

(1099)

Numb. 55.

PHILOSOPHICAL TRANSACTIONS.

January 17. 1670.

The Contents,

An Account of such of the more notable Celestial Appearances of the Year 1670, as will be conspicuous in the English Horizon; and among them, an Eclipse of the Sun, in part visible here in England, though pretermitted, as such, by others; as also of divers Stellar Eclipses, to be caused by the Moon, covering several Fix'd Stars. Some Observations concerning the Barometer and Thermometer, made by Dr. Beale in Somerset; and others of the like nature, made by Dr. John Wallis in Oxford. An Account of a small Tract, entituled, THOMÆ HOBBS Quadratura Circuli, Cubatio Sphæræ, Duplicatio Cubi, (Secundo Edita,) Denuò Refutata, A. JOH. WALLIS, S. T. D. &c.

An Account of such of the more notable Celestial Phenomena of the Year 1670, as will be conspicuous in the English Horizon; written by the Learned and Industrious Mr. John Flamsteed Novemb. 4. 1669. and by him addressed and recommended for encouragement, to the Right Honorable, the Lord Viscount Brouncker, as President of the Royal Society.

My Lord,

AMong those many Illustrious, Noble, and Generous Persons, who have the honour to be in the List of the R. Society, I find numbered some Astronomers, whom our Age accounts its Glory, and our Arts their Support: which induces me

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to believe that among all those Ingenuous Arts and Sciences, which have put themselves under their Patronage, and look for an improvement from their Industry, the *Celestial* are not to be accounted the last. Their Excellent History shews, that they have not neglected the *Heavens*. And their endeavours for the Improvement of *Optick Glasses*, and Encouragement of such as labour therein, do more than obscurely indicate those high respects they have for the Sublimest of Human Sciences, *Astronomy*.

The considerations invited me to address myself, with these my following labours, to your Honor, who hold so high a place in that illustrious Body, and are known to excel in the knowledge as well, as the Love of that Science, I stand engaged in. You know, *My lord*, How much it conduceth to the Advancement of *Astronomy*, and the Correction of our *Canons*, to have the Celestial Appearances accurately observed, and how much it concerns the Observer to have notice of what *Phænomena* the Heavens exhibit convenient for his Observation. I have endeavoured in the following pages to accommodate him with the Calculations of such of the more notable *Phænomena* of the Year 1670, as will be conspicuous in the English Horizon, if the Heavens be clear; and shall, God willing, performe the like for future Years, if I may be but encouraged by the acceptance of these

I was excited to this task by perusing the *Mercurius in Sole visus* of the Excellent *Hevelius*, who hath obliged Astronomy by his accurate Observations of the *Moons transits* by and over *Saturne*, and her occultations of *Spica Virginis*, and the *Clara in fronte Scorpii*. I saw nothing to hinder Us from performing as much, since we cannot want instruments, at least, as good as His, if we had but the like industry, and notice also of the time, when the Appearances would present themselves. Though I was not furnish't with very fit Instruments, yet hoping, that I might do somewhat worth my labour, I revolv'd Mr. *Wings Ephemerides* for this year, to find, what Stars the *Moon* might cover, and how often, in her Revolution. Those Occultations, which I collected might be conspicuous, I re-calculated from the exactest Tables, I know in
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being, the *Caroline*, of Mr. *Street*, and these I shall here present you with at large. These Supputations, when I first framed them, I fitted to the Meridian of my habitation, intending them only for my own private use; but upon second consideration, finding, how much the Observations, if rightly and accurately performed, might conduce to the better stating the Dimensions of the Moons Orbits, and solving the Irregularities of several *Phænomena*, I resolv'd to communicate them to the Ingenious, and to desire their utmost care in observing these Appearances, which I had not un-accurately calculated. And I now humbly prostrate them to their perusal, desiring, that, if they seem worthy, you will be pleased to impart them in such a way, as you shall think fit, to such intelligent and industrious persons either of the R. *Society*, or others, as will be accurate in their Observations, and willing to communicate what they shall have observed,

I hope, *My Lord*, you will not account me faulty for having adapted the Calculations to the *Meridian* of a place no more famous than *Derby*. You had the occasion before; to which I may add, that the *Meridian* passing over *Derby* is nearer the middle of *England*, than that of *London*; and that its *Latitude* bisects it nearer, than any yet stated: So that this *Town*, which is seated in *Umbilico quasi Regni*, must needs be the most convenient place, that can be chosen, where-on to fix our Calculations. For, the distance of any place within this kingdom from it, will not much vary the manner of their Appearance in any of the *Phænomena*, except the Eclipse of the Sun: for, in the Occultations, the Stars will appear to pass nearly under the same Angles and Spots of the

Moon ; nor will the times of the *Phases* , or the *Mora sub Luna* differ much in any place of the Kingdom ; nor at all , if a due consideration be had of the *Differences of Meridians* , and the *Laws of Parallaxes*.

I come now to the *Phænomena* themselves. Mr. *Wing's Ephemerides* and others tell us , that we shall have but one Eclipse , and that of the Moon , conspicuous this Year. But , *pace hujus Astronomi* , I dare affirm , that a part of an Eclipse of the Sun will , if the weather permit , be visible to us also : Which I have therefore calculated from the *Caroline Tables* to the *Meridian of Derby* , whose *Longitude* from *London* , I have us'd in this Eclipse , is 6 min. to the West , and *Latitude* 52 deg. 57 min.

By which Tables on Saturday *April 9th.* at the time of Sun-set , supposed at 7 ho. 3 minutes P. M. I find ,

	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>	
The Suns Mean Anomaly	9	21	13	52	
The Moons Mean Anomaly	7	9	31	43	
The Place of her Apogeeum	5	7	40	31	
The Place of her Node	0	21	38	20	
The Suns true place,	γ	29	55	25	
The Moons true place,	δ	0	23	46	
With North-Latitude		0	45	47	
The Point culminating,	Ω	11	6	29	
The Horoscope,	m	0	1	20	
The Altitude of the Moons Center		0	44	10	
The Parallaetical Angle		33	55	35	
The Parallax of the Moon from the Sun in	}	Altitude	0	59	39
		Longitude	0	49	30
		Latitude	0	33	18
Therefore the Moons visible place, in Antecedence of the Sun	γ	29	34	16	
With Visible North-Latitude		0	21	9	
The distance of the Sun and Moons Centers		0	12	29	
The Suns Semi-diameter		0	24	34	
The Moons Semi-diameter	}	0	15	49	
Summe		0	16	7	
Parts defective		0	31	56	
		0	7	22	
		dig.			
Therefore the digits darknd		2	47	40	
The Inclination of this <i>Phasis</i> above the Ecliptick, is		0	30	33	
		deg.			
And from the Suns Zenith		115	31	33	

By this *Calculus* it appears, that the Sun is so far from not being eclipsed, that he is obscured near 3 digits in the setting.

Now to find, when the Eclipse begins, I re-calculate the places of the Sun and Moon to 6 h. 46 m. *P. M.* and investigate

	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>	
The Suns place,	γ	29	54	44	
The Moons place,	δ	0	13	19	
With North-Latitude		0	44	50	
The Mid-heaven,	Ω	6	54	28	
The Point descending,	γ	27	6	10	
The Altitude of the Moons Center		3	1	14	
The Parallaetical Angle		33	7	40	
The Parallax of the Moon from the Sun in	}	Altitude	0	59	33
		Longitude	0	49	56
		Latitude	0	32	54
The Moons Visible place,	γ	29	23	23	
With Visible North-Latitude		0	12	16	
Less then at 7 h. 3 m. by		0	0	13	
Ergo, The Angle of the Moons visible way with the Ecliptick	}	1	8	26	
The Angle of Incidence in the beginning		23	48	18	
Motion seen from 6 h. 46 m. to the inclination		0	1	53	

There-

Therefore the time of the beginning, *6 h. 49 min. P. M.* The first contact will appear *122 d. 55 m.* from the Sun's Zenith. And I am perswaded, that this *Calculus* doth exhibit this *Phænomenon* nearly, as it will appear unto us: And I question not, but that in and near our *Meridian* it will be observable, if the Air hinder not. It is an Appearance that will richly merit the accuratest of our Observations. For the Moon's mean Anomaly being about *7 Sign. 11 deg.* we may the better judge by the Observation, Whether the *Æquations* of her *Orbite* be *Oscillatory*, or not. Nor need we scruple about the *Æquation* of *Natural days*: I have fully demonstrated the *Æquations*, so that I am perswaded, no one hereafter will controvert them; and I shall ere long, if God will, commit them to your and the publick censure.

I suppose the beginning of this Eclipse may, if the Air be serene, appear at *London*; but its *Meridian* being removed to the East from ours, *5* or *6 minutes*, and its Latitude being less, so that the Altitude of the *90 deg.* and consequently the Parallax of Longitude will be greater, and of Latitude, less: It follows, that the Eclipse will be retarded, and that only the beginning thereof, scarce to *one digit* Observation, will there appear; but in the *North* and the *Western* parts of *England* and *Scotland*, it will appear more fully: and in *Ireland* it will be visible to the middle of the Eclipse.

For the well-observing of this noble Appearance, I need not suggest the way of casting the *Species* of the Sun through a good Telescope of a competent length, on an extended paper, placed behind the Eye-glass so far, as that the said *Species* may appear at least *6 inches* over; then dividing both his *Periphery* into *360 degrees*, for the better observing the *Inclination* of the *Cusps* of each *Phasis*; and his *Diameter* into *digits*, and their parts by *Concentrick Circles*, for measuring the quantities of the obscured parts. For the measuring of time, the skilful Observer will be furnished with good *Quadrants*, *Clocks*, or *Pendulums*.

But

But to proceed to the Occultations, that may be made by the Moon, of the lesser Lights; I shall take notice, That those Stars, that have not above 6 *d.* 20 *m.* Latitude from the *Ecliptick*, may all of them, some time or other, be cover'd by the Moon, in her passing through the *Zodiack*: Of which sort I have numbred, from the *Ty-chonick Catalogues*, the Stars so lying as you see in the annex'd Table: And I find in the *Zodiack* 189, with 6 in the *Pleiades*, 12 in the Northern, and 5 in Southern Constellations, plac'd out of the *Ecliptick*; the total is 212. Of these the Moon frequently hides one or other, yet no notice taken of it by the *Ephemerides* of our Astrologers.

It would be too large a labour for one man to undertake the calculating of all the Occultations observable in this year, nor is it perhaps so needful: for, the Stars of the 5th and 6th Magnitude are more numerous, nor so accurately (I doubt) rectified, and the Moon approaching them within 4 or 5 degrees, absconds them to the naked eye; and if the Observation be undertaken with a Telescope, other smaller Stars may be mistaken for those, the *Calculus* intends, and so both the Observer deluded, and the Art prejudiced.

But the Moon will several times this year cover two noted Fix'd Stars; of which, that I may gratifie the Curious, and excite the Industrious to the like endeavors, I shall give here the *Calculus* of the Occultations and Transits, from the *Caroline Tables*.

<i>Aries</i>	12	
<i>Taur.</i>	21	
<i>Gem.</i>	21	
<i>Canc.</i>	12	
<i>Leo</i>	22	
<i>Virg.</i>	18	
<i>Libr.</i>	12	
<i>Scorp.</i>	8	
<i>Sagitt.</i>	14	
<i>Capr.</i>	20	
<i>Aquar.</i>	16	
<i>Pisc.</i>	13	
<i>For. Aurigæ</i>	5	} <i>Bor.</i>
<i>Ophiuch.</i>	7	
<i>Cete</i>	3	} <i>Aust.</i>
<i>Orion.</i>	2	
<i>Pleiad.</i>	6	<i>Bor.</i>
Sum	212	

	<i>d.</i>	<i>m.</i>	<i>sec.</i>
Her visible Motion from 7 <i>h.</i> 28 <i>m.</i> to 8 <i>h.</i> 18 <i>m.</i> is	0	22	52
The difference of the Moons visible Latitudes	0	2	45
The Angle of the Moons visible way with the Eclip.	6	51	27
Her visible Latitude at the apparent Conjunction	1	35	12
The Angle of Immersion beneath a straight line drawn through her Center parallel to the Ecliptic	}	—	
Motion from the Immersion to the visib. Conjunct.	0	9	1
The Angle of Emerision beneath the parallel	37	42	5
The visib. Motion from the 0 <i>m.</i> to the Egress appar.	0	11	30
Apparent Mot. from 7 <i>h.</i> 28 to the Immersion	0	0	36
Apparent Mot. from 8 18 to the Stars Egress	0	1	55
The time from 7 28 to the Sub-ingress	0	2	9
The time from 8 18 to the Stars Emerf.	0	4	22

Therefore the Sub-ingress 7 29 6.
 Emerision 8 13 38.

The Stars *Mora* under the Moon 0 44 32.

The Stars Latitude from a line drawn over the Moons Cen- ter parallel to the Ecliptick	}	in the	}	Immersion	11	17
				Egress	8	50

Over what Spots of the Moon, the seeming way of the Star would pass, I do not here shew, because I dare not rely on our Selenographical Tables. I proceed therefore to the next.

III. *March* 3. in the morning, the Moon passeth over *Antares*, or the *Scorpions heart*, whose Longitude to the *Caroline Author* is then *Scorpio* 5 deg. 7 *m.* 20 *sec.* and Latitude South 4. 27. The Ecliptical Conjunction by the *Ephemerides* was *March* 2. 16 *h.* 54 *m.* P. M. Wherefore, for the better investigating the times of the beginning and end of this Occultation, I have calculated the true and visible places of the Moon to 16 *h.* 39 *m.* 52 *sec.* and to 17 *h.* 49 *m.* 52 *sec.* P. M. by the said Tables to the Meridian and Latitude of *Derby*, as follows;

To 16 h. 39 m. 52 sec. To 17 h. 39 m. 52 sec.

	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>
The Moons mean Anomaly	2	28	22	56	2	29	1	3
Her true place	†	4	41	0	†	5	18	18
The Argument of Latitude	7	12	4	41	7	12	40	10
The Moons true Latit. South		3	32	0		3	34	30
The Horizontal Semi-diameter			15	21			15	21
Parallax			56	45			56	45
The Suns true place	⋈	22	57	21	⋈	23	0	15
The Suns right Ascension		353	32			353	35	
The right Ascension of the Mid-heaven		243	30			261	3	
The Mid-heaven	†	5	26		†	21	47	
The Horoscope	≈	3	10		≈	7	31	
The Angle Orient		18	42			14	15	
The ♀ from the Ascend. in the Eclipt.		58	29			87	47	
In a great Circle		58	33			87	47½	
The true Altit. of the Moons Center		19	21			17	45	
Her Azimuth from the Horoscope		56	26			87	40	
Her Parallactical Angle		79	47			89	26	
Her Parallax in								
{ Altitude			53	50			54	18
{ Longitude			9	33			9	32
{ Latitude			52	59			54	18
Therefore her apparent place	†	4	50	33	†	5	17	46
In Antecedence of the Star			16	47	in conf.	10	26	
With Latitude South, then the Star less			2	1	more	1	48	
So her visible motion to 1 h. 10 m. is						0	27	13
The difference of her Latitudes						0	3	49
The Angle of her visible way with the Ecliptick						7	59	0
The Angle of Incidence under a parallel line to the Ecliptick						6	45	32
Angle of emerfion above the line drawn by the Moons Center						9	12	28
		<i>h.</i>	<i>m.</i>	<i>sec.</i>				
The apparent motion from 16 39 52. to the sub-ingress						1	27	
The apparent motion from 17 39 52. to the emerfion						4	49	
The time from						3	46	t
{ 16 39 52. to the sub-ingress						3	46	t
{ 17 39 52. to the egress of the Star						13	32	
		<i>h.</i>	<i>m.</i>	<i>sec.</i>				
Therefore at Derby the								
{ sub-ingress		16	43	18	} P. M.			
{ emerfion		18	0	24				
The Stars <i>Mora</i> under the Moon		1	18	46.				
						<i>m. sec.</i>		
The Stars Latitude from a line drawn through					} in the	Ingress	1	54
the Moons Center parallel to the Ecliptick						Egress	3	7
								South
								North

At the middle of this Stellar Eclipse the Moons Center is but 20 *sec.* more to the South than the Star; so that, if the Libration of the Moon be known, the protraction of the Star's way in this Appearance will be facile. And this *Phænomenon* is highly worth our strictest Observations; for, the Moon being almost in her *Mean* distance (where there is no great difference among Astronomers about her primary æquations) we may the more securely judge of her *second* inæqualities, and perhaps discover a *third*, which may promote the Moon, and accelerate the times in this Appearance. If diligent heed be given to the times of the sub-ingress and emersion of the Star, and with what Spots on the Moons face it keeps in a right line, we may be well assisted, by the obserued *Mora* to judge of her *Diameter*; for I question not, but her Apparent Horary Motion, may, with some little trouble, be exactly enough investigated either from the *Wingian* or the *Caroline* Tables.

IV. March 24. h. 15. 35 m. P. M. by the *Ephemerides*, the Moon will be in the same *Longit.* with the fore-mention'd Star in *ala Virg*; with almost 2 degrees *North-Latitude*: whence at first I expected an Occultation; but upon a better *Examen* I find the *Caroline* Tables only present a *Transit*, as I shall prove by this *Calculus*, framed to the *Meridian* and *Latitude* of *Derby*: by which at *15 h. 42 m. 24 sec. P. M.*

	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>
The Moons <i>Mean</i> Anomaly is	0	15	10	37
Her true place	≈	0	5	33
The Argument of Latitude	5	6	38	46
The Moons true Latitude North		1	59	16
Her Horizontal Parallax			52	49
Her Horizontal Semi-diameter			14	17
The Suns Right Ascension		13	28	
The Right Ascension of the Mid-heaven		249	4	
The Mid-heaven	‡	10	41	
The Horoscope	≈	12	31	
The Angle Occident		16	58	

	f.	d.	m.	sec.
The Moon from the Horoscope in the Ecliptick		47	34	
In a great Circle		47	36	
Her Azimuth from the Horoscope		45	53	
The Altitude of her Center		14	23	
Her Parallaxial Angle		78	17	
Her Parallax in	}	Altitude	51	21
		Longitude	10	25
		Latitude	50	17
Hence her visible place	☾	29	54	48
With visible North-Latitude		1	8	59
Therefore she is in Antecedence of the Star		15	25	
With less North-Latitude		16	1	

Now the Moons Semi-diameter being only 14 *m.* 17 *sec.* it appears, that the Star is more to the North, than the Moons Limb, by 1 *m.* 44 *sec.* and the Moons Latitude decreasing together with the Altitude of the 93^d degree, causeth the *Apparent* Motion to be visible in a line bending down from the Star; so that near the visible Conjunction the Star may stand about 3 *min.* to the North from the Moons Limb. Though this be not like to prove an Occultation, yet let me desire those, who have fit Glasses and Instruments, to observe this *Transit*; and how far the Star may stand from the Limb of the Moon at the time of the visible Conjunction, that we may be the better enabled to define, both how the Motion of the Moon's Latitudes, which shall need its limitations, is to be reform'd, and whether that *Æquation* of the *Nodes*, allow'd by the *Caroline* Author and some other Moderns, be firm and valid.

V. The last Occultation happens on *May 23*; when 12 *h.* 17 *m.* *P. M.* by the *Ephemerides* the Moon will be in Conjunction with *Antares*. To define the Beginning and End of it, I have computed the Moon's true and visible places to 12 *h.* 28 *min.* 42 *sec.* and 13 *h.* 43 *m.* 40 *sec.* *P. M.* at *Derby*, by the *Caroline Tables*, and I find,

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To 12 h. 28 m. 42 sec. To 13 h. 43⁷. 40

	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>	<i>f.</i>	<i>d.</i>	<i>m.</i>	<i>sec.</i>	
The Moons mean Anomaly	2	17	23	52	2	18	4	41	
Her true place	♄	4	52	48	♄	5	33	41	
The Argument of Latitude	7	15	12	26	7	15	56	11	
The Moons true Latitude South			3	33	0		3	35	37
The Suns true place	♂	12	30	43	♂	12	33	42	
The Suns right Ascension		71	2 ¹			71	5		
Right Ascension of the Mid-heaven		258	13			277	0 ¹		
The Mid-heaven	♄	19	10		♄	6	25		
The Horoscope	♁	1	0	asc.	♁	17	48	desc.	
The Angle Orient		14	41			13	56		
The Moon is dist. from the Horoscope		86	7			47	52		
The true Altitude of the Moon's Center		18	11			13	49		
The Azimuth from the Horoscope asc.		85	55			46	18 ¹	desc.	
Her Parallactical Angle		88	58			80	25		
The Moons Parallax in	}	Altitude		52			54	1	
		Longitude		0	57		8	59	
		Latitude		52	52		53	16	
So the Moons visible place is	♄	4	53	45	♄	5	24	42	
With visible South-Latitude		4	25	52		4	28	53	
In Antecedence of the Star			13	46	in conf.		17	11	
With South-Latitude than the Star less			1	8	greater		1	53	
So the Moons visible motion to 1 h. 14 m. 58 sec. is							30	57	
The difference of her apparent Latitudes							3	1	
The Angle of her way with the Ecliptick							5	34	0
The Angle of Incidence, under a Parallel to	}	the Ecliptick, through the Moons Center	_____		}		4	46	32
The Angle of Emerfion above the said Parallel									
			<i>h.</i>	<i>m.</i>	<i>sec.</i>				
Motion seen from the Sub-ingress to			12	28	42 is			1	12
Motion seen from the Emerfion to			13	43	40 is			2	16
Time from the	}	Sub-ingress to	12	28	42 is			2	54 ¹
		Emerfion to	13	43	40 is			5	28 ¹
Therefore the Stars	}	Sub-ingress at	12	25	48				
		Emerfion at	13	38	12				
The Star's <i>Mora</i> under the Moon			1	12	24				
The Latit. of the Star from a line drawn parallel to the Ecliptick over her Center	}	in the	Sub-ingress		}	<i>m. sec.</i>			
			Emerfion			1 15 South.			
						1 40 North.			

In this Occultation, as in the preceding, the Center of the Moon passes very near the Star, so that we may well hereby define, as was advertised in the last Occultation, both of her *Diameter*, and of the places and *æquations* of her *Nodes*. For in *this*, at 12 h. 28 m. 42 sec. P. M. the mean Node was in *Aries* 19 d. 19 m. 34 sec. and the *æquation* of the Node to be added, 26 m. 52 sec. which makes the true Node *Aries* 19 d. 46 m. 26 sec. But in that of *March* 2 at 16 h. 39 m. 52 sec. the mean Node was in *Aries* 23 d. 39 m. 33 sec. the *æquation* was 55 m. 59 sec. to be subtracted; so the true Node was in *Aries* 22 d. 43 m. 34 sec. Now if this *Æquation* of the *Nodes* should be neglected, it might make about 5 min. difference of the *Latitudes*, which I have here collected. The *Ingenious* therefore will observe with all possible accuracy, both under what spots of the Moon the Stars shall enter and emerge in these and all other Occultations; and they will note the *Times* exactly, considering the benefit, that will thence accrue to *Astronomy*. The *Observers* must not content themselves with the times acquired by *Clocks* or rectified *Watches*, but also take the *Altitudes* of some fixt Star, free from *Refraction*, and remov'd from the *Meridian* both at the beginning and end of the Occultations, with exact *Instruments* of *Brass* well divided.

So far this diligent Author for this time. The other particulars, contained in his Papers, may perhaps be publisht hereafter. We were to reserve a part of this Tract for some other Communications.