‡1 Fabricated Transit Data by Abram Robertson

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A Robertson's Data

A1 Pages from the 1811-1812 observing books of Abram Robertson, then director of Oxford University's Radcliffe Observatory, were copied and sent to me by C. A. Murray (1991) of the Royal Greenwich Observatory with permission from the Royal Astronomical Society's Manuscripts Division. The observations are transit-times[2] recorded with a five-wire telescopic instrument at Oxford, where Robertson's predecessor, Rev. Thos. Hornsby, had previously established an excellent observing record (including what is now our best set of early post-discovery observations of Uranus).

A2 All the data from two consecutive pages (covering about three weeks) of Robertson's 1811 January transit-times are listed here in the left-hand section of Table 1 (next two pages), transcribed exactly as they appear in the notebook, with superscripts added for clarity. (A few obvious, harmless scribal errors are put in italics.) Each row represents the data (ideally for all 5 wires) of a transiting object. The timeminutes and timeseconds are generally listed for all wires; the hours are listed for the middle (3rd) wire only. Sometimes the timings are listed to an integral number of seconds of time ("xx"); sometimes they are listed to a half second of time ("xx.5") or a tenth second of time ("xx.x"); and occasionally the 2nd or 4th wire is listed to one-quarter or three-quarters of a second of time ("xx.25" or "xx.75").

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[1] [Note by DR.] Myles Standish is prime author of the internationally renowned solar, lunar, & planetary tables of the *Astronomical Almanac*, published annually by the US Naval Observatory and the Royal Greenwich Observatory. A recent Chair of the American Astronomical Society's Division on Dynamical Astronomy, Standish is one of the most deservedly admired of astronomers, both for his accomplishments and for his concern for organized science's maintenance of high scholarly and ethical standards.

[2] Astronomers have used transit circles at least since Timocharis (Alexandria, early 3rd century BC), to take advantage of the fact that spherical astronomy becomes simple arithmetic on the meridian (the celestial great circle containing the Earth's poles and the observer's zenith-nadir axis). "Transit" means literally crossing that meridian. The objects Robertson observed in transit were mostly stars (predominantly bright ones), but also included solar & lunar limbs, and planet-centers.

Table 1: Abram Robertson's 1811 January Transit Data and Wire-Sums

Day	Wire 1	Wire 2	Middle Wire	Wire 4	Wire 5		1+5	2+4	2·Mid
6	$2^m54^s.6$	$18^s.3$	$19^h\ 3^m41^s.8$	$4^m\ 5^s.3$	$28^s.7$	*	$23^s.3$	$23^s.6$	$23^s.6$
	5^m16^s	$39^s.4$	$19^h\ 6^m\ 2^s.9$	$26^s.5$	50^s	*	6^s	$5^s.9$	$5^s.8$
	7^m17^s	30^s	$2^h\ 7^m53^s$	8^m16^s	39^s	*	56^s	46^s	46^s
	49^m45^s	$50^m\ 8^s$	$2^h50^m31^s$	54^s	51^m17^s		2^s	2^s	2^s
	$25^s.5$	25^m48^s	$4^h26^m11^s$	34^s	57^s	*	$22^s.5$	22^s	22^s
7	34^m50^s	35^m21^s	$20^h35^m52^s$	23^s	36^m54^s		44^s	44^s	44^s
	9^s	32^s	$4^h25^m55^s.5$	26^m18^s	41^s	*	50^s	50^s	$51^s.0$
	$31^s.5$	3^s	$5^h\ 2^m35^s$	$3^m\ 6^s$	37^s	*	$8^s.5$	9^s	10^s
	21^s	46^s	$5^h14^m11^s$	36^s	$15^m\ 1^s$		22^s	22^s	22^s
8	53^m24^s	$48^s.5$	$22^h54^m13^s$	$37^s.5$	$55^m\ 2^s$		26^s	$26^s.0$	26^s
11	15^m43^s	17^m57^s	$2^h20^m\ 9^s$	22^m25^s	24^m41^s	*	24^s	22^s	18^s
	$10^m\ 2^s$	$24^s.75$	$4^h10^m47^s.5$	$11^m10^s.75$	11^m33^s	*	35^s	$35^s.50$	$35^s.0$
	15^m37^s		$4^h16^m23^s$		$17^m\ 9^s$		46^s		46^s
	$23^m\ 4^s$	$26^s.75$	$4^h23^m49^s.5$	$24^m12^s.25$	35^s		39^s	$39^s.00$	$39^s.0$
	12^m15^s	$40^s.25$	$5^h13^m\ 5^s.5$	$30^s.75$	56^s		11^s	$11^s.00$	$11^s.0$
13	$27^m50^s.5$	$28^m18^s.5$	$18^h28^m46^s.5$	$29^m14^s.5$	$42^s.5$		$33^s.0$	$33^s.0$	$33^s.0$
	$33^m27^s.8$	$51^s.5$	$19^h34^m15^s.3$	$39^s.1$	$35^m\ 2^s.8$		$30^s.6$	$30^s.6$	$30^s.6$
	35^m48^s	$36^m11^s.7$	$19^h36^m35^s.5$	$59^s.3$	37^m23^s		11^s	$11^s.0$	$11^s.0$
15	26^m15^s	26^m43^s	$18^h27^m11^s$	27^m39^s	$28^m\ 7^s$		22^s	22^s	22^s
	$51^m25^s.5$	50^s	$22^h52^m14^s$	39^s	$53^m\ 4^s$	*	$29^s.5$	29^s	28^s
	$14^m58^s.6$	$15^m20^s.7$	$2^h15^m42^s.8$	$16^m\ 4^s.9$	27^s		$25^s.6$	$25^s.6$	$25^s.6$
	$21^m\ 3^s.8$	$30^s.1$	$2^h21^m56^s.4$	$22^m22^s.7$	49^s		$52^s.8$	$52^s.8$	$52^s.8$
	$37^m32^s.4$	$56^s.8$	$2^h38^m21^s.2$	$45^s.6$	39^m10^s		$42^s.4$	$42^s.4$	$42^s.4$
	$44^m\ 4^s.2$	$26^s.4$	$2^h44^m48^s.6$	$45^m10^s.8$	33^s		$37^s.2$	$37^s.2$	$37^s.2$
	23^s	56^s	$3^h\ 8^m29^s$	$9^m\ 2^s$	35^s		58^s	58^s	58^s
	$13^m33^s.4$	$56^s.3$	$3^h14^m19^s.2$	$42^s.1$	$15^m\ 5^s$		$38^s.4$	$38^s.4$	$38^s.4$
	$20^m52^s.3$	$21^m14^s.6$	$3^h21^m36^s.9$	$59^s.2$	$22^m21^s.5$		$13^s.8$	$13^s.8$	$13^s.8$
	$57^m32^s.1$	$58^m\ 5^s.2$	$3^h58^m38^s.3$	$59^m11^s.4$	$44^s.5$		$16^s.6$	$16^s.6$	$16^s.6$
	5^m52^s	6^m15^s	$4^h\ 6^m38^s$	$7^m\ 1^s$	24^s		16^s	16^s	16^s
	21^m54^s	22^m17^s	$4^h22^m40^s$	$23^m\ 3^s$	26^s		20^s	20^s	20^s
16	48^m23^s	$48^m58^s.5$	$17^h49^m34^s$	$50^m\ 9^s.5$	45^s		8^s	$8^s.0$	8^s
	18^m31^s	$18^m54^s.5$	$19^h46^m18^s$	$46^m41^s.5$	$47^m\ 5^s$		36^s	$36^s.0$	36^s
	47^m51^s	$48^m14^s.5$	$19^h48^m38^s$	$49^m\ 1^s.5$	25^s		16^s	$16^s.0$	16^s
17	16^s	$\mathit{3}^m39^s$	$4^h\ 6^m\ 2^s$	25^s	48^s		4^s	4^s	4^s
	13^m49^s	14^m12^s	$4^h14^m35^s$	14^m58^s	15^m21^s		10^s	10^s	10^s
	21^m18^s	21^m41^s	$4^h22^m\ 4^s$	22^m27^s	22^m50^s		8^s	8^s	8^s
	25^m31^s	$26^m\ 1^s$	$4^h26^m31^s$	$27^m\ 1^s$	27^m31^s		2^s	2^s	2^s
	$17^s.4$	$38^m44^s.8$	$4^h39^m12^s.2$	$34^m39^s.6$	$35^m\ 7^s$		$24^s.4$	$24^s.4$	$24^s.4$
	41^m49^s	42^m15^s	$4^h42^m41^s$	$43^m\ 7^s$	33^s		22^s	22^s	22^s
	47^m44^s	48^m19^s	$4^h48^m54^s$	49^m29^s	$50^m\ 4^s$		48^s	48^s	48^s
	$8^m59^s.5$	$9^m24^s.75$	$5^h\ 9^m50^s$	$10^m15^s.25$	$40^s.5$		$40^s.0$	$40^s.00$	40^s
	$\mathit{18}^m56^s.6$	$38^m19^s.2$	$5^h38^m41^s.8$	$39^m\ 4^s.4$	27^s		$23^s.6$	$23^s.6$	$23^s.6$
18	$28^s.5$	52^s	$19^h54^m15^s.5$	54^m39^s	$55^m\ 2^s.5$		$31^s.0$	31^s	$31^s.0$
	48^s	$56^m11^s.5$	$19^h56^m35^s$	$56^m58^s.5$	57^m22^s		10^s	$10^s.0$	10^s
	$0^m\ 6^s.8$	$29^s.6$	$6^h\ 0^m52^s.4$	$1^m15^s.2$	38^s		$44^s.8$	$44^s.8$	$44^s.8$
19	59^m27^s	$50^s.5$	$20^h\ 0^m14^s$	$0^m37^s.5$	$1^m\ 1^s$		28^s	$28^s.0$	28^s
	1^m46^s	$2^m\ 9^s.5$	$20^h\ 2^m33^s$	$2^m56^s.5$	3^m20^s		6^s	$6^s.0$	6^s
	11^m13^s	11^m46^s	$3^h12^m19^s$	12^m52^s	13^m25^s		38^s	38^s	38^s

Table 1: Abram Robertson's 1811 January Transit Data and Wire-Sums

Day	Wire 1	Wire 2	Middle Wire	Wire 4	Wire 5		1+5	2+4	2·Mid
	29^m51^s	30^m23^s	$3^h30^m55^s$	31^m27^s	31^m59^s		50^s	50^s	50^s
	47^m14^s	47^m41^s	$3^h48^m\ 8^s$	48^m35^s	$49^m\ 2^s$		16^s	16^s	16^s
	25^m42^s	$26^m\ 5^s$	$4^h26^m28^s$	26^m51^s	27^m14^s		56^s	56^s	56^s
	$49^m42^s.8$	$50^m11^s.6$	$4^h50^m40^s.4$	$51^m\ 9^s.2$	51^m38^s		$20^s.8$	$20^s.8$	$20^s.8$
	59^m13^s	35^s	$4^h59^m57^s$	0^m19^s	0^m41^s		54^s	54^s	54^s
	$12^m21^s.4$	49^s	$5^h13^m16^s.6$	$44^s.2$	$14^m11^s.8$		$33^s.2$	$33^s.2$	$33^s.2$
	$28^m35^s.9$	$29^m\ 0^s.3$	$5^h29^m24^s.7$	$49^s.1$	$30^m13^s.5$		$49^s.4$	$49^s.4$	$49^s.4$
	$40^m38^s.4$	$41^m\ 5^s$	$6^h41^m31^s.6$	$58^s.2$	$42^m24^s.8$		$3^s.2$	$3^s.2$	$3^s.2$
20	24^s	$47^s.2$	$20^h\ 7^m10^s.4$	$7^m33^s.6$	$7^m56^s.8$		$20^s.8$	$20^s.8$	$20^s.8$
	$8^m43^s.8$	$9^m\ 7^s$	$20^h\ 9^m30^s.2$	$9^m53^s.4$	$10^m16^s.6$		$0^s.4$	$0^s.4$	$0^s.4$
	29^m34^s	$30^m\ 6^s.2$	$3^h30^m38^s.4$	$31^m10^s.6$	$31^m42^s.8$		$16^s.8$	$16^s.8$	$16^s.8$
	46^m55^s	47^m22^s	$3^h47^m49^s$	48^m16^s	43^s		38^s	38^s	38^s
	$17^m53^s.6$	$18^m17^s.2$	$4^h18^m40^s.8$	$19^m\ 4^s.4$	28^s		$21^s.6$	$21^s.6$	$21^s.6$
	$25^m25^s.8$	25^m48^s	$4^h26^m11^s.8$	$\mathit{34}^m34^s.8$	26^m57^s	*	$22^s.8$	$22^s.8$	$23^s.6$
	48^m31^s	$49^m\ 1^s.25$	$4^h49^m31^s.5$	$50^m\ 1^s.75$	32^s		3^s	$3^s.00$	$3^s.0$
	58^m55^s	59^m17^s	$4^h59^m39^s$	$0^m\ 1^s$	23^s		18^s	18^s	18^s
	2^m50^s	3^m21^s	$5^h\ 3^m52^s$	4^m23^s	54^s		44^s	44^s	44^s
	14^m36^s	$15^m\ 1^s$	$5^h15^m26^s$	51^s	16^m16^s		52^s	52^s	52^s
	$36^m36^s.7$	$0^s.9$	$5^h37^m25^s.1$	$49^s.3$	$38^m13^s.5$		$50^s.2$	$50^s.2$	$50^s.2$
	45^m18^s	40^s	$5^h46^m\ 2^s$	24^s	46^s		4^s	4^s	4^s
21	46^m35^s	$47^m\ 3^s$	$2^h47^m31^s$	59^s	48^m27^s		2^s	2^s	2^s
	52^m34^s	52^m56^s	$2^h53^m18^s$	53^m40^s	$54^m\ 2^s$		36^s	36^s	36^s
	10^m37^s	11^m10^s	$3^h11^m43^s$	12^m16^s	49^s		26^s	26^s	26^s
	16^m58^s	$17^{\mathit{m}}20^s$	$3^h17^m42^s$	$18^m\ 4^s$	26^s		24^s	24^s	24^s
	31^m28^s	31^m51^s	$3^h32^m14^s$	37^s	$33^m\ 0^s$		28^s	28^s	28^s
	$25^m\ 8^s$	31^s	$4^h25^m54^s$	17^s	26^m40^s		48^s	48^s	48^s
	47^m14^s	48^m44^s	$4^h49^m14^s$	49^m44^s	50^m14^s		28^s	28^s	28^s
	58^m38^s	$59^m\ 0^s$	$4^h59^m22^s$	59^m44^s	$0^m\ 6^s$		44^s	44^s	44^s
	6^m31^s	6^m53^s	$5^h\ 7^m15^s$	7^m37^s	59^s		30^s	30^s	30^s
	14^m19^s	14^m44^s	$5^h15^m09^s$	15^m34^s	15^m59^s		18^s	18^s	18^s
	26^m41^s	$27^m\ 3^s$	$5^h27^m25^s$	27^m47^s	$28^m\ 9^s$		50^s	50^s	50^s
	$45^m\ 0^s$	45^m22^s	$5^h45^m44^s$	$46^m\ 6^s$	46^m28^s		28^s	28^s	28^s
24	$22^m\ 7^s$	30^s	$20^h22^m53^s$	23^m16^s	39^s		46^s	46^s	46^s
	24^m25^s	48^s	$20^h25^m11^s$	34^s	57^s		22^s	22^s	22^s
25	5^m33^s	$55^s.5$	$3^h\ 6^m18^s$	$40^s.5$	$7^m\ 3^s$		36^s	$36^s.0$	36^s
	$28^m\ 6^s$	28^m38^s	$3^h29^m10^s$	29^m42^s	30^m14^s		20^s	20^s	20^s
	$51^m\ 3^s.4$	$51^m37^s.6$	$3^h52^m11^s.4$	$52^m45^s.2$	53^m19^s	*	$22^s.4$	$28^s.8$	$28^s.8$
	1^m33^s	1^m55^s	$4^h\ 2^m17^s$	2^m39^s	$3^m\ 1^s$		34^s	34^s	34^s
	22^m17^s	22^m46^s	$4^h23^m15^s$	23^m44^s	24^m13^s		30^s	30^s	30^s
	$13^m\ 8^s$	13^m33^s	$5^h13^m58^s$	14^m23^s	48^s		56^s	56^s	56^s
27	50^m45^s	$51^m\ 7^s$	$2^h51^m29^s$	51^m51^s	52^m13^s		58^s	58^s	58^s
	$54^m\ 1^s$	$54^m29^s.5$	$2^h54^m58^s$	$55^m26^s.5$	55^m55^s		56^s	$56^s.0$	56^s
	4^m58^s	$5^m20^s.5$	$3^h\ 5^m43^s$	$6^m\ 5^s.5$	6^m28^s		26^s	$26^s.0$	26^s
	$7^m49^s.8$	$8^m22^s.8$	$3^h\ 8^m55^s.8$	$9^m28^s.8$	$10^m\ 1^s.8$		$51^s.6$	$51^s.6$	$51^s.6$
	$27^m29^s.4$	$28^m\ 2^s$	$3^h28^m34^s$	$29^m\ 6^s.3$	$29^m38^s.5$	*	$7^s.9$	$8^s.3$	8^s
	$40^m28^s.5$	$40^m54^s.1$	$3^h41^m19^s.7$	$41^m45^s.3$	$42^m10^s.9$		$39^s.4$	$39^s.4$	$39^s.4$
	50^m48^s	$51^m11^s.7$	$3^h52^m35^s.4$	$52^m59^s.1$	$53^m22^s.8$		$10^s.8$	$10^s.8$	$10^s.8$
	30^m31^s	30^m55^s	$6^h31^m19^s$	31^m43^s	$32^m\ 7^s$		38^s	38^s	38^s

B A Startling Symmetry

B1 For the initial analysis, I wondered if it would be sufficient to use only the reading from the central wire, since, after all, the average of the times for the 2nd and 4th wires should be approximately equal to the middle wire time, and similarly for the 1st and 5th wires. Upon testing this hypothesis, I found that, Lo and Behold: these averages were not *approximately* equal; instead, for a great majority of the stars, they were **exactly** equal!
B2 The right-hand section of Table 1 shows (in successive columns): the 1st & 5th wires' sum ("1+5"), the 2nd & 4th wires' sum ("2+4"), & the center wire doubled ("2·Mid"). All sums are expressed modulo 60 and are printed to the same precision with which the individual wires were recorded by Robertson. An asterisk indicates those few cases where the three sums are *not* all exactly equal. Note also that in every case where the 2nd wire is listed as "xx.25" or "xx.75", the 4th wire is also listed as "xx.25" or "xx.75".

C Explaining the Mystery: Fabrication Established

C1 Can it possibly be that Robertson's observations are accurate below the level of 0.1 timeseconds? The answer is no. I have modelled Robertson's observations using a more detailed analysis which determined corrections to each individual star position and to each night's clock readings. After taking account of all of these factors, I found that the mean error of a single observation was more than a half a timesec. Such inaccuracy is not remarkable for observations of that era, though it should be noted that the mean error of Lalande's earlier star-transit data (published in 1801) is less than half Robertson's.
C2 Is there another explanation for the artificial symmetry of Robertson's data? Occasionally, astronomers produce predictions of observations: using present knowledge, they predict the future result of some observation. (Galileo did this with the satellites of Jupiter in order to demonstrate the ability to predict the satellites' positions in advance.) However, in Robertson's notebook there appear notes in the right-hand margin: "High wind" and "small flying clouds during the time of these observations"; also, instances are noted where it is written, "After this observation I put the Clock forward 2' ". Clearly, this was not a prediction notebook.
C3 Is there any other possible explanation for the remarkable agreement? Yes, sadly, there is. The observations were not honestly recorded; they were fabricated. For what reason, I don't know.

Appended Comments by DR

D Reconstructing Robertson's Methods

D1 It is statistically self-evident that Table 1 cannot be purely the result of real empirical observations. Assuming that some of the Robertson wire-data are genuine, he evidently filled in numerous gaps in an embarrassingly intermittent[3] record (or adjusted a nearly full set of real, perhaps unsatisfactory data)[4] largely by extrapolation and-or interpolation, which could be accomplished by grade-school arithmetic, using wire-intervals found either empirically (eqs. 1&2) or from a list (of such intervals) kept for the purpose (§F).
D2 E.g., if $w2$ was missing, he could just empirically interpolate:

$$w2 = (w1 + w3)/2 \tag{1}$$

Or, in case $w1$ was wanting, he could empirically extrapolate:

$$w1 = 2 \cdot w2 - w3 \tag{2}$$

D3 By chaining such elementary means, it would be possible also to create $w4$&$w5$. Thus, for any star, Robertson could observe-record merely two wire-times and quickly manufacture the other three. For that star, this would force all three sums (right-hand side of Table 1) to be equal — and force all four inter-wire intervals to be equal. So this explanation is consistent with well over 80% of the Table 1 data set. (However, another explanation will work for numerous data here, as we will see below at §F.)

E Hints of Fabrication

E1 Standish notes (§B2) that all the $1^s/4$ and $3^s/4$ endings occur strictly for the 2nd and 4th wires. A similarly peculiar pattern: of the ten suspect stars where all the wire-times are alternately integral and half-integral, nine (90%) have $w2$&$w4$ with the half-timesec ending while $w1$&$w3$&$w5$ are integral. Both statistical asymmetries are what we expect when data are being interpolated[5] instead of observed. Assuming the central wire was observed for most 1811 stars, the asymmetries suggest (but do not prove) application of eq. 1 to a pair of non-adjacent, usually integral wire-data ($w1$&$w3$ or $w3$&$w5$). However, these 15 stars reflect but a minority of the whole sample. So it may be that Robertson customarily fabricated by extrapolation (eq. 2) — that is, if he built a star's five-wire record from merely two wire-data (§D3), the two wires were usually adjacent. (E.g., $w2$&$w3$ or $w3$&$w4$ or such.) One possible motive for such selectivity will soon (§E5) become evident.

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[3] The final rendition is so full that, for 95 of the 96 stars of Table 1, Robertson provides times for all five wires. The sole exceptions occur on 1811/1/11, when: [a] Only $w5$ was recorded for that evening's 1st star (Hamal), and the hour & minute were missed, so the record is not entered in Table 1. [b] For the star 78 Tau (miscalled 79 Tau), only $w1$, $w3$, & $w5$ were recorded.

[4] A possible alternate theory: Robertson usually took all 5 wire-times, but the original data showed so much random scatter that he later "tidied up" the record — and way overfaked it. For circumstances in favor of this theory, see §E8 & fn 27. Also: there is no overlap of any of the stars' 5-wire time-sets. (I.e., if the observer intended to take only $w2$&$w3$ for a star, then he might go on to another star right away — and thus might inadvertently create temporal overlap of the two stars' eventual 5-wire sets of data.) But no such overlaps appear in Table 1. However, there are other explanations for this.

[5] But there is a suggestion of at-least-temporary use of an interval-list (§F) in the fact that, in Table 1, two of the five cases of quarter-timesec intervals are for the same star: β Tau (1811/1/11 & 1/17) — and the interval is identical: $25^s 1/4$. (By contrast, the correct interval by eq. 6 is 25^s.) Another explanation for the β Tau data: only 3 wire-times were observed (see also §F10), say, $w1$&$w5$ on 1/11 and $w3$ on 1/17 (all integral) — and the other 7 data were then fabricated via eqs. 1&2, adopting the 1/11 interval for 1/17.

E2 There are (see Table 1) more than 20 perfect-symmetry cases involving wire-times ending in timesec-tenths. Now, if Robertson were using eq. 1 as often as eq. 2 we would expect a sizable fraction of these cases to create data ending in timesec-twentieths. Yet not one does so — a highly unlikely coincidence. This again (as with §E1) is consistent with preferential use of adjacent wire-data — which obviates the need for eq. 1. (Possible alternate explanation: §F.)

E3 However, we recall that §E1's 15 cases suggested that eq. 1 was used on occasion. So why is there a complete lack (§E2) of endings in timesec-twentieths (which would occur for about half of all tenth-timesec-precision data when eq. 1 was used)? The answer, of course, is that such claimed precision would be incredible on its face. (See §E5.)

E4 In exploring this matter, we first note that even for the dozen asterisked cases (where all three sums aren't equal), most of the stars show equality for two of the three sums. (See right-hand side of Table 1.) This points the way to a few realizations about the asterisked stars: [a] Some of the inequalities may just be from scribal or arithmetical errors. [b] Some may be stars for which 4 or 3 wires (not just two) were observed, so that only 1 or 2 wire-data (not three) needed to be faked to flesh out the apparent record.

E5 For the 2[nd] star of Table 1 (where none of the 3 wire-sums are exactly equal), we may wonder how likely it is that $w2$ = $5^{\mathrm{m}}39^{\mathrm{s}}.4$ would accidentally agree with interpolation (from eq. 1) within $0^{\mathrm{s}}.05$. Ignoring hours, we have

$$(w1 + w3)/2 = (5^{\mathrm{m}}16^{\mathrm{s}} + 6^{\mathrm{m}}02^{\mathrm{s}}.9)/2 = 5^{\mathrm{m}}39^{\mathrm{s}}.45 \qquad (3)$$

And the same star's $w4$ = $6^{\mathrm{m}}26^{\mathrm{s}}.5$ also agrees with interpolation, to the same amazing precision; proceeding analogously to eq. 1 or eq. 3:

$$(w3 + w5)/2 = (6^{\mathrm{m}}02^{\mathrm{s}}.9 + 6^{\mathrm{m}}50^{\mathrm{s}})/2 = 6^{\mathrm{m}}26^{\mathrm{s}}.45 \qquad (4)$$

These coincidences both occur in a data-set whose standard deviation is an ordmag larger (§C1). It is more reasonable to suppose that $w1$&$w3$&$w5$ were observed and $w2$&$w4$ fabricated therefrom via eq. 1 — but both results had to be rounded[6] (to timesec-tenths) when the computed figures exhibited the ridiculous precision of $0^{\mathrm{s}}.05$. Perhaps such uncomfortable experiences nudged Robertson to prefer *adjacent* wire-pair data (§F5) whenever taking tenth-timesec data — thereby avoiding the halving process (eq. 1) that caused the need for rounding.

E6 Curiously, one of the weirdest instances (where it appears that 1/20th timesec was shaved off data) occurs for an *un*asterisked case. The 1811/1/13 solar limb wire-time sets are both preternaturally symmetric: for both limbs, the 3 wire-sums are identical (thus the lack of asterisk in Table 1) — this despite the fact that (in both cases) the intervals are not quite uniform! Again, the most likely explanation: this is a case in which (at least) $w2$&$w4$ were created by interpolation (as in eqs. 3&4) — but the former was then diminished by 1/20th of a timesec, while the latter[7] was identically enhanced. (Indeed, for the 2[nd] limb data, it appears that, instead of writing the endings as "xx.75" & "xx.25", Robertson simply rounded[8] to "xx.7" & "xx.3".) He thereby neatly ensured that, for both limbs, all 3 wire-sums would be identical. Thus, computation of the mean transit time (w_{m}: eq. 5) here was childsplay[9] — circularity required that w_{m} was just equal to $w3$.

[6]When Ptolemy indoor-calculated his allegedly-outdoor 1025-star catalog, he confronted a similar overprecision problem. His sly solution (discovered by the genius of the late Robert Newton) is explained at *DIO 4.1* ‡3 §C1 and independently confirmed in detail elsewhere in the same article.

[7]Note that the former-vs-latter situation is the same for both limbs' data.

[8]By 1812, Robertson was recording "xx.7" for virtually all cases where he formerly would have written "xx .75".

[9]Which was the prime intent of these fabrications. See §G5.

E7 As for §E4's proposal that some asterisked data are slips: suggestive instances are not hard to find. E.g., for the 3[rd] star in Table 1, $w1$ = $7^{\mathrm{m}}17^{\mathrm{s}}$ looks like a tens-place miswrite (or miscalculation) for $w1$ = $7^{\mathrm{m}}07^{\mathrm{s}}$. And, for the 2[nd] star of 1811/1/11, $w4$ = $11^{\mathrm{m}}10^{\mathrm{s}}3/4$ may be another slip. (The correct mean of $w3$&$w5$ is $11^{\mathrm{m}}10^{\mathrm{s}}1/4$.)

E8 An independent bit of evidence of data-wrenching: on the handwritten record, the three 1811/1/11 entries involving 1/4 timesec precision are plainly peculiar. The ".25" and ".75" are visibly scrunched (the figures smaller than normal), in five out of the six renderings. It is obvious to the eye that each of these endings was jammed-into the appropriate space only after the integer portion of the data had been entered. (See §F4 & fn 4.) The handwriting looks like Robertson's.

E9 Speaking of the entire 1811 January record: it is remarkable that such a data-set ever got into the record of an eminent observatory. Could any astronomer have expected the data of the 4[th] star of 1811/1/27 to be believed? (*All five* of its wire-times end in eight-tenths of a timesec.) And, though the frequency of fabrication declines after 1811 January, we find just as incredible a 5-wire set of data atop the record for 1812/4/18:[10] all five times end in nine-tenths of a timesec. And two stars later, all five times end in seven-tenths of a timesec. (Same for the last star of 1812/4/21.)

E10 The 1812 Spring records include a column explicitly reducing all wire-times to a middle-wire mean time, w_{m}. If all five wire-times are taken, then

$$w_{\mathrm{m}} = (w1 + w2 + w3 + w4 + w5)/5 \qquad (5)$$

E11 But, for an asymmetic set, it is not so simple. An example is the two-limb solar record for 1812/4/20. For the 1[st] limb, $w1$&$w2$ were not recorded, and $w3$ = $1^{\mathrm{h}}52^{\mathrm{m}}49^{\mathrm{s}}$, $w4$ = $[53^{\mathrm{m}}]11^{\mathrm{s}}.5$, $w5$ = $53^{\mathrm{m}}33^{\mathrm{s}}.5$. For the 2[nd] limb, $w1$ = $54^{\mathrm{m}}15^{\mathrm{s}}$, $w2$ = $[54^{\mathrm{m}}]37^{\mathrm{s}}.5$, $w3$ = $1^{\mathrm{h}}55^{\mathrm{m}}0^{\mathrm{s}}$, $w4$ = $[55^{\mathrm{m}}]22^{\mathrm{s}}.5$, $w5$ = $56^{\mathrm{m}}45^{\mathrm{s}}$. (The precisely-uniform-interval 2[nd] limb data look fleshed-out by the same fabrication-approach as the 1811 January data.) Reconstructing: Robertson, using a $22^{\mathrm{s}}.5$ interval (from 2[nd] limb data or eq. 6), reduces the 1[st] limb's $w4$&$w5$ to the middle wire (i.e., subtracts $22^{\mathrm{s}}.5$ from $w4$ & 45^{s} from $w5$), and averages these to find w_{m} = $52^{\mathrm{m}}48^{\mathrm{s}}.83$. (All the data in his record are rounded to hundredths of arcsec.) This he averages with the 2[nd] limb w_{m}, 55^{m}, to find solar-center w_{m} = $53^{\mathrm{m}}54^{\mathrm{s}}.415$, which (rounding as usual) he writes as $53^{\mathrm{m}}54^{\mathrm{s}}.41$. This is an at-least-partly-proper record. But the whole procedure illustrates how his awareness of intervals was used in arriving at such means. (Robertson used the means to check his sidereal clock's rate.)

F One Wire-Time Per Star? — Using a List of Wire-Intervals

F1 Though empirical extrapolation-interpolation is a possible solution of the suspicious Robertson data, there is another simple explanation that can also account for many of the fabrications (e.g., §G4), namely: Robertson had at hand (or in memory, at least in part) a list providing the mean inter-wire time-intervals t for bright stars — or, simply a table[11] providing t for, say, every degree of δ. Since the equatorial wire-interval t_{o} was about[12] 22^{s}, he could compute any star's wire-interval t_{o} from its declination δ via the simple equation:

$$t = t_{\mathrm{o}}/cos\delta \qquad (6)$$

[10] A few days later: we find Regulus' $w2$&$w5$ wire-times are identical (ending in $24^{\mathrm{s}}.7$ and $31^{\mathrm{s}}.7$, resp) for 1812/4/21&22, which is slightly odd. (Regulus' $w1$&$w4$ wire-times are not the same; $w3$ data are not recorded for either day.) And, nearby in this record, three out of the four repeated wire-times for ϵ Leo (precision half-timesec) are identical for 1812/4/19&20.

[11]In his *Histoire Céleste*, Lalande provides just such a table of computed wire-intervals, arranged for zenith distance — but, of course (see his p.576), computed from declination (as in our eq. 6).

[12]To compute his stars' intervals t, Robertson seems to have used either 22^{s} or $21^{\mathrm{s}}.8$ as t_{o} in eq. 6.

F2 Thus, he could easily (in just a few seconds) flesh out a full five-wire display for any familiar star, after taking but a *single* wire-time: merely by forming integral multiples of t and adding them to (or subtracting them from) the sole real wire-time. (In the long term, this technique would not be so simple for non-stellar objects, whose δ — and thus t — will not in general stay effectively-fixed for years[13] on end.) We will (by contrast to §D2) call this: non-empirical extrapolation. (Meaning that the interval t is computed or assumed[14] not observed.) In this connection, one notices that (in the Oxford 1811 record), some bright stars' wire-time-intervals t are frequently identical from night to night. E.g., α Tau $23^{\rm s}$, β Tau $25^{\rm s}$, α Lyr $28^{\rm s}$, β Gem $25^{\rm s}$, α Gem $26^{\rm s}$, α Per $33^{\rm s}$, δ Per $32^{\rm s}$ or $32^{\rm s}1/4$,[15] α CMa $23^{\rm s}$, α CMi $22^{\rm s}$, α Aur $31^{\rm s}$ or $31^{\rm s}.2$. (The data for Castor & Pollux exhibit particularly uniform spacing in 1811. And, though their data for 1812/5/3 are irregular, the only value for $w_{\rm m}$ computed there is slightly erroneous, due to quick&dirty use of the same[16] old $25^{\rm s}$ Pollux interval: see §F9.)

F3 Below (§G14), we will see large-scale evidence against the one-wire-time theory. Other, smaller problems with it follow here.

F4 On 1811/1/11, α Tau and β Tau were expressed to $1^{\rm s}/4$ precision ($t = 22^{\rm s}3/4$ & $25^{\rm s}1/4$, resp), though the real t in each case was actually near-integral ($23^{\rm s}$ & $25^{\rm s}$, resp). Thus, the 1811/1/11 record suggests empirical interpolation (eq. 1), not the use of §F2's list. Note that this is the very night where we find physical evidence of fudging: §E8.

F5 And use of a list seems unlikely to explain the case[17] of ϵ Aur (magn 3.0), where we find at least three variants for t: $30^{\rm s}$ (1811/1/21 & 1/29, etc), $30^{\rm s}1/4$ (1811/1/20), and $30^{\rm s}1/2$ (1811/2/13). (Since δ was $43°46'$, the real t was about $30^{\rm s}1/2$.) There is a provocative implication here: in a five-wire set, a variation of $1^{\rm s}/2$ in t will entail a discrepancy of $2^{\rm s}$ in the quantity $w5 - w1$. Such an error is too large for real 5-wire transit-observations. (The least ambiguous indication is that ϵ Aur could not have been on the list of major-star intervals hypothesized at §F.) But it could easily happen to someone estimating (to crude fractions of timesec) a single interval of *adjacent* w (see §E5) — and then fabricating all the other wire-times. This appears to have repeatedly occurred for ϵ Aur. (At §G, we will find confirmation of the suspicion that such fabrication was indeed a regular occurrence in this record.)

F6 In early 1811, the interval t for Jupiter's center[18] was $22^{\rm s}.9$. Either the fabricator kept this figure at his side, or, on 1811/2/1, he opportunistically used the t already adopted for the 1811/1/15 Jupiter record.

F7 Indeed, the very same day (1811/2/1), he also used the same $t = 22^{\rm s}.9$, for all eight intervals of his 5-wire observations of both limbs of the Sun (which happened to be near Jupiter's declination). Similar artificiality in solar observations appears in the data (all 5-wire sets, for both limbs: see Table 1) for 1811/1/16, 18, & 19, where *all twenty-four intervals* are identical at $t = 23^{\rm s}.5$. (There are no solar data for 1/17.)

F8 The 1812/5/8 observation of α Gem is a curious hybrid,[19] based on two wire-times: instead of interpolating, Robertson (or whoever) simply extrapolated (using his standard $26^{\rm s}$ interval for α Gem) from each of the two observed w. Result: $w1 = 23^{\rm m}14^{\rm s}.5$, $w2 = 23^{\rm m}40^{\rm s}.5$, $w3 = 7^{\rm h}24^{\rm m}6^{\rm s}.7$, $w4 = 24^{\rm m}32^{\rm s}.7$, $w5 = 24^{\rm m}58^{\rm s}.7$.

[13] But days are another matter. Especially for the outer planets: see §F6.

[14] A clear example at §F10.

[15] There is a $1^{\rm s}$ arithmetic slip for $w5$ on 1811/1/29.

[16] The 5-wire Pollux record of 1812/2/13 is in perfect accord with the same $t = 25^{\rm s}$, despite "High Wind". The Gemini twins' regularity may have a partly empirical cause: eq. 6 yields Pollux $25^{\rm s}.0$, Castor $26^{\rm s}.0$.

[17] A less flagrant example is 137 Tau: constant interval $22^{\rm d}.6$ on 1811/1/18, vs. $22^{\rm d}.8$ on 1811/2/2. Small difference — but large implication: t was not based on a pre-listed interval for this star.

[18] On 1811/1/15 and 2/1, all four intervals t for Jupiter's *center* are $22^{\rm s}.9$. Since Jupiter's width is several time-secs, this is quite an implicit precision-claim!

[19] The β Gem data of 1811/1/14 are probably a similar set.

F9 On 1812/5/3, we find the data for β Gem (Pollux): $w1 = [7^{\rm h}]34^{\rm m}27^{\rm s}.5$, $w2 = 34^{\rm m}52^{\rm s}.7$, $w3$ omitted,[20] $w4 = 35^{\rm m}42^{\rm s}.7$, $w5$ = "clouds". Robertson's computed $w_{\rm m}$: $[7^{\rm h}35^{\rm m}]\ 17^{\rm s}.7$. Here it seems that $w1$&$w2$ were real, and he may simply have computed both $w4$ and $w_{\rm m}$ by adding appropriate multiples of the usual (§F2) $25^{\rm s}$ onto $w2$.

F10 The opportunism cited at §F6 reaches an artful pinnacle with the solar observations of 1811/2/16. First limb: $w1 = 56^{\rm m}29^{\rm s}.2$, $w2 = 56^{\rm m}53^{\rm s}.2$, $w3 = 21^{\rm h}57^{\rm m}15^{\rm s}.2$, $w4$ & $w5$ omitted.[21] Second limb: $w1 = 58^{\rm m}42^{\rm s}$, $w2 = 59^{\rm m}6^{\rm s}$, $w3 = 21^{\rm h}59^{\rm m}28^{\rm s}$, $w4 = 59^{\rm m}50^{\rm s}$, $w5 = [22^{\rm h}]0^{\rm m}12^{\rm s}$. With solar δ at about $-12°1/2$, we know (from eq. 6) that the real t was $22^{\rm s}1/2$. A reasonable reconstruction of the fabricator's work here requires only three real observations (similar to fn 5): if we assume he meant to get $w1$ & $w5$ of both limbs but missed $w5$ for limb 1 (due to wind: fn 21), then he got: $w1$ of the 1st limb, and $w1$ & $w5$ of the 2nd limb. (All three are in fact quite accurate.) The fabricator then, so near the equator, sloppily set t equal to the equatorial $t_{\rm o} = 22^{\rm s}$. Next, he non-empirically[22] extrapolated by subtracting multiples of t from $w5$. (Since he was fabricating by using a value for t that was a half-timesec low, the gap between $w2$ and $w1$ ended up quite wrong: $24^{\rm s}$.) Finally, he found the difference between[23] the two limbs' $w1$ to be $2^{\rm m}12^{\rm s}.8$ and subtracted that from the 2nd limb's $w2$ and $w3$ to get the corresponding wire-times for the 1st limb. The theory accounts for both these bizarre data-sets, in which (if we do not acknowledge fabrication here), we must believe that the observer found all intervals equal to $22^{\rm s}$ except the first, which instead was $24^{\rm s}$, that is, $2^{\rm s}$ greater. Unlikely enough even in isolation; but the ultimate peculiarity is that the weirdly exaggerated $24^{\rm s}$ interval occurred identically for both limbs (to the tenth of a timesec) — *and* at the same wire-interval (the first: $w2 - w1$). Not remotely credible.

G Detailed Proof of Computational Fabrication

G1 Up to this point, we couldn't be sure whether data were being smooth-fudged or outright fabricated. But two stars in Taurus will now settle the question: 25η Tau (Alcyone, in the Pleiades) and 125 Tau.

G2 Our search for evidence that would answer the §G1 question was a good bet to get results, because humans are fallible; thus, we have yet another[24] application of statistical common-sense to this case: no one who bluffs on a large scale (whether an individual, or a bluffia-clique) can escape making the occasional muff that reveals the truth. (See, e.g., the case of Ptolemy, whose published[25] observations — on which his theories were fraudulently[26] founded — were massively faked. Some of his most amusing giveaway pratfalls are revealed at ‡5 §B5 [below], and at *DIO 1.1* ‡6 §H5 and fn 37.)

G3 The 5.2 magn star 125 Tau was observed on consecutive nights, 1811/1/28&29. Its δ was $25°47'$, so (eq. 6) actual $t = 24^{\rm s}1/2$. And on 1/28, all 4 intervals (between wire-times) are just that amount. But, the next night (1/29), all 4 intervals are equal to $25^{\rm s}1/2$: $w1 = 26^{\rm m}14^{\rm s}$, $w2 = 26^{\rm m}39^{\rm s}.5$, $w3 = 5^{\rm h}27^{\rm m}5^{\rm s}$, $w4 = 27^{\rm m}30^{\rm s}.5$, $w5 = 27^{\rm m}56^{\rm s}$. Since Robertson wrote a "5" over the last digit (altering $w5$ by $-1^{\rm s}$), the final record shows errors of $+2^{\rm s}$ in both $w4$ and $w5$. Because $w2$ is about accurate, it appears that a $1^{\rm s}$ error in $w1$ or $w3$ caused

[20] This is one of a number of 1812 cases where unrecorded $w3$ would be identical to recorded $w_{\rm m}$.

[21] "High wind" is noted beside the 1811/2/16 solar data.

[22] See §F2.

[23] Grabbing off previous data is also evident at fn 10.

[24] See also §D & §E.

[25] Another point in Oxford's favor: Robertson did not publish his fabrications.

[26] I.e., Ptolemy pretended that his "observations" proved his theories, when in truth the observations were computed *from* the theory. See, e.g., R.Newton *Crime of Claudius Ptolemy* (Johns Hopkins Univ 1977) or here at ‡5 §B5. For modern mass-pretense, see above at News Notes fn 2.

the other wire-times to be calculated by false extrapolation, whose error of course ballooned to 2^s or more for the last two wires. In real observations, such errors are ludicrously unlikely to occur for two consecutive wires.

G4 As for Alcyone (magn = 2.9), it was observed 1811/1/28 & 2/1. On both occasions, the fabricator faked most of the wire-times, using $t = 23^s$ — perhaps borrowing the interval of Alcyone's fellow-Bullstar, Aldebaran. However, Aldebaran's δ was $16°07'$, while Alcyone's δ was $23°31'$, so (by eq. 6) Alcyone's actual $t = 24^s$. Therefore, both these Alcyone records contain *perfectly* systematic errors in $w5 - w1$, amounting to *four timesec*. On each night the observer could have recorded only one wire-time (say, $w3$) and later fabricated the other four wire-times (using $t = 24^s$). Thus, the consistent falsity of the Alcyone data is neatly explained by the 5-wires-from-1 hypothesis of §F. Though, 5-from-2 (via eq. 2) works as well (assuming Alcyone $t = 24^s$ was a 2-wire empirical accident one night, copied therefrom the other night — to fatten the latter's 1-wire record). But, regardless of the precise method of indoor invention, the critical point here is that, when two consecutive recordings of Alcyone *both* involve rigidly uniform systematic errors that entail 4^s errors in $w5 - w1$, then: we know to a certainty that most of these data are fabricated.

G5 The bottom line here appears to be pretty elementary: whoever doctored the Oxford transit data realized that, the fewer wires he was actually using in his computations (and-or the more symmetric his wire-time data became via fudging or fabrication), the less time & computational labor would be required to [a] observe them, and [b] to reduce them — all while [c] leaving a busy-looking data-record. So he leaned in the direction of streamlining, neatness, and simplicity.

G6 The Robertson record as we now have it is a copy[27] of prior raw-data records. (Which leaves open the possibility[28] that he was not the fabricator. However, alot of suspect data appear to be in his hand, and the pages are all signed by him, as observatory-director. So he — at the very least — bears the responsibility for lending his name & Oxford's to patently incredible data-sets: §E9.)

G7 Realization of this non-primary nature of the record led me momentarily into a merciful hope of explaining the fabrications as part of an innocent calculational checking-scheme, carried out to help ensure correct reduction. However, sobriety soon set in: that theory cannot explain why all but ordmag 1% of the Table 1 stars displayed all 5 wires' times. There must have been plenty of cases where two symmetric wire-times were obtained ($w2$&$w4$ or $w1$&$w5$): in these instances, checking one's math would not require filling out a full 5-wire record. (This was done for show, presumably to fool employers.)

G8 I.e., there is no way around Standish's conclusion that the record is at least a heavily doctored one. Indeed, in such a suspicious context, the fact that the extant record is but a copy raises the question of what the original looked like: Was it sparse? Or full, but as-yet unsmoothed?

G9 Regardless, the party (or parties) responsible kept up the pretense for many months. His methods were as various as opportunistic, e.g., §D2, §F, and fn 23. But the purpose appears to be common: doing less work while pretending to more.

G10 However, though the foregoing several examinations of fabrication show that the 1811 January record contains dishonest elements, they also imply (§D3) that: [a] At least a substantial fraction of the data are real. [b] Fudging or smoothing did not (§§G13-G14) result in huge disagreement with real positions.

G11 A passing comment on "fudging": fudging real data may be less reprehensible than fabricating data outright. (Though, there is unambiguous evidence of the latter recourse here: see §F5 & §G.) But in one sense the two crimes are the same; after all, if one is forcing a datum, then: *to what value is it being made equal*? A fabricated one. (Or, in other arenas, a plagiarized[29] one.) We occasionally need to be explicitly reminded of the common truth implicit in such cases.

G12 **An ancient error-theory lesson.** The latter point in §G10 reminds one of the case of the 2nd most remote transit observer known to us, Aristyllos, a conscientious and able astronomer, who observed (presumably in Alexandria) c.260 BC[30] and who (perhaps out of caution at his data's seemingly meaningless slight inconstancy) rounded[31] all his reduced stellar declinations (of which only six survive: *Almajest* 7.3) to quarter-degree precision. Upshot: Aristyllos (whose accuracy was perhaps the ancients' best — *DIO 1.2* fn 126) is the only empirical astronomer all of whose extant data are correct. Which sounds like a compliment — until one realizes the ironic consequence of the very perfectionism which caused both the accuracy and the smoothing: he lowered the ultimate value of his hard-earned data (inadvertently degrading the precise accuracy of their mean and its standard deviation), by over-rounding them so conservatively.

G13 Returning to point [b] in §G10, we have a little mitigation of Robertson's misbehavior: his fabrications are unlike the very many[32] of Ptolemy or the very few[33] of Tycho, in that the fudging is not betrayed by large[34] departures from reality (other than statistical).

G14 Though the case of Alcyone (§G4) suggests (without proving) that the fabricator used the 5-wire-times-out-of-1-wire-time method (§F) on occasion, the previous point (§G13) poses a difficulty (even aside from fn 17) with proposing it as a common method for all the 1811 stars, namely: there seem to be approximately zero Oxford stars that are out of place by serious amounts of time. Probable explanation: taking at least two transit data provides a check against large blunders in time; so, the virtual nonexistence of such is consistent with there generally having been multiple real wire-times per star.

G15 Thus — though [a] padding is awful science, and [b] the stars' mean accuracy is not impressive[35] — still, these transit data are (in a technical sense) not entirely valueless.

G16 On the other hand: given the availability of other observatories' entirely real raw transit data from the same era, one may doubt whether anyone today would wish to use the fudge-neatened Robertson transit material.

G17 Bottom line: there's no patient that doctoring kills deader than empirical data.

[27] In the 1811/2/13 record, Robertson accidentally skipped the 5-wire record for Capella and wrote down the 5-wire record for β Tau before realizing his omission. He then scratched out the β Tau data and wrote Capella's on the next line, and β Tau's on the line following. Such a sequence could not have happened were the record being made in real time. (The same slip occurs in the 1811/1/29 record, for ϵ Aur [temporarily skipped] and 125 Tau [first entry scratched].)

[28] Standish has wondered if this transit work was funded on a per-star basis. Whether or not Robertson was paid (rigidly) so, the general theory seems reasonable. Also, if an underling was doing the actual observing, payment per full-wire-set could help explain the creation of this odd record. If Robertson was the padder (§E8), he was probably doing other work simultaneously and was understandably bored with transit observing. I.e., he should have delegated it (as Flamsteed sometimes did, and [*DIO 2.3* ‡7 fn 1] J.Lalande did entirely) — & later checked output. But all these are feeble excuses. The immortal theorist Bessel did lots of dull transit work, yet the drone-nature of it did not lead him to fake data.

[29] See *DIO 1.3* §N15, and *DIO 2.1* ‡2 §H14 [bracketed].

[30] Rawlins 1991W fn 126; Rawlins 1994L §§F7&9, Table 3.

[31] Perhaps he or others took slight discrepancies between his results and Timocharis' data (c.300 BC: fn 30) as reflecting on his abilities. Did timidity cost Aristyllos the discovery of precession? By contrast, his contemporary Aristarchos distinguished between the sidereal & tropical years (*DIO 1.1* ‡1 fn 25, ‡6 fn 1), which implies recognition of precession in the 3rd century BC.

[32] E.g., ‡5 fn 16 & fn 17.

[33] *DIO 2.1* ‡4 Tables 1&2.

[34] The errors noted at §F5 & §G are statistically excessive but not great in timesec.

[35] See §C1. Note: in a typical five-wire data-set here, we do not usually know which w are-is real.