XIV. *An Inquiry into the Quantity and Direction of the proper Motion of* Arcturus; *with some Remarks on the Diminution of the Obliquity of the Ecliptic: By* Thomas Hornsby, *M. A.* Savilian *Professor of Astronomy in the University of* Oxford, *and F. R. S.*

Read Dec. 24, 1772.

AS an accurate knowledge of the *position of the fixed stars* is of the greatest importance, being the basis and foundation of astronomy, it is no wonder that the astronomers of different nations have given great attention to this matter. By comparing *antient* with the best *modern observations*, it appears that some of the fixed stars have a *proper motion*, independent of any motion hitherto known in our own system; or that, in other words, the *angular distances of the fixed stars have not always continued the same*, and in some of them the alteration is so very considerable as to be easily perceived in the course of *a few years*, with instruments accurately made, and nicely adjusted. Of all the stars visible in our hemisphere, the *variation* in the place of *Arcturus is the most remarkable*, and such as cannot possibly be attributed to the uncertainty of observation. It has accordingly been taken no-

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tice of by many aſtronomers: in particular, Dr. *Halley* mentions it in N° 355 of the Philoſophical Tranſactions: Mr. *Caſſini*, in the Memoirs of the Academy of Sciences for 1738, p. 231, has ſhewn, that there is a variation of *five minutes* in the latitude of that ſtar between his own time and that of Tycho, in an interval of a *century and a half*: and M. le *Monnier*, in the Memoirs of the Academy of Sciences for 1767, p. 417, proves, that the *latitude* of Arcturus varies at the rate of *two ſeconds* every *year*; and that the *longitude* decreaſes at the rate of 60″ in a hundred years *. But as an *inquiry* as well into the true *quantity* as into the *direction* of this motion has not hitherto been made public, I propoſe to give ſome account of my own obſervations made expreſsly with this view in the years 1767 and 1768, with a tranſit inſtrument of 44 inches, and a moveable mural quadrant of 33 inches, both conſtructed by Mr. Bird, and of the concluſions reſulting from a compariſon between them and ſome obſervations made by Mr. Flamſteed in 1690.

It may perhaps be objected, that the differences of right aſcenſion, as determined by Mr. Flamſteed's mural inſtrument, are not to be depended upon from the very nature of his inſtrument. Mr. Flamſteed was himſelf too good an obſerver not to be aware of this; and accordingly in the Prolegomena to the third volume of the *Hiſtoria Cœleſtis*, p. 132, he informs us in what manner he determined the error of

* See alſo the Memoirs of the Academy of Sciences for 1769, p. 21. See alſo Aſtronomiæ Fundamenta, by the Abbé de la Caille; who, in reducing his obſervations of Arcturus, ſuppoſes the annual motion of declination in that ſtar ≐ 19″,0. p. 169, and 187.

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the plane at different diſtances from the zenith. By diſtributing theſe errors in the beſt manner I could, I am of opinion, that the error of the plane of his inſtrument may be ſuppoſed to decreaſe uniformly at the rate of half a ſecond in time for every degree of zenith diſtance from 28° to 60°, the error being 39″ at the former, and 23″ at the latter, by which quantity ſtars paſſed the horary wire, in his inſtrument, before they came to the true meridian. It ſhould ſeem alſo that the error continued nearly the ſame from 60 to 75 degrees, being at the latter only 22″: but that it decreaſed irregularly from 75° to 85°, viz. 1″ in time for each degree from 75° to 80°, and 0″,4 for each degree from 80° to 85 degrees. The mural arc was fixed upon a ſtone pier, the ſouthern part of which was found to ſettle yearly, from whence the error of the line of collimation to the ſouth neceſſarily became every ſucceſſive year greater and greater. As Mr. Flamſteed ſeems not to have had any method of adjuſting his inſtrument by a plumb-line, theſe errors muſt have been irregular at different ſeaſons of the ſame year, and were perhaps never truly determined. But as the obſervations here referred to were made on the ſame day, and within the compaſs of an hour, they are probably not affected with this latter error. We are at preſent concerned with the difference of two zenith diſtances, and not with the abſolute quantity of thoſe zenith diſtances. The concluſions may indeed be affected with an error in the diviſions; and from the examination which I have been able to make, I am of opinion that the arc of Mr. Flamſteed's inſtrument was not of the proper quantity; and that, though the obſervations

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generally erred in defect, they in some parts erred in excess.

On the 14th of February, 1690, Mr. Flamsteed observed, that a small star, of the seventh or eighth magnitude, whose place is not determined in the British catalogue, and which star was named by him *Infra Arcturum*, preceded Arcturus three seconds in time, or 3″,3, when an allowance is made for the error of the plane of the instrument = 0′ 42″, 6, and was 26′ 30″ to the south of Arcturus *. By a mean of eight observations made at Oxford, on and near June the 10th, 1767, with the transit instrument, and with a refracting telescope of eight feet, furnished with a micrometer; the difference of right ascension was 1′, 8″,75 of a degree, the star following Arcturus; and by a mean of three observations, the extremes differing only 3″, the small star was 23′ 55″,0 to the south of Arcturus.

The right ascension of Arcturus and the small star being nearly the same, the change in declination ought to be so likewise. But, from the observed difference in declination, the right ascension of the two stars must vary unequally, though with a very small difference. Accordingly it appears from computation (in which the annual precession is supposed = 50″,35, the obliquity of the ecliptic at the middle of the interval of the time = 23° 28′ 30″, and the right ascensions and declinations of the two stars taken at a mean between the times of observation) that the variation of Arcturus in right ascension was 3270″,6, and of the small star 3277″,6 in

* This is the only observation of that star made by Mr. Flamsteed.

77,287 years. Therefore the right aſcenſion of Arcturus alters leſs than that of the ſtar; and conſequently Arcturus ſhould in 1767 have followed the ſtar by 42″,6. But the ſtar was obſerved to follow Arcturus by 1′ 8″,75. The right aſcenſion therefore of Arcturus has increaſed leſs than that of the ſtar, or Arcturus has moved weſtward 1′ 51″,35 in 77,287 years; and has gone ſouthward 2′ 35″ in the ſame time, ſuppoſing the ſmall ſtar not to have moved, which is highly probable.

On the ſame day the difference of right aſcenſion in time between the ſtar η Bootis and Arcturus was 21′ 32″ of mean ſolar time, = 5° 24′ 02″,2, when a proper allowance is made for the going of the clock, and for the error of the plane of the inſtrument; and the difference of declination was 50′ 45″,6, when an allowance is made for refraction. On the 24th, 26th, and 29th of May, and the 9th of June, of the year 1768, I determined the difference in right aſcenſion to be 21′ 27″ of ſidereal time by the two former obſervations, and 21′ 26¾″ by the two latter, the difference in declination being 49′ 48″,7, by a mean of the obſervations in May, the extremes differing only four ſeconds. It appears from computation, that between the times of obſervation the variation of η Bootis in right aſcenſion was 3371″,7, and 1417″,3, in declination; of Arcturus 3311″,7 in right aſcenſion, and 1347″,9 in declination: The difference of variation in right aſcenſion is 1′ 0″, and of declination 1′ 9″,4; by the former the difference in right aſcenſion was diminiſhed, and in declination increaſed by the latter, agreeably to the places of the two ſtars. The difference in right aſcenſion

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therefore in 1768, if neither of the ſtars had moved, ſhould have been = 5° 23′ 02″,2, and 51′ 55″ in declination; but they were obſerved to be 5° 21′ 43″,4, and 49′ 48″,7. Arcturus therefore by this obſervation has in 78,257 years gone 1′ 18″,8 to the weſt, and 2′ 06″,3 to the ſouth, ſuppoſing η Bootis not to have any proper motion.

On the 5th of April, 1691, the difference in right aſcenſion between η Bootis and Arcturus was 21′ 33″ of mean ſolar time, = 5° 24′ 14″,0; and the difference of declination 50′ 45″,6, as in the preceding example. The difference of variation in right aſcenſion is 59″,1, and in declination 1′ 8″,4. The difference of right aſcenſion therefore at the latter end of May, 1768, ſhould have been 5° 23′ 14″,9, and 51′ 54″,0 in declination; but, according to obſervation, they were 5° 21′ 43″,4, and 49′ 48″,7. Arcturus therefore, according to this obſervation, has moved 1′ 31″,5 to the weſt, and 2′ 05″,3 to the ſouth in 77,120 years.

On the 4th of May, 1691, the difference of right aſcenſion between η Bootis and Arcturus was 21′33″ of mean ſolar time, = 5° 24′ 14″,3 when allowance is made for the going of the clock and the error of the plane of the inſtrument, and the difference of declination on the 3d of May = 50′ 50″,6. According to computation, thoſe differences ſhould have been 5° 23′ 15″,2 and 51′ 59″,0 reſpectively; but they were obſerved to be 5° 21′ 43″,4, and 49′ 48″,7. Arcturus therefore in 77,071 years has moved 1′ 31″,8 weſtward, and 2′ 10″,3 ſouthward. N. B. The zenith-diſtance of Arcturus, as

as determined by Mr. Flamſteed, on the 4th of May, is manifeſtly erroneous.

On the 27th of May, 1692, η Bootis preceded Arcturus in right aſcenſion by 21′ 32″,5 of mean ſolar time, = 5° 24′ 10″,1, the difference of declination being 50′ 50″,6. In 75,978 years the difference of right aſcenſion ſhould have been 5° 23′ 11″,8 and 51′ 58″,0 in declination; but thoſe differences were obſerved to be 5° 21′ 43″,4 and 49′48″,7. Arcturus therefore has moved 1′28″,4 weſtward, and 2′ 09″,3 ſouthward.

On the 27th of May, 1692, Arcturus preceded π Bootis in right aſcenſion by 24′ 35″,5 of mean ſolar time, = 6° 9′ 32″,2, when an allowance is made for the going of the clock and the error of the plane of the inſtrument, the difference of declination being 3° 2′ 28″,9. On the 24th and 26th of May, and 5th of June, 1768, the difference of right aſcenſion between the ſame ſtars obſerved at Oxford was 24′ 44″,58 of ſidereal time, = 6° 11′ 9″,1, the difference of declination being 2° 58′ 24″,2. In 1768, the difference of right aſcenſion ſhould have been 2″,7 greater, = 6° 9′ 34″,9; and the difference of declination 1′ 31″,7 leſs, = 3° 0′ 57″,2. But they were obſerved to be 6° 11′ 9″,1, and 2° 58′ 24″,2. Arcturus therefore in 75,978 years has, by a compariſon with this ſtar, moved 1′ 34″,2 weſtward, and 2′ 33″,0 ſouthward.

Again, the difference of declination between Arcturus and π Bootis was obſerved to be 3° 2′ 33″,9 on the 14th of February, 1690, when the difference of right aſcenſion between theſe two ſtars was not obſerved by Mr. Flamſteed. It appears by compu-

tation, that the difference of variation in declination between the times of obſervation was 1′ 34″,5, by which quantity the difference of declination was diminiſhed, and ſhould therefore in 1768 have been 3° 0′ 59″,4. But it was 2° 58′ 24″,2 by actual obſervation. Arcturus therefore by this obſervation has moved ſouthward 2′ 35″,2 in 78,255 years.

By the foregoing compariſons Arcturus appears to have moved as in the following table.

	years.	Weſtwd. ′ ″	Southwd. ′ ″
By the ſmall ſtar Feb. 14, 1690, in	77,237	1 51,35	2 35,0
η Bootis Feb. 14, 1690, in	78,257	1 18,8	2 6,3
η Bootis Apr. 5, 1691, in	77,120	1 31,5	2 5,3
η Bootis May 4, 1691, in	77,071	1 31,8	2 10,3
η Bootis May 27, 1692, in	75,978	1 28,4	2 9,3
By π Bootis May 27, 1692, in	75,978	1 34,2	2 33,0
π Bootis Feb. 14, 1690, in	78,257	not obſ.	2 35,2

As the quantity of the motion of Arcturus ſouthward in declination, as deduced from a compariſon with η Bootis, differs conſiderably from the quantities given by the ſmall ſtar and π Bootis, which agree very nearly together, I have compared η Bootis with ſome of the neighbouring ſtars, as that ſtar, though of the third magnitude only, may have a ſmall motion of its own.

On the 14th of February, 1690, the difference of declination between η and π Bootis was obſerved by Mr. Flamſteed to be = 2°, 11′ 47″,8. By computation, that difference in 1768 ſhould have been 2′ 43″,9 leſs, = 2° 9′ 3″,9: but it was actually obſerved

obſerved to be 2° 8′ 34″,3 only. The ſtar η Bootis therefore appears by this compariſon to have moved ſouthward 29″,6 in 78,257 years.

On the 27th of May, 1692, η Bootis was obſerved by Mr. Flamſteed to be 2° 11′ 37″,8 to the north of π Bootis, which quantity ſhould by computation be 2′ 39″,1 leſs in 1768, or 2° 8′ 58″,7. But it was found to be 2° 8′ 34″,3. The ſtar η therefore appears to have moved ſouthward 0′ 24″,4 in 75,978 years.

On the 25th of April, 1693, η Bootis was obſerved to be 40′ 20″,8 to the ſouth of *f* Bootis, a ſtar of the 6th magnitude; and by myſelf that difference was obſerved to be 42′ 37″,5, by taking the mean of two obſervations on the 24th and 26th of May, 1768, differing only 4″,7. According to computation, the variation of η Bootis in declination during the interval of the two obſervations was 1359″,3, and of *f* Bootis 1256″,0; and therefore the difference of variation in declination was 1′ 43″,3, by which the diſtance of the ſtars was increaſed. The difference in declination therefore in 1768, if neither of the ſtars moved, ſhould have been 0° 42′ 04″,1; but it was obſerved to be 33″,4 greater, by which quantity therefore η Bootis muſt have moved ſouthward in 75,052 years.

By reducing all the foregoing deductions to 78 years, Arcturus appears to have moved,

Weſtw.

	Westw. ′ ″	Southw. ′ ″
By the small Star, Feb. 14, 1690	1 52,380	2 36,43
η Bootis Feb. 14, 1690	1 18,541	2 5,88
η Bootis Apr. 5, 1691	1 32,557	2 6,75
η Bootis May 4, 1691	1 32,906	2 11,87
η Bootis May 27, 1692	1 30,752	2 12,74
By π Bootis May 27, 1692	1 36,707	2 37,07
π Bootis Feb. 14, 1690	not observ.	2 34,69

But the Star η Bootis appears also to have moved Southward.

		′ ″
By π Bootis	Feb. 14, 1690	0 29,503
π Bootis	May 27, 1692	0 25,049
By *f* Bootis	Apr. 5, 1693	0 34,712
By a mean		0 29,755

As Arcturus appears to have moved southward of η Bootis 2′ 9″,31, by taking a mean of the four quantities resulting from the comparisons with that star; and as η Bootis has also moved southward of some of the neighbouring small stars by 29″,755 in the same time, Arcturus upon the whole has moved 2′ 39″06 to the south, by the comparisons with η Bootis only; and therefore, by taking a mean of all the results, Arcturus has altered its right ascension less than the neighbouring stars by 1′ 33″,97 in 78 years, in which time it has also moved 2′ 36″,81 to the south of the same stars.

In order to see how far the motion of right ascension is to be depended upon, which is deduced from the above comparisons, I have selected and computed the following observations, made at Shirburn castle

caſtle with a tranſit inſtrument of $5\frac{1}{4}$ feet, placed exactly in the plane of the meridian, and conſequently more to be relied upon than thoſe made with a mural inſtrument.

By a mean of five obſervations, made on the 7th, 12th, 23d, 24th, and 31ſt of May, 1741, O. S. the difference in right aſcenſion between η Bootis and Arcturus was 5° 22′ 38″,9, the extremes differing only 4″,4 of a degree. The difference in the variation of right aſcenſion to the end of May, 1768, is 20″,5, by which the aſcenſional difference is diminiſhed. It ſhould therefore have been 5° 22′ 18″,4; but it was obſerved to be 5° 21′ 43″,4. Therefore in 27 years Arcturus has moved weſtward 35″,0.

On the 16th and 20th of May, 1744, the difference in right aſcenſion between η Bootis and Arcturus was 5° 22′ 30″,0 by each of the obſervations, which difference ſhould have been, ſuppoſing neither of the ſtars to have any proper motion, 5° 22′ 11″,7 in May, 1768. But it was found to be 28″,3 leſs; by ſo much therefore had Arcturus moved weſtward in 24 years.

On the 24th of May, and 8th of June, 1746, the difference in right aſcenſion between the ſame ſtars was 5° 22′ 26″,2, by taking a mean of the two obſervations; that difference ſhould have been 5° 22′ 09″,5 in 1768. But it was obſerved = 5° 21′ 43″,4. Arcturus therefore in 22 years has moved 26″,1 to the weſt.

Laſtly; on the 16th of April, and 27th and 28th of May, 1747, the difference in right aſcenſion between η Bootis and Arcturus, by taking a mean of the three obſervations, was 5° 22′ 25″,0. By computation

putation the variation in the difference of right afcenfion was 16″,0, by which the afcenfional difference fhould have been diminifhed, and = 5° 22′ 09″,0. But by obfervation it was found = 5° 21′ 43″,4: Arcturus therefore by this laft obfervation appears to have gone 25,6,″ weftward.

By the obfervations therefore at Shirburn Caftle Arcturus appears to have gone weftward as in the following table; in the laft column of which are contained the quantities refulting from the obfervations of each year, reduced to 78 years.

	′ ″	′ ″
1741	0 35,0	1 41,11
1744	0 28,3	1 31,97
1746	0 26,1	1 32,59
1747	0 25,6	1 34,90
	Mean	1 35,14

The mean of all the obfervations, when reduced to an interval of 78 years, is 1′ 35″,14, which differs only 1″,17 from the mean of the other comparifons.

As then the proper motions of Arcturus weftward in right afcenfion = 1′ 33″,974, and 2′ 36″, 81 in declination fouthward, feem well eftablifhed, the real motion of Arcturus is inclined in an angle of 30° 56′ to the weft of the meridian or horary circle, and to be in that direction 3′ 2″,81 in 78 years, or at the rate of 2″,343 in a year. As this direction of its motion is nearly perpendicular to the plane of the ecliptic, the latitude of Arcturus muft diminifh yearly almoft in the fame proportion; and its longitude will alter lefs than that of other ftars, though not fo confiderably as its right afcenfion.

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The proper motion of Arcturus then, in right ascension Westward, being 1″,205, and in declination 2″,005, its annual precession in right ascension is 41″,108, and in declination 19″,133; and the true right ascension of Arcturus, on Jan. 1, 1773, is 211° 19′ 47″,4, and declination North 20° 22′ 23″,3.

As none of the other principal stars have been found to have a motion so considerable as this, though many of the stars of the first magnitude, as for instance, Sirius, Procyon, α Aquilæ, α Orionis, as also β Aquilæ of inferior magnitude, do really vary their positions (and perhaps all of the first order will hereafter be found to have a proper motion), we may, I think, fairly conclude that Arcturus is the nearest star to our system, visible in this hemisphere. If therefore the annual parallax of the fixed stars can ever be discovered, that is, if the diameter of the annual orbit bear a sensible proportion to the distance of the nearest fixed star, it is most likely to be discovered from the observations of Arcturus. The system of the world, considered in an enlarged sense, and agreeable to the idea we may entertain of an all-powerful benevolent Creator, may be taken to occupy the whole abyss of space, and to consist of an assemblage of bodies, having different magnitudes, and emitting various degrees and modifications of light. The apparent change of situation visible from the planet which we inhabit, and which revolves round one of the great bodies constituting a part of the general system, as a center, may be owing either to the motion of our own system in absolute space, or, if our system should be at rest, to a real motion in

the ſtars themſelves: from whence the angular diſtances of the ſtars muſt vary in proportion to the velocity of thoſe motions, or to the direction of thoſe motions with reſpect to ourſelves. I have reaſon, at preſent, to believe that a ſmall motion may be diſcovered in the ſtar *o* Ceti, and perhaps in other ſtars that vary in degrees of brightneſs, which the diligence of future aſtronomers will diſcover, and perhaps in leſs time than at firſt ſight might ſeem neceſſary, when we conſider the ſeveral improvements which have of late been made in the methods of obſerving the heavenly bodies.

As the motion of Arcturus in declination (the quantity of which we have thus endeavoured to aſcertain) has been often acknowledged, it is matter of wonder that ſome aſtronomers, by comparing either the altitude or zenith diſtance of the Sun's limb with Arcturus, without previouſly ſettling the quantity of that ſtar's motion in declination, or at leaſt doing it indirectly, ſhould endeavour to determine whether the obliquity of the ecliptic hath remained conſtant, or ſtill continues to diminiſh, as it ſhould ſeem to have done for many centuries paſt, from the obſervations of ſucceſſive aſtronomers. Mr. Caſſini, and Mr. le Monnier, have both practiſed this method, and are of opinion, that the obliquity of the ecliptic hath not altered; or, if it hath altered, that the quantity of its alteration is not near ſo conſiderable as hath been imagined by ſome celebrated aſtronomers. By obſerving for ſeveral days before and after the ſolſtice the altitude or zenith diſtance of the Sun's limb, and that of a ſtar ſituated near the ſame parallel, the differences to be remarked in proceſs of

time

time in the diſtances of the Sun from that ſtar (the motion of the ſtar in declination being allowed for during that interval of time), will be the quantity by which the Sun will have approached to or have receded from the ſtar. If the ſtar were abſolutely a fixed point, and the obſervations ſufficiently numerous, that, by taking a mean, the neceſſary and unavoidable errors in obſervation might either be conſiderably diminiſhed or almoſt annihilated, the method might be practiſed to great advantage. But as the ſtar (Arcturus) had a proper motion, and its apparent place was continually varying from the effect of the nutation of the earth's axis; as the limb of the Sun was ſometimes approaching to, and ſometimes receding from, the ſtar, by a kind of libratory motion from the effect of the nutation; alſo and as the obliquity of the ecliptic itſelf was, in all probability, continually diminiſhing; from a combination and as it were involution of theſe motions no certain concluſion could be drawn, ſince, in the ſpace of a few years, the apparent obliquity may be the ſame, and yet the mean obliquity may have diminiſhed, or perhaps, in the ſpace of a few years, the obliquity may appear to have increaſed, when it may really have become leſs. Whereas, by reducing the obſervations to their mean poſition, and by aſſigning to each known cauſe its proper and allowed effect, a regularity and uniformity muſt neceſſarily take place, as far at leaſt as is conſiſtent with the unavoidable errors in obſerving.

Mr. Caſſini, in the Memoirs of the Academy of Sciences for 1767, acquaints us, that, in 1748, the apparent diſtance of Arcturus from the upper limb

of the Sun, at the time of the folftice, was the fame as in 1766.

	°	′	″	‴
In 1748. Diftance of Arcturus from the folftitial limb of the Sun	3	13	36	40
Altitude of Arcturus	61	41	17	0
Therefore the apparent folftitial altitude	64	55	13	40
In 1766. Diftance of Arcturus from the folftitial limb of the Sun	3	19	32	0
Altitude of Arcturus	61	35	42	0
Therefore the apparent folftitial altitude	64	55	14	0

The fame aftronomer has, in the Memoirs for 1759, p. 325, communicated the following conclufions.

		Dift. of the ftar from ☉'s limb.			Reduction.			Solftitial diftance.		
1763.		°	′	″		′	″	°	′	″
June	14.	3	7	29	+	11	1	3	18	30
	15.	3	10	16	+	8	13	3	18	29
	25.	3	15	40	+	2	48	3	18	28
July	1.	2	59	1	+	19	22	3	18	23
	2.	2	54	55	+	23	33	3	18	28
	3.	2	50	18	+	28	8	3	18	26
						Mean		3	18	27

Mr. le Monnier, in the Memoirs for 1762, p. 269, has publifhed the following diftances of Arcturus from the limb of the Sun, reduced to the folftitial point, with a view to obtain differences in the apparent obliquity of the ecliptic: and, from the obfer- vations

vations made with the gnomon of St. Sulpice, and communicated by Mr. le Monnier, in the ſame volume, it ſhould ſeem that that aſtronomer is of opinion, that the obliquity of the ecliptic hath no other variation than what the nutation of the earth's axis will occaſion; and that therefore we muſt either abandon the abſolute diminution of the ecliptic, or at leaſt ſuppoſe it extremely ſmall, ſince, in the ſpace of eighteen years, it hath not produced a ſenſible alteration.

	°	′	″	
1738.	3	10	15	
1740.	3	11	5	
1742.	3	11	48	
1763.	3	18	40	with the mural quadrant of 5 feet.
	3	18	35	with the large mural inſtrument.

As the reſult of the obſervations only, and not the obſervations themſelves, are communicated, I have only to obſerve, that there is a very conſiderable difference between the concluſions of the two aſtronomers for the ſame year 1763, and, at the ſame time, to declare my ſuſpicion, that if the *apparent* (for ſuch I apprehend them to be) were reduced to the *mean* diſtances, they would probably afford a confirmation of the diminution of the ecliptic. For the following obſervations of the Sun's zenith diſtance, made at Shirburn Caſtle, near the ſummer ſolſtices of the years 1743, 1746, 1748, and 1766, and of Arcturus in the years 1743, 1746, and 1766, when reduced to their mean ſtate at the ſolſtice, do not confirm the aſſertion of Mr. Caſſini, but are an evident

and

and abſolute proof that the obliquity of the ecliptic has ſenſibly diminiſhed during an interval of 23, and even of 18 years.

The obſervations of 1743 were made with a mural quadrant of five French feet, conſtructed by the late Mr. Siſſon: but as the linear diviſions were found to be ſomewhat leſs accurate than was expected, and as the body of the quadrant was not framed with proper ſtrength and ſolidity, Mr. Bird was employed in the ſummer of the year 1745, by the Earl of Macclesfield, (the body of the inſtrument having been ſtrengthened by ſcrewing a large and broad plate of braſs upon the croſs-bars), to put a ſet of points upon the limb between the 90 and 96 arches of linear diviſions. By theſe operations the line of collimation was found to have varied, and to be $= 6'',3$, by which the zenith diſtances were given too ſmall, by the poſitive diviſions, from the end of 1746 to the end of June 1751, when Mr. Bird biſected the ſpaces between the points which he had formerly added in 1745. But after the year 1751, the error of the line of collimation was $= 2'',6$, as appears from obſervations of γ Perſei, β and γ Draconis, by which the zenith diſtances are alſo given too ſmall; and in that ſtate the inſtrument continued to the year 1767, when a new ſet of wires was put into the teleſcope, and the line of collimation thereby altered. The error of the line of collimation from 1743 to 1745 cannot directly be aſcertained, for want of zenith obſervations; but, from ſome indirect methods, it ſhould ſeem that the error was as nearly as poſſible $= 2''$, to be added to the obſerved zenith diſtances.

1743.

	Observed zenith distance.	Barometer.	Thermometer.	Refraction.	Sun's semidiameter.	Dist. from solstice.	Observations reduced to solstice.
1743.	° ′ ″			″ +	′ ″	° ′ ″	° ′ ″
June 7.	Up. L. 28 37 39	29,54	62	30,2	+ 15 48,1	0 43 5,7	28 10 51,6
8.	Lo. L. 29 3 37	29,36	60	30,8	− 15 48	37 22,3	28 10 57,5
9.	Up. L. 28 26 44,2	29,46	59½	30	+ 15 47,9	32 3,3	28 10 58,8
12.	Up. L. 28 13 14,5	29,72	61½	29,9	+ 15 47,6	18 31,6	28 11 0,4
18.	Up. L. 27 57 9	29,81	67	29,4	+ 15 47,3	2 30	28 10 55,7
19.	Lo. L. 28 27 28,5	29,54	67½	29,8	− 15 47,2	1 16,1	28 10 55
21.	Up. L. 27 54 41,8	29,66	66	29,1	+ 15 47,1	0 2,8	28 10 55,2
22.	Lo. L. 28 26 22,2	29,50	63	29,8	− 15 47	0 3,4	28 11 1,6
23.	Up. L. 27 55 10,2	29,59	61	29,5	+ 15 47	0 28,6	28 10 58,1
24.	Lo. L. 28 27 35,5	29,59	58	30,4	− 15 46,9	1 18,8	28 11 0,2
25.	Up. L. 27 57 15,5	29,39	58	29,5	+ 15 46,9	2 33,7	28 10 58,2
27.	Lo. L. 28 32 34	29,57	58	30,5	− 15 46,9	6 17,9	28 10 59,7
				Mean			28 10 58,2
				Sun's parallax			— 4,1
							28 10 54,1
				Nutation			+ 6,7
							28 11 0,8
				Line of collimation			+ 2
				Mean solstitial zenith distance, 1743,			28 11 2,8

	Observed zenith distance.	Barometer.	Thermometer.	Refraction.	Sun's semidiameter.	Dist. from solstice.	Observations reduced to solstice.
1746.	° ′ ″			″	′ ″	° ′ ″	° ′ ″
May 31.	Lo. L. 29 57 50,5	29,48	78	30,5	− 15 48,8	1 31 41,9	28 10 50,3
June 5.	Up. L. 28 48 24,8	29,62½	64 −	30,4	+ 15 48,3	53 50	28 10 53,5
6.	Lo. L. 29 13 36,3	29,62	65	30,8	− 15 48,2	47 26,3	28 10 52,6
7.	Up. L. 28 35 58,9	29,53	71 +	29,4	+ 15 48,1	41 24,3	28 10 52,1
10.	Lo. L. 28 52 1,8	29,28	67	29,8	− 15 47,8	25 49,8	28 10 54
16.	Up. L. 28 0 14,4	28,69	59½	28,7	+ 15 47,3	5 34,6	28 10 55,8
19.	Lo. L. 28 27 5,1	29,60	58½	30,3	− 15 47,2	0 59,8	28 10 48,4
22.	Up. L. 27 54 45	29,75	63½	29,4	+ 15 47	0 8	28 10 53,4
23.	Lo. L. 28 26 47,4	29,85	64	30,2	− 15 47	0 40,4	28 10 50,2
26.	Up. L. 27 59 23,4	29,63	69	29	+ 15 46,9	4 45,9	28 10 53,4
27.	Lo. L. 28 33 6,6	29,63	74½	29,2	− 15 46,9	6 57,1	28 10 51,8
28.	Up. L. 28 4 11,8	29,50	65½	29,3	+ 15 46,9	9 32,9	28 10 55,1
30.	Lo. L. 28 42 5,9	29,22	63½	30,2	− 15 46,9	15 58,2	28 10 51
July 4.	Up. L. 28 28 16,6	29,67	69	29,6	+ 15 46,9	33 40,1	28 10 53
				Mean			28 10 52,5
				Sun's parallax			— 4,1
							28 10 48,4
				Nutation			+ 9,4
							28 10 57,8
				Error of the line of collimation . .			+ 6,3
				Mean solstitial zenith distance, 1746,			28 11 4,1

1748.

	Observed zenith distance	Baro-meter.	Thermo-meter.	Refrac-tion.	Sun's semi-diameter.	Dist. from solstice.	Observations reduced to solstice.
1748.	° ′ ″			″ +	′ ″	° ′ ″	° ′ ″
June 15.	Up. L. 28 1 21,1	29,51½	64	29,3	+ 15 47,4	0 6 38,6	28 10 59,2
16.	Lo. L. 28 30 41,3	29,55	60	30,3	— 15 47,4	4 31,9	28 10 52,3
20.	Up. L. 27 54 45,7	29,86½	63½	29,5	+ 15 47,2	0 5,7	28 10 56,7
21.	Lo. L. 28 26 11,3	29,65½	75 +	29,2	— 15 47,1	0 1,3	28 10 52,1
22.	Up. L. 27 55 3,5	29,67	81½	28,2	+ 15 47	0 21,4	28 10 57,3
23.	Lo. L. 28 27 18,7	29,60½	72 —	29,3	— 15 47	1 6,7	28 10 54,3
24.	Up. L. 27 56 59,7	29,55+	65	29	+ 15 46,9	2 16,7	28 10 58,9
29.	Lo. L. 28 40 29,3	29,90	64	30,5	— 13 46,9	14 18,7	28 10 55,2
				Mean			28 10 55,8
				Sun's parallax			— 4,1
							28 10 51,7
				Nutation			+ 6,1
							28 10 57,8
				Error of the line of collimation			+ 6,3
				Mean solstitial zenith distance, 1748,			28 11 4,1

	Observed zenith distance	Baro-meter.	Thermo-meter.	Refrac-tion.	Sun's semi-diameter.	Dist. from solstice.	Observations reduced to solstice.
1766.	° ′ ″			″	′ ″	° ′ ″	° ′ ″
June 11.	Lo. L. 28 47 12	29,51	62 —	30,4	— 15 47,7	0 20 42,3	28 11 12,4
12.	Up. L. 28 11 38,3	29,38	61 —	29,6	+ 15 47,6	16 47,1	28 11 8,4
17.	Lo. L. 28 29 47,9	29,15½	66	29,4	— 15 47,3	3 20,2	28 11 9,8
21.	Up. L. 27 54 57,4	29,72	68¾	29	+ 15 47,1	0 29	28 11 13,5
22.	Lo. L. 28 26 39,6	29,87½	70¾	29,7	— 15 47	0 11,9	28 11 10,4
23.	Lo. L. 28 27 19,2	29,95½	75½	29,5	— 15 47	0 48,6	28 11 13,1
24.	Up. L. 27 56 45,7	29,80	78¼	28,4	+ 15 46,9	1 50,1	28 11 10,9
25.	Lo. L. 28 29 41,2	29,49	74	29,2	— 15 46,9	3 16,2	28 11 7,3
27.	Up. L. 28 2 18,5	29,40	67	28,9	+ 15 46,9	7 22,6	28 11 11,7
29.	Lo. L. 28 29 30,6	29,28	66	29,7	— 15 46,9	13 7	28 11 6,4
				Mean			28 11 10,5
				Sun's parallax			— 4,1
							28 11 6,4
				Nutation			+ 7,6
							28 11 14
				Error of the line of collimation			+ 2,6
				Mean solstitial zenith distance, 1766,			28 11 16,6

	Observed zenith dist. of Arcturus.			Refraction.	Aberration.	Nutation.	Precession.	Observations reduced.		
	°	′	″	″	″	″	″	°	′	″
1743.										
May 12.	31	6	57,8	34	— 1,9	+ 1,4	+ 2,1	31	7	33,4
17.	31	6	57,8	34	— 0,8	+ 1,4	+ 1,8	31	7	34,2
18.	31	6	57,8	34	— 0,6	+ 1,4	+ 1,8	31	7	34,4
June 5.	31	6	52,3	34	+ 2,9	+ 1,2	+ 0,9	31	7	31,3
9.	31	6	50,3	34	+ 3,8	+ 1,2	+ 0,7	31	7	30
10.	31	6	52	34	+ 4	+ 1,2	+ 0,6	31	7	31,8
16.	31	6	57	34	+ 5,3	+ 1,2	+ 0,3	31	7	37,8
18.	31	6	54,8	34	+ 5,5	+ 1,2	+ 0,1	31	7	35,6
25.	31	6	52	34	+ 6,7	+ 1,2	— 0,2	31	7	33,7
July 1.	31	6	52	34	+ 7,8	+ 1,2	— 0,5	31	7	34,5
Mean								31	7	33,6
Error of the line of collimation										+ 2
Mean zenith distance of Arcturus, June 21, 1743, . .								31	7	35,6
Mean zenith distance of the Sun's center, June 21, 1743,								28	11	2,8
Mean distance of Arcturus from the Sun's center, 1743,								2	56	32,8
1746.	°	′	″	″	″	″	″	°	′	″
June 4.	31	7	51,1	34	+ 2,5	— 5,8	+ 1,1	31	8	22,9
21.	31	7	53,1	34	+ 6,1	— 5,9	0	31	8	27,3
22.	31	7	50,2	34	+ 6,3	— 5,9	0	31	8	24,6
23.	31	7	52,3	34	+ 6,4	— 5,9	— 0,1	31	8	27,7
Oct. 9.	31	7	58,6	34	+ 8,9	— 6,4	— 5,7	31	8	29,4
Mean								31	8	26,4
Error of the line of collimation										+ 6,3
Mean zenith distance of Arcturus, June 21, 1746, . .								31	8	32,7
Mean zenith distance of the Sun's center, June 21, 1746,								28	11	4,1
Mean distance of Arcturus from the Sun's center, 1746,								2	57	28,6

	Observed zenith dist. of Arcturus.	Barometer.	Thermometer.	Refraction.	Aberration.	Nutation.	Precession.	Observations reduced.
1766.	° ′ ″			″	″	″	″	° ′ ″
May 13.	31 14 20,7	29,46	43	34,9	—1,9	—7,6	+2	31 14 48,1
21.	31 14 23,1	29,81	46	35,1	—0,2	—7,6	+1,7	31 14 52,1
22.	31 14 19,9	29,67	49	34,7	0	—7,6	+1,6	31 14 48,6
June 23.	31 14 20,8	29,90	70	33,1	+6,4	—7,7	—0,1	31 14 52,5

Mean	31 14 50,3
Error of the line of collimation	+ 2,6
Mean zenith distance of Arcturus, June 21, 1766, . .	31 14 52,9
Mean zenith distance of the Sun's center, June 21, 1766,	28 11 16,6
Mean distance of Arcturus from the Sun's center, 1766,	3 3 36,3

From the foregoing observations, it appears that the mean solstitial zenith distance in summer was as follows.

	°	′	″	Variation in 100 years. ″
1743.	28	11	2,8	60
1746.	28	11	4,1	62,5
1748.	28	11	4,1	69,4
1766.	28	11	16,6	

And, by comparing the three former with the latter, the variation of the obliquity of the ecliptic in 100 years is as is expressed in the last column of the table.

By comparing the distance of Arcturus from the center of the Sun in 1743, with the same distance as observed in 1766 (an allowance being made for the proper motion of the star during the interval, as also for its variation in declination arising from the pre-

cession

ceſſion of the equinoxes), it appears that its diſtance is 17″,3 leſs than it would have been, if the diſtance of the Sun's center from the equator had remained unvaried. By that quantity, therefore, the obliquity of the ecliptic has altered in 23 years; which is at the rate of 75″,2 in 100 years.

By comparing, in like manner, the diſtance in 1746, the obliquity of the ecliptic has diminiſhed 15″,6 in 20 years, or 78″ in 100 years.

	°	′	″		°	′	″
Diſtance in 1743	2	56	32,8	In 1746.	2	57	28,6
Motion of the ſtar in decl. Southward		7	20,8			6	23,3
Computed diſtance in 1766 . .	3	3	53,6		3	3	51,9
Obſerved diſtance in 1766 . . .	3	3	36,3		3	3	36,3
Variation of obliquity			17,3				15,6

The foregoing deductions prove, I think, beyond all doubt, that the obliquity has become leſs; but as the interval of time between the two terms of compariſon is ſo ſhort, that the errors committed in obſerving may bear a ſenſible proportion to the ſmall quantities juſt now found, and which, perhaps, are ſomewhat too large; let us have recourſe to Mr. Flamſteed's obſervations, and compare them with obſervations made by myſelf, in the courſe of the laſt and preſent years. For this purpoſe, I have reduced all the obſervations of the Sun, made in 1690, from May 26 to June 24, O. S. and alſo all the obſervations of Arcturus, made in the ſame year, to their mean poſition at the ſummer ſolſtice of that year. The obſervations, together with my own made at Oxford, are as follows.

 1690.

	Observed zen. dist. of the Sun's limbs.	Refraction.	Sun's semidiameter.	Dist. from solstice.	Observations reduced.
	° ' "	"	' "	° ' "	° ' "
1690.					
May 26.	Lo. L. 29 6 20	31,8	15 46,4	0 50 26,1	28 0 39,3
	Up. L. 28 34 50	31,1	15 46,4		41,4
June 2.	Lo. L. 28 31 35	31,1	15 45,7	0 15 28,3	52,1
	Up. L. 28 0 5	30,4	15 45,7		52,8
3.	Lo. L. 28 28 20	31	15 45,6	0 12 8,6	56,8
	Up. L. 27 56 45	30,3	15 45,6		51,1
4.	Lo. L. 28 25 15	30,9	15 45,5	0 9 10,9	49,5
	Up. L. 27 53 55	30,3			28 0 59,9
6.	Lo. L. 28 20 40	30,8	15 45,5	0 4 30,1	28 0 55,2
	Up. L. 27 49 15	30,2			28 1 0,6
7.	Up. L. 27 47 10	30,1	15 45,4	0 2 46,8	28 0 38,7
	Lo. L. 28 18 40	30,8			28 0 38,6
10.	Lo. L. 28 16 10	30,7	15 45,3	0 0 5,5	28 0 49,9
	Up. L. 27 44 40	30,1			28 0 49,9
12.	Up. L. 27 44 50	30,1	15 45,3	0 0 22	28 0 43,4
	Lo. L. 28 16 45	30,8			28 1 8,5
13.	Lo. L. 28 17 17,5	30,8	15 45,1	0 1 7,4	28 0 55,8
	Up. L. 27 45 50	30,1			28 0 58,8
14.	Up. L. 28 13 30	30,8	15 45,1	0 2 17,6	28 0 58,1
	Lo. L. 27 46 50	30,1			28 0 47,6
16.	Up. L. 27 50 40	30,2	15 45,1	0 3 51,8	28 1 3,5
	Lo. L. 28 22 15	30,9			28 1 9
17.	Up. L. 27 53 5	30,2	15 45	0 8 16,4	28 1 3,8
	Lo. L. 28 24 30	30,9			28 0 59,5
20.	Lo. L. 28 34 15	31,1	15 45	0 17 56,4	28 1 4,7
	Up. L. 28 2 45	30,4			28 1 4
24.	Up. L 28 21 5	30,8	15 45,1	0 36 30,6	28 0 50,3

Mean	28 0 54,2
Error of the line of collimation	1 30
	27 59 24,2
Sun's parallax	— 4,1
	27 59 20,1
Nutation	+ 9,5
Mean solstitial zen. dist. of the Sun's center, June 11, 1690, O. S.	27 59 29,6

	Observed zenith dist. of Arcturus.	Refraction.	Aberration.	Nutation.	Precession.	Observations reduced.
1690.	° ′ ″	″	″	″	″	° ′ ″
Feb. 14.	30 39 20	33,8	—12,2	— 5,1	— 2,3	30 39 34,2
Apr. 13.	30 39 20	33,8	— 5,5	— 5,3	— 5,4	30 39 37,6
25.	30 39 10		— 3,3	— 5,4	— 6	29,1
26.	30 39 15		— 2,9	— 5,4	— 6,1	34,4
May 13.	10		+ 0,4	— 5,5	— 6,9	31,8
14.	10		+ 0,6	— 5,5	— 7	31,9
15.	30 39 10	33,8	+ 0,8	— 5,5	— 7	32,1
20.	10		+ 1,9	— 5,5	— 7,3	32,9
22.	10		+ 2,3	— 5,5	— 7,4	33,2
24.	30 39 5		+ 2,7	— 5,6	— 7,5	28,4
June 12.	10	33,8	+ 6,4	— 5,6	— 8,5	36,1
13.	10		+ 6,6	— 5,6	— 8,6	36,2
16.	30 39 10		+ 7,1	— 5,6	— 8,7	36,6
17.	10		+ 7,2	— 5,6	— 8,8	30 39 33,4
July 1.	30 39 10	33,8	+ 9,4	— 5,7	— 9,5	30 39 30,6
Dec. 13.	30 39 35	33,8	— 6,6	— 6,5	—18,1	30 39 37,6
14.	30 39 40	33,8	— 6,8	— 6,5	—18,2	30 39 42,3

Mean, January 1, 1690, O. S.	30 39 34
Preceſſion to June 11, 1690	+ 8,4
Mean zenith diſtance of Arcturus, June 11, 1690 . .	30 39 42,4
Mean ſolſtitial zenith diſtance of the Sun's center, June 11, 1690	27 59 29,6
Mean diſtance of Arcturus in declination from the Sun's center, 1690	2 40 12,8

1771.

	Observed zenith distance of the Sun's upper limb.	Barometer.	Thermometer.	Refraction.	Sun's semidiameter.	Dist. from solstice.	Observations reduced.
1771.	° ′ ″			″	′ ″	° ′ ″	° ′ ″
June 8.	28 36 47,6	30,08½	64⅓	30,9	15 48	0 36 0,4	28 17 6,1
14.	28 11 38,1	29,94	63 —	30	15 47,4	10 46,6	8,9
18.	28 3 4,4	29,75	61 +	29,7	15 47,2	2 8,3	13
21.	28 0 55,4	30,08⅔	65⅓	29,7	15 47	0 0,8	11,3
22.	28 1 1,4	30,07	66 +	29,6	15 47	0 7,6	28 17 10,4
24.	28 2 26,1	30,07	62	30	15 46,9	1 35,8	7,2
25.	28 3 46,9	30,05	69	29,5	15 46,9	2 56,8	6,5
26.	28 5 38,1	29,97½	68	29,5	15 46,9	4 42,7	11,8
29.	28 13 21,3	29,84	61 —	30,2	15 46,9	12 27,7	28 17 10,7

Mean	28 17 8,7
Sun's parallax	— 4,1
	28 17 4,6
Nutation	— 6,8
	28 16 57,8
Error of the line of collimation	+ 4,8
Mean solstitial zenith distance of the Sun's center, 1771,	28 17 2,6

1772.

1772.	Observed zenith distance of the Sun's limbs. ° ′ ″	Barometer.	Thermometer.	Refraction. ″	Sun's semidiameter. ′ ″	Dist. from solstice. ° ′ ″	Observations reduced. ° ′ ″
June 8.	Lo. L. 29 4 31,3	30,18	71	30,7	− 15 48	0 31 59,9	28 17 14,1
9.	Up. L. 28 28 1	30,05¼	67½	30,1	+ 15 47,9	27 5,4	21 17 13,6
11.	Lo. L. 28 51 5,5	30,10½	71¾	30,3	− 15 47,7	18 29,2	18,9
12.	Lo. L. 28 47 15,7	30,22⅔	60⅔	31,2	− 15 47,6	14 48,4	10,9
14.	Up. L. 28 9 34,4	30,15½	63	30,1	+ 15 47,4	8 38,4	13,5
	Lo. L. 28 41 11,1			30,8			16,1
15.	Up. L. 28 7 5,4	29,94½	72	29,2	+ 15 47,3	6 10,7	11,2
	Lo. L. 28 38 40,8			29,8			28 17 12,6
16.	Up. L. 28 5 0,3	29,82½	70¾	29,1	+ 15 47,3	4 7,6	9,1
	Lo. L. 28 36 38,6			29,8			13,5
18.	Up. L. 28 2 16,4	30,02¾	71½	29,2	+ 15 47,2	1 15,6	17,2
	Lo. L. 28 33 48,1			29,7			15
19.	Up. L. 28 1 26,3	29,97	75⅓	28,8	+ 15 47,1	0 26,8	15,4
	Lo. L. 28 32 55,8			29,5			11,4
20.	Lo. L. 28 32 30,3	29,93	79	29,1	− 15 47,1	0 2,8	28 17 9,5
21.	Lo L. 28 32 32,8	29,79	72	29,6	− 15 47	0 3,5	11,9
22.	Up. L. 28 1 24,8	30,00¼	73	29	+ 15 47	0 29,9	28 17 10,9
23.	Up. L. 28 2 14,4	30,01	76¼	28,8	+ 15 47	1 19,4	28 17 10,8
	Lo. L. 28 33 54,1			29,5			17,2
26.	Up. L. 28 7 20,3	29,96	85 —	28,2	+ 15 46,9	6 18,9	16,5
	Lo. L. 28 38 50,4			28,8			28 17 13,4

	° ′ ″
Mean	28 17 13,4
Sun's parallax	− 4,1
	28 17 9,3
Nutation	− 8,7
	28 17 0,6
Error of the line of collimation	+ 4,8
Mean solstitial zenith distance of the Sun's center, 1772,	28 17 5,4

	Observed zenith distance of Arcturus.	Barometer.	Thermometer.	Refraction.	Aberration.	Nutation.	Precession.	Observations reduced.
1772.	° ′ ″			″	″	″	″	° ′ ″
July 11.	31 21 53,6	29,87	73	32,9	+ 9,4	+ 1,9	— 10,1	31 22 27,7
Aug. 11.	31 21 56,6	29,91	64 —	33,8	+ 12,2	+ 2,1	— 11,7	33
17.	50,6	29,93	75 +	32,8	+ 12,2	+ 2,1	— 12	25,7
19.	54,6	29,76	77 —	32,5	+ 12,3	+ 2,2	— 12,1	29,5
Oct. 10.	31 21 58,1	29,99¾	61	34,2	+ 7,7	+ 2,6	— 15,1	27,2
Nov. 2.	31 22 3,3	29,32¼	49 —	34,5	+ 4,4	+ 2,7	— 16	28,9
7.	22 3,5	29,25	49	34,3	+ 3,8	+ 2,7	— 16,3	28
12.	8,3	29,82	38	35,9	+ 2,1	+ 2,7	— 16,5	32,5
20.	31 22 12,3	29,85	46 +	34,1	+ 0,4	+ 2,7	— 16,9	31 22 32,6
21.	10,3	29,50 +	40 —	35,4	+ 0,2	+ 2,7	— 17	31,6
25.	11,3	29,37	40	35,2	— 0,2	+ 2,7	— 17,2	31,8
Dec. 10.	15,3	29,62	39⅓	35,7	— 3,9	+ 2,9	— 18	32
16.	31 22 12,3	29,69	45¼	35,1	— 5	+ 2,9	— 18,3	31 22 27

	° ′ ″
Mean zenith distance of Arcturus, January 1, 1772	31 22 29,8
Precession to June 21, 1772	+ 9
Mean zenith distance of Arcturus, June 21, 1772	31 22 38,8
Error of the line of collimation	+ 4,2
True mean zenith distance of Arcturus, June 21, 1772	31 22 43
Mean zenith distance of the Sun's center, June 21, 1772	28 17 5,4
Mean distance of Arcturus in declination from the Sun's center, June 21, 1772	3 5 37,6

	° ′ ″
Mean distance in June 1690 . . .	2 40 12,8
Precession, &c. to June 1772 . . .	26 16,4
Computed distance in June 1772 .	3 6 29,2
Observed distance in June 1772 .	3 5 37,6
Diminution of obliquity in 82 years	51,6

From

From the foregoing obſervations it appears that, at the ſummer ſolſtice of the year 1690, Arcturus was 2° 40′ 12″,8 to the South of the Sun's center in declination: the motion of the ſtar, in declination, from that time to the ſummer ſolſtice of the year 1772, including its proper motion, is 26′ 16″,4. Arcturus, therefore, in 1772, ſhould have been 3° 6′ 29″,2 to the South of the Sun's center, if the angle of the ecliptic and equator had not varied: but that diſtance was found by actual obſervation to be 51″,6 leſs. By ſo much therefore muſt the obliquity of the ecliptic have become leſs in an interval of 82 years; and, conſequently, the variation in 100 years will be 62″,92.

If the obſervations of Arcturus be reduced to the ſolſtice of 1771, and the zenith diſtance of the Sun's center, as obſerved in that year, be made uſe of in the ſame manner, the variation of the obliquity in 81 years will be found = 48″,8, and in 100 years = 60″.

If the quantity of the arc of Mr. Flamſteed's inſtrument were accurately known, the obſervations which he made at the winter ſolſtice in 1690 might be compared with later obſervations, in order to determine both the quantity of the obliquity in 1690, and alſo the variation ſince his time. Accordingly, I have endeavoured to determine the error of the arc of the inſtrument between 28° and 75° of zenith diſtance, and proceeded in the following manner. I computed ſeveral obſervations of the ſtars ζ Tauri, η Pleïadum, η and μ Geminorum, and φ, σ, and o Sagittarii, as obſerved by Mr. Flamſteed, in the years 1690, 1691, and 1692, and reducing them

 to

to the years 1760 and 1766, I compared the differences of declination between thoſe ſtars, reſulting from Mr. Flamſteed's obſervations, with the differences given by the places of the ſame ſtars, as ſettled by Dr. Bradley in 1760, and alſo by actual obſervations of the ſame ſtars made at Shirburn-Caſtle in 1766; and, by combining theſe differences together, I found that the whole arc of 90 degrees was too ſhort by 43″. Suppoſing the error to be uniform, the proportional part of this quantity, thus found for the ſolſtitial zenith diſtance of the Sun in June = 13″,4, is nearly confirmed upon the authority of Mr. Flamſteed himſelf, who, in the prolegomena to the third volume of the Hiſtoria Cœleſtis, where he is deducing the latitude of the Royal Obſervatory at Greenwich, and the quantity of the obliquity in 1690, from his own obſervations, allows the zenith diſtances at 28°, 36°, and 40°, on his inſtrument, to be too ſmall by 15′ and by 20″, at 75°.

I have therefore computed the obſervations of the Sun, made from November 30 to December 20 of 1690, which, reduced to the ſolſtice, are as in the following table; to which are ſubjoined the obſervations made by myſelf at Oxford, at the winter ſolſtice of 1771.

		Observed zenith distance of the Sun's limbs.	Refraction. +	Sun's semi-diameter.	Dist. from solstice. +	Observations reduced.
1690.		° ′ ″	′ ″	′ ″	° ′ ″	° ′ ″
Nov. 30.	Lo. L.	74 45 17,5	3 27,9	— 16 16,6	0 25 43,1	74 58 11,9
	Up. L.	74 12 40	3 19,6	+ 16 16,6		74 57 59,3
Dec. 2.	Lo. L.	74 54 5	3 28,7	— 16 16,6	17 16,1	74 58 33,2
2.	Up. L.	74 21 25	3 21,7			19,4
10.	Lo. L.	75 11 0	3 32,7	— 16 17,2	0 4,6	20,1
	Up. L.	74 38 35	3 25,4			22,2
13.	Lo. L.	75 9 50	3 32,4	— 16 17,2	1 24,4	74 58 29,6
	Up. L.	74 37 15	3 25,3			21,9
15.	Lo. L.	75 6 45	3 31,6	— 16 17,3	4 39,4	74 58 38,7
	Up. L.	74 34 5	3 24,5			26,2
17.	Lo. L.	75 1 30	3 30,2	— 16 17,3	9 46,9	29,8
20.	Up. L.	74 13 15	3 19,8	+ 16 17,3	25 38,8	74 58 30,9
	Lo. L.	74 46 5	3 27	— 16 17,3		74 58 53,5

Mean	74 58 25,9
Error of the line of collimation	— 1 10
	74 57 15,9
Sun's parallax	— 8,5
	74 57 7,4
Nutation	— 9,6
Mean solstitial zenith distance of the Sun's center, Dec. 1690,	74 56 57,8

	Observed zenith distance of ☉'s upp. limb.	Barometer.	Thermometer.	Refraction.	Sun's semidiameter. +	Dist. from solstice. +	Observations reduced.
	° ′ ″			′ ″	′ ″	° ′ ″	° ′ ″
1771.							
Dec. 8.	74 11 1,7	29,43	44¼	3 21	16 18	0 42 26,3	75 13 12,2
12.	74 32 25,4	29,56⅓	47 +	3 25,2	16 18,5	21 3,4	17,7
16.	74 46 32,3	28,68	45⅔	3 22,7	16 18,7	7 2,5	21,8
19.	74 51 57,3	29,23	42	3 29,6	16 19	1 26,1	17,2
24.	74 51 48,5	29,07	40	3 29,6	16 19,1	1 31	13,4
25.	74 50 24,2	29,43	41¼	3 31,2	16 19,2	2 56,9	16,7
27.	74 46 13,3	29,42½	48½	3 26,6	16 19,2	7 13,4	17,7
30.	74 36 13,9	30,13	39¼	3 34,1	16 19,3	17 9,3	75 13 21,8

Mean	75 13 17,3
Sun's parallax	— 8,5
	75 13 8,8
Nutation	+ 7,9
	75 13 16,7
Error of the line of collimation	+ 4,8
Mean solstitial zenith distance of the Sun's center, December 1771,	75 13 21,5

The mean obliquity of the ecliptic resulting from the zenith distances, as observed at the two solstices in 1690, by applying the known latitude of the place, will be found to be widely different, if no correction be applied for the error of the instrument.

	° ′ ″		° ′ ″
June, zenith distance	−27 59 29,6	Dec. zen. dist.	74 56 57,8
Latitude of Greenwich	51 28 38		−51 28 38
	23 29 8,4		23 28 19,8

But if the observations be corrected by the error of the instrument, the two results will be found to agree together as nearly as can be expected.

	°	′	″		°	′	″
	27	59	29,6		74	56	57,8
		+	13,4			+	35,8
	—27	59	43		74	57	33,6
	51	28	38		—51	28	38
Obliquity	23	28	55		23	28	55,6

Or, if the obliquity be required independent of a knowledge of the latitude of the place, it will be found to be = 23° 28′ 55″,3.

	°	′	″
December	74	57	33,6
June	—27	59	43
Difference	46	57	50,6
Mean obliquity 1690, ½ Diff.	23	28	55,3

By commparing the obſervations at the ſummer ſolſtices of 1771 and 1772 with thoſe at the winter ſolſtice of 1771, it appears that the mean obliquity was about the beginning of the year 1772 = 23° 28′ 9″,4 and 23° 28′ 8″. I ſuppoſe therefore the mean obliquity to be 23° 28′ 8″ at the beginning of the preſent year; and conſequently, the obliquity has diminiſhed, by my obſervations, 47″ in 81 years, ſince Mr. Flamſteed's time, or at the rate of 58″ in 100 years, a quantity which will be found nearly at a mean of the computations framed by Mr. Euler and Mr. de la Lande, upon the principles of attraction.

Oxford, Dec. 23, 1772.

XV. *New*