do a run test. Although only five of the data are accepted by the experimenters and authorities this is not much help as the MSSD changes little for these five data.

Conclusions

With 15 of 18 results on c-tables and 12 of 14 c-dependent tables indicating a time dependent trend it is reasonable to conclude that 'c' has been decreasing with time. Whether it is continuing today may be open to question. The acceptance of constancy in 11 of 13 tests on c-independent constants strongly confirms that only c-dependent quantities are changing with time.

How coincidental are these predictions? Suppose six of 11 physical quantities were chosen randomly. The odds of choosing the six time-dependent ones would be only 1 in 462. This shows that Setterfield's theory is highly restrictive in its predictions yet exactly accurate in choosing those which the statistical tests indicate as time-dependent. Given a decline in c, the five remaining values are restricted to trend in one direction. Using one-half as the probability of up or down, there is only 1 chance in 32 of choosing the combination required by Setterfield's theory. Together the chances are 1 in almost 15,000. In addition, Setterfield and Norman's Table 24 (1987) on the percentage change per year show that the percentage rate of change of all five time-dependent values are very close to each other and that there is a consistent decline in all rates coincidentally. These tables support the conclusion of a monotonic decline in c with time with covarying c-dependent values. The author cannot think of another factor that would account for all of these coincidences.

Remarks on the Statistical Work of Setterfield and Norman

Although Setterfield and Norman's paper (1987) has much to commend it there are some areas which require improvement. Their analysis uses the least squares regression method, a valid measure of the average rate of decline. However, the use of confidence levels is not strictly valid because, by their own admission, the c-curve is not linear. Even if the c-curve were linear, a check that the residuals are normally distributed is required to justify the use of confidence levels. Since the best fitted c-curves are approximately linear over short time periods some values may still be correct. Their conclusions on radioactive decay are not strong, and they are overstated. A quick comparison of the rates of change in half-lives with all other c-dependent values indicate that they are not coincidental. Some values show change rates 1000 times greater than corresponding 'c' rates. Obviously, other factors, such as low accuracy of results, are at work.

Much of the credibility of the Setterfield and Norman study depends on the explanation of the post-1966 'c' data, that there is no appearance of change in c due to the use of atomic time clocks instead of the standard clocks. This needs clear documentation. Since c-dependent data also have values in that era, it is necessary to specify which time clock is applicable in each experiment. For example, the test statistics for the Hall resistance show change over time. This only supports Setterfield's theory if dynamic time standards are used. Documentation of the timing standard is necessary to validate these results.

Remarks on the Statistical Work of Aardsma, Humphreys and Brown

Aardsma (1987, p. 36) and Humphreys (1987, p. 40) have claimed support for c constancy using a weighted linear analysis. There are two major problems with this claim. First, a weighted linear regression is meaningless if the relationship is not linear, especially when the results have a very low coefficient of determination or poor fit. Before a weighted analysis is done, the residuals of the simpler linear regression should be analyzed. A funnel shaped pattern of residuals indicates that the linear relationship is right but that there is a variation in the standard deviation of the data. This can be adjusted by a weighted linear analysis described in Draper and Smith, 1966, p. 98. The residual on the least squares linear regression actually show a bow shape. Typically, this is indicative of the need for a time dependent polynomial function of degree two as the regression line. The functions in Setterfield and Norman's study (1987, p. 46) including the polynomial show excellent fit to data. The residuals are funnel shaped indicating a weighted regression line on these formulae.

Second, Aardsma has chosen to weight the data by the inverse square of the error bars rather than the number of observations or the inverse variance of the observations. The normal practice would be the inverse of the error bar or one of the other two. His choice results in the worst fit of any method. The residuals of Aardsma's line are badly skewed and he is forced to resort to the "intellectual phase-locking" argument. This says that experimenters prejudice their results to fit results of previously published experiments. No details are given as to how this worked on the Bradley aberration method where the post-1900 results are conspicuously below both today's values and the other values of its day. That this rationalizing of results could affect 163 data collectively and yet go undetected is a strong claim.

The statistical arguments against the Setterfield hypothesis are even weaker than they appear, as they fail to cope with the most powerful of confirming evidence. The c-dependent values, such as m and h, also vary with time in the direction and approximate magnitude of c. Do critics believe "intellectual phase-locking" has occurred not once but six times? Is the direction of this phase-locking merely coincidentally in favor of Setterfield's theory? Is the magnitude of change in percentage per year so close by chance? Is the lack of any intellectual phase-locking in c-independent constants also mere coincidence? The failure to come to grips with this evidence is indeed a major flaw in the criticisms.

Brown (1988, p. 91) also claims that no variance with time can be found. His analysis shows that the data are within two population standard deviations of the sample mean. Since the random variable for the t test is the sample mean of size n, the standard deviation of the sample mean is required rather than that of the population. By confusing these two, he has arrived at a spurious conclusion. The Student's t statistic expressed as

$$t = \frac{x - \mu}{s/\sqrt{n}} \tag{1}$$

and never as

$$t = \frac{\bar{x} - \mu}{\sigma}, \tag{2}$$

where $\bar{x}$ = sample mean, μ = expected value, $s/\sqrt{n}$ = sample standard deviation and σ = population standard deviation. The statistical arguments against Setterfield's hypothesis are unconvincing.

Theoretical Considerations

I avoid the use of the term decay as it suggests loss of energy or organization. None is evident in Setterfield and Norman's paper (1987). The term decrease has been used so as not to lead the reader to premature conclusions. *Is a c decrease viable with respect to energy emission and reception rates in the past?* Higher radioactivity in the past produced more photons per second than today. This is balanced by a lowering in energy density of the individual photons so that collectively a beam of light has the same energy density as a beam today. In the past, however, the energy in the beam would arrive at a faster rate which causes Aardsma (1988) to question whether this would produce unacceptable temperatures. Temperature is dependent on two factors: energy received and the energy emitted per unit time. Since conductivity is proportional to c, matter loses energy faster in the past. It requires more energy transmission in the past to keep matter at the same temperature. In other words increased energy reception is balanced by a proportional increase to energy emission from the receiving object.

Does the decrease in the speed of light cause a redshift? Setterfield suggests that decreasing c causes an increase in energy density and a corresponding increase in E_0, the electrical component of light. This results in a redshift curve where z varies directly with the changes in c. The resulting redshift curve does not fit observed values well and Setterfield must add the additional constraint that the universe is contracting. However, the galaxies themselves are not contracting. Therefore they should exhibit the c decrease redshift without correction for universal contraction. But the required redshift does not fit observations. For example, a star on the galactic perimeter may be 30,000 light years away. Under the cosecant squared formula,

$$c(t)/c_0 = 58 \tag{3}$$

so that z = 57. No such redshift value exists in our galaxy.

I suggest that Setterfield's energy density for photons

$$W(t) = \epsilon_0 E_0^2/8\pi \tag{4}$$

requires an additional factor of $c_0/c(t)$ so that

$$W(t) = \epsilon_0 E_0^2/(8\pi c(t)/c_0) \tag{5}$$

where the additional factor represents the increased volume that the photon travels through at time t. Since at time t, atomic sources give off $c(t)/c_0$ times as many photons per second, a beam of photons will have an energy density of

$$c(t)/c_0 W(t) = \epsilon_0 E_0^2/8\pi \tag{6}$$

i.e. a constant. This would imply no redshifting due to a decrease in c.

Another way of looking at the redshift situation is this: since all photons are traveling at the same speed at the same time it is impossible to change the distance between them by decreasing c alone. This implies no change in wavelength and no redshift. An interesting non-Hubble model for the red shift was proposed by LaViolette (1986). He assumes a static Euclidean universe in which 5-7% of the photon's energy is lost every one billion light years. This model is superior to the Big Bang model in four cosmological tests.

Does c decrease cause a time dilation effect? By time dilation, I mean that the slowing of light causes us to see events in slow motion. Setterfield (1983) used this time dilation effect to explain why changes in redshift were not observable, i.e., why we see them in super slow motion. Consider an event in Andromeda occurring at creation. The light showing this event arrives at the Earth some months later. Today, supposedly 6,000 years later, another event occurs. The light will not arrive here for another two million years! Thus two events 6,000 years apart will not be observed 6,000 years apart but two million years apart. This can only happen if events are seen in slow motion.

For atomic processes at time t, an observer today sees them at $c_0/c(t)$ of the actual rate. But the actual rate is $c(t)/c_0$ times faster than today so that they cancel and are observed at the current rate. For non-atomic processes, however, the observer sees the event at $c_0/c(t)$ of the actual rate. This has two important consequences.

The observation of superluminal velocities cannot be due to a decrease in c. Whatever relationship is observed today also exists at the source at time t in the past. A decrease in c will change the frame of reference but it does not change the relationships. Superluminal velocities still require reconciliation with relativity. It does raise an interesting question. Suppose some quasar had an initial velocity many times the current c_0. What happens as c(t) falls below the velocity?

Secondly, over the course of time the ratio $c_0/c(t)$ will increase causing non-atomic events to appear to increase in speed. Thus, binary stars' motions should appear to increase in velocity and their periods should undergo a corresponding decrease. I suggest that this is a test for Setterfield's theory and a method of establishing fossilized values of c.

Does a c decrease give results compatible to carbon-14 testing? Aardsma (1988) points out that the polynomial of degree 8 does not give reasonable results for carbon-14 dating. However, the cosecant function gives very good agreement, even to objects dated 4000 B.P. Since at least one curve conforms to carbon-14 dating, Setterfield's hypothesis is not refuted. *Does Setterfield's theory contradict gravity?* Setterfield's treatment (1987, p. 44) of gravity is confusing. He identifies Einstein's gravitational tensor

$$\kappa = 8\pi G/c^4 \tag{7}$$

as a constant. This implies that G varies as c^4. He later states that according to observed values of G, they are constant. He uses gravitational permeability to explain the difference between the two. It becomes clearer if one introduces

$$G^* = G\mu^{*2} \tag{8}$$

as the gravitational constant with G as the atomic counterpart. This differentiates the terms for gravity in the same fashion as he has distinguished gravitational mass from atomic rest mass. Then the gravitational force

$$F = \frac{Gm_1m_2}{r^2} = \frac{G^*m_1m_2}{\mu^{*2}r^2} = \frac{G^*M_1M_2}{r^2} \tag{9}$$

where $M = m/\mu^*$ is the microscopic mass, G* is the microscopic gravitational constant and m_1 and G are the corresponding atomic values and vary as $1/c^2$ and $1/c^4$.

Summary

Setterfield and Norman have made a major contribution to science and creationism. They are to be commended for their perseverance in compiling, analyzing and documenting an enormous quantity of data from many different sources. Although the report needs additional information on time-clocks used in various tables and a more cohesive explanation of gravity, it contains a wealth of data to support the hypothesis that c is time dependent. The statistical evidence provided here unequivocally supports the Setterfield hypothesis and its consequences to c-dependent physical values. Critics have been unable to establish a major point of refutation. Humphreys' suggestion that Setterfield should provide a statistically oriented report to establish the basic hypothesis and follow it with another on the geological, physical and astronomical consequences in a later report is still valid. There remains much theory to settle once the statistical justification is solidly established.

I am indebted and grateful to Stephen Cheesman for clarifying many of the issues involving energy density, wave amplitude and time dilation. I would also like to thank Lambert Dolphin for his encouraging words.

References

CRSQ—Creation Research Society Quarterly

Aardsma, G. E. 1988. Has the speed of light decayed recently? —paper 1. *CRSQ* 25:36-40.

Bhattacharyya, G. and R. Johnson. 1977. Statistical concepts and methods. John Wiley and Sons. New York.

Brown, R. H. 1988. Statistical analysis of "The atomic constants, light and time" *CRSQ* 25:91-95.

Crow, E. L., F. A. Davis-and M. W. Maxwell. 1978. Statistics. Coles Publishing. Toronto.

Draper, N. S. and H. Smith. 1966. Applied regression analysis. John Wiley and Sons. New York.

Humphreys, D. R. 1988. Has the speed of light decayed recently? —paper 2. *CRSQ* 25:40-45.

LaViolette, P. A. 1986. Is the universe really expanding *Astrophysical Journal* 301:544.

Lindgren, B. W. 1962. Statistical theory. Macmillan. New York.

Setterfield, B. 1983. The velocity of light and the age of the universe. Creation Science Association. Adelaide, Australia.

Setterfield, B. and T. Norman. 1987. The atomic constants, light and time. Flinders University. Adelaide, Australia.

SPEED OF LIGHT STATISTICS

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Abstract

This is a response to the Alan Montgomery article (CRSQ 26:138-42), and also a supplement to my earlier article (Brown, 1988).

The academic community is deeply indebted to Trevor Norman and Barry Setterfield (1987) for the information regarding the propagation speed of electromagnetic radiation which they have brought together and made conveniently accessible. They and others who share a similar commitment deserve particular commendation for effort to establish an uncompromising and sound coordination between the testimony of Scripture and information which comes under the classifications of natural science.

Readers who wish to get a complete perspective on the Montgomery manuscript, and the issues it treats, should carefully reread the earlier Aardsma (1988), Humphreys (1988) and Brown (1988) manuscripts. The conclusions from an analysis such as that presented by Norman and Setterfield, or by Montgomery, must be kept subject to a rigid evaluation of the applicability of the technique employed. The papers by Aardsma and Humphreys clearly indicate that Norman, Setterfield, and Montgomery have reached unwarranted conclusions. Figure 1 in each of these papers gives adequate support for an assertion that within the available experimental data there is *no* evidence for a significant change in the propagation speed of electromagnetic radiation. Any claim that such change has occurred is a purely theoretical or philosophical proposition, regardless of the mathematical adornment with which it is presented.

Before becoming aware of the analyses made by Aardsma and Humphreys, I had prepared for private distribution an evaluation of the Norman and Setterfield report. When my analysis was published as part of the symposium on the speed of light, I was certain that some readers who had strong reasons for proposing a major decline in the speed of light would object to my handling of the square root of n factor (Brown, 1989). My position in that analysis was to advocate only views which were consistent with a sound unbiased data evaluation such as may readily be made from the Aardsma and Humphreys Figure 1 plots.

I thank Alan Montgomery for the impetus to share a statistical treatment which I had considered including with my 1988 feature. This is a regression confidence limits analysis of the data from which the Aardsma and Humphreys Figure 1 plots were made. In my data set I use the corrected Roemer value, as discussed by Humphreys (1988) and I omit the Cassini value on the basis of the evidence that it is in need of correction, but adequate information with which to make a reliable correction is lacking (Humphreys, 1988). Any analysis of 163 data points that is *critically* affected by discarding any one point is not a sound analysis. In statistical analysis of data it is standard practice to discard outlyers as far removed from the data trend as is the Cassini value—a practice which is justified as long as such outlyers are rare, their rejection is acknowledged, and can be defended.

During the time that was available to me for preparation of this response, I did not have access to computer facilities that were capable of plotting a regression analysis for the entire data set as a unit. Because

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