



J. Wale del.

A. Grignon sculp.

THE  
YOUNG GENTLEMAN AND LADY'S  
PHILOSOPHY,  
IN A  
CONTINUED SURVEY  
OF THE  
WORKS OF NATURE AND ART;  
*By Way of DIALOGUE.*

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VOLUME I.

CONTAINING,  
The PHILOSOPHY of the HEAVENS  
and of the ATMOSPHERE.

Illustrated by Thirty-three COPPER-PLATES.

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THE SECOND EDITION CORRECTED.

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By BENJAMIN MARTIN.

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L O N D O N,

Printed and Sold by W. OWEN, *Temple-Bar*; and  
by the AUTHOR, at his House in *Fleet-Street*.

MDCCLXXII.

like a *Sky-Rocket*, while they spend themselves, so this *Meteor* seemed like a shooting or *falling Star*, till it became extinguished; according to the Poet.

*Thus oft before tempestuous Winds arise,  
The seeming Stars fall headlong from the Skies,  
And shooting thro' the Darknes, gild the Night  
With sweeping Glories, and long Trails of Light.*

DRYDEN'S VIRGIL.

Thus also *Manilius*;

*But still, when wand'ring Stars adorn the Night,  
The falling Meteors draw long Trains of Light;  
Like Arrows shot from the celestial Bow,  
They cut the Air, and strike our Eyes below.*

LIB. I.

## DIALOGUE V.

### *Of an ECLIPSE of the SUN.*

*Euphrosyne.*

I Have been very anxious about the Weather To-day, how it might chance to fall out, on Account of the Eclipse of the Sun that is to be this Afternoon; but it is at present fine, and I hope the Clouds will forbear, and permit us the extraordinary Sight, especially now you are here.

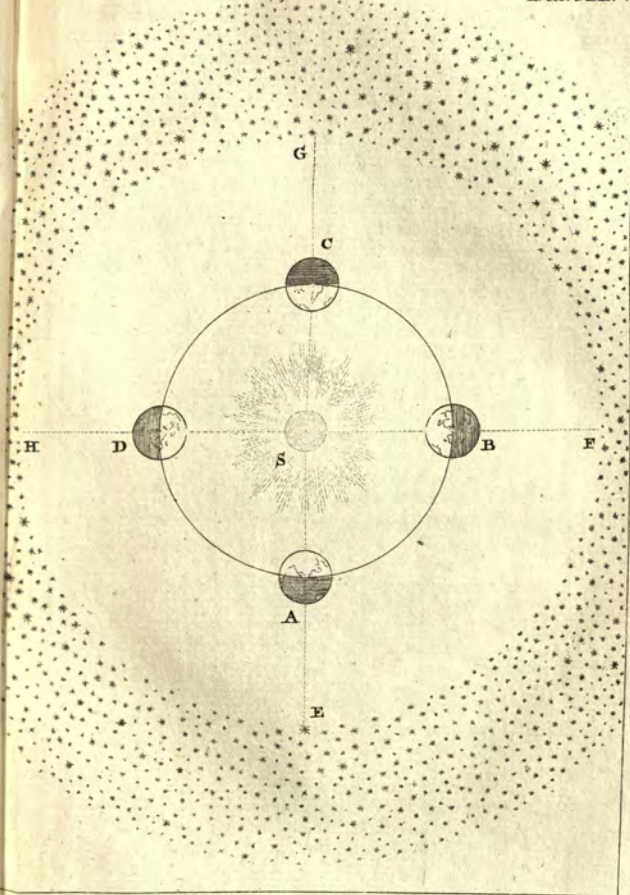
*Cleon.* I believe it will be a fine Day throughout: It will begin just at  $39\frac{1}{2}$  Minutes after Three o'Clock, against which Time I will get the Telescope and darkened Chamber in Readiness for the Observation.

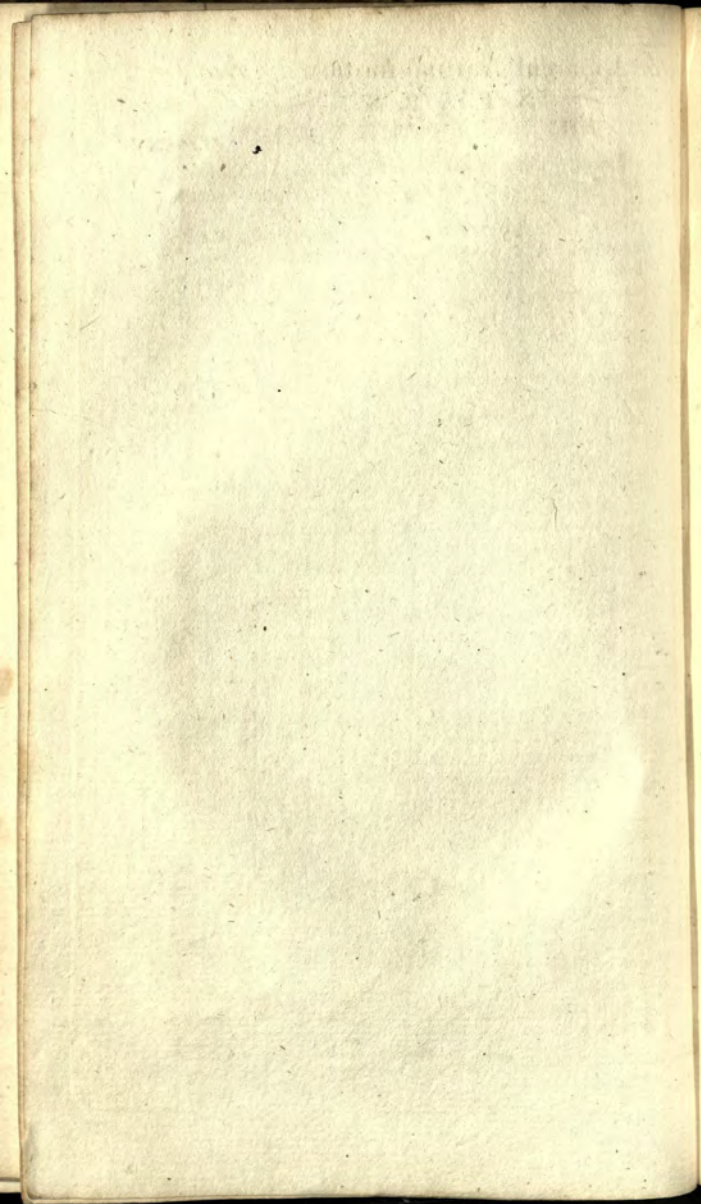
*Euphros.* What I have often wondered at, *Cleonicus*, is, how any Body can tell when an Eclipse will happen so long before-hand, and to such Exactness of Time.

*Cleon.* It does seem wonderful to those who know not the Principles they go upon: but I do assure you, my *Euphrosyne*, the Astronomer can foreknow and predict the Time of an Eclipse to a Minute, with the same Ease, and in the same Time as you can raise a Mince-Pye.

The Apparent Annual motion of the  
S T A R S.

Plate XV.





*Euphras.* Indeed! Well, that old Saying is good,  
*All Things are easy when understood.* But, pray, what is  
the Meaning of the Word *Eclipse*?

*Cleon.* The very Nature of the Thing is implied in  
the Word, which is of Greek Original, and signifies a  
*Defect* or *Deficiency*; and therefore is properly applied to  
express the *Loss of Light* in the *Sun* or *Moon*. The  
Word *Eclipse* also signified to *faint, swoon, or be sick*;  
and was generally applied to People when in a *fainting*  
*Fit, or dying away*; and the ancient ignorant Heathens,  
thinking this to be the Case with the *Sun* and *Moon* at  
such Times, used to say they were *eclipsed*. Thus  
*Lucretius*;

*Eclipses may be solv'd a thousand Ways,  
For if the Moon can stop descending Rays  
By thrusting her dark Self between, and so  
Bring sudden Shade, and Night on all below;  
Then give me Reasons why there cannot be  
Another Thing, too dark for us to see,  
And sit to stop the Rays, as well as she?  
Or, why the circling Sun, in passing by  
Some venomous Places of the neighbouring Sky,  
May not grow sick, and pale, and almost die?  
Those past, grow well, regain his former Light?  
Thus sometime make us Day, and sometime Night.*

BOOK V.

Thus *Virgil* also in his *Petition* to the *Muses*;  
*Give me the Way of wand'ring Stars to know,  
The Depths of Heav'n above, and Earth below;  
Teach me the various Labours of the Moon,  
And whence proceed th' Eclipses of the Sun.*

GEORG. II.

*Euphras.* I could heartily join with *Virgil* in his *Prayer*,  
but I am afraid my *Stars* never designed me for an  
*Astronomer* good enough to understand the *Nature* of  
*Eclipses*.

*Cleon.* Don't think ill of your *Stars* till you know you  
have *Reason*; I believe there are few *Ladies* who have  
not *Intellects* sufficient to understand the general *Doctrine*  
of *Eclipses*, especially as to the *Manner* of them, with-  
out the *mathematical Principles*, on which the *Theory*  
depends.

*Euphros.* I shall be glad if I can be an Instance of this to the rest; I presume you must go to Scheming again, if you intend I should understand any Thing of the Matter.

*Cleon.* Without Figures, or Schemes, none can understand it; but with those Helps they easily may. See here a little Draught of an *Eclipse of the Sun and Moon.*

*Euphros.* I do; and can assure you that it appears at first Sight so easy and expressive, that I am in Hopes I shall give you but little Trouble in the Explication. I see the Earth in its Orbit about the Sun, and the Moon in two Positions in her Orbit about the Earth; in the first, she is between the Earth and Sun, and casts her Shadow upon the Earth; in the latter, she is involved in the Shadow of the Earth, which is then interposed between her and the Sun.

*Cleon.* You conceive a very good Notion of the Thing in general, and a few Particulars explained will give you a good Idea of both Kinds of Eclipses. And first, for an *Eclipse of the Sun*, you see that is occasioned by the *New Moon* coming between the Earth and Sun, by which Means her Shadow often falls upon the Earth in some Part, as at C; for to an Inhabitant at C, the Moon will appear to cover the whole Face of the Sun very nearly, and so cause what we call a *total Eclipse of the Sun*. This is evident by drawing the Lines CMD and COE, (from an Eye at C,) touching the two extreme Parts of the Moon, M and O; for those Lines continued to the Sun will very nearly include his whole Body, as you see; and consequently it can't be seen by the Eye at C.

*Euphros.* I understand you pretty well as to that; but you seem to intimate that the Moon does not wholly and entirely eclipse the Sun's Body, when she is directly between us and him.

*Cleon.* No, she does not always; because her apparent Face or Disk is sometimes somewhat less than the apparent Face of the Sun, the Proportion being about 31 to 32; and therefore in a central Eclipse of the Sun, there will be sometimes a very small *Annulus*, or Ring, on the Sun's Extremity not eclipsed, but visible, as you will see ere long.

*Euphros.* Besides the dark Shadow MCO, there is a fainter Sort of Shadow AMOB; pray, what am I to understand by that?

*Cleon.* That is called the *Penumbra*, or *partial Shadow*, because a Person any where on the Earth's Surface between C and A will see only a Part of the Sun's Face eclipsed; but so much a greater Part as he is nearer to C, or a less Part as he is nearer to A; for 'tis manifest when the Spectator is at A, he will see no Eclipse at all, but the whole Face of the Sun will there be visible, since the Line AME touches the Extremities of the Moon and Sun that are next to each other.

*Euphros.* I apprehend you very well; for since in any Part between C and A there will be more or less of the Sun's Light, the Shadow arising from the eclipsed Part will not be so dark as at C, where there is no Light, or next to none; and the same I see will happen all around the dark Shadow to the Distance of CA or CB.

*Cleon.* I am glad to see you understand the Nature of an Eclipse so well; you will as easily conceive that this penumbral Shadow will be darker about C, and less so towards the Extremities of the Cone A and B, where it becomes insensible.

*Euphros.* I do, *Cleonicus*; but see, the Time is at Hand for the Eclipse to begin—It wants  $5\frac{1}{2}$  Minutes by my Watch.

*Cleon.* Well, we are prepared for it, happen as soon as it will; I have fixed the Telescope in a proper Position for viewing it; and thereby you will see it in the Heavens. I have also darkened the Chamber, wherein you will see the Eclipse in Miniature very perfectly; and have so ordered it that you only need to step out of one Room into another to see both.

*Euphros.* Dear *Cleonicus*, I am greatly obliged to you; but let me seat myself at the Telescope to observe the Beginning.

*Cleon.* Do so immediately; there is a Piece of dark Glass before the Eye-Glass in the Telescope, through which you may view the Sun without hurting your Eyes.



*Euphros.* Very good, *Cleonicus*; let me view him——  
I see his glorious Face, and the several Spots which beautify it——there is yet no Appearance of an Eclipse.

*Cleon.* In half a Minute you'll see it.

*Euphros.* I do:——The Moon just touches him on the right Side——and covers a very small Part——let me see it in the Chamber——

*Cleon.* Look in——

*Euphros.* 'Tis just as I saw it at large in the Telescope; how beautiful it appears in that small Picture! But here it begins on the left Side, how is that?

*Cleon.* That is, because the Image of the Sun is inverted by the single Glass in the Scioptric Ball——See, there is a large Spot, which the Moon will presently hide,—view it in the Telescope——

*Euphros.* I will—the Moon is almost upon it—it disappears—also another small Spot below—she advances apace—the Sun is near one quarter eclipsed—I'll see it now in the dark Chamber——

*Cleon.* Do; I'll look through the Tube—Tell when you see a Spot just going to be hid——

*Euphros.* I will—the dark Circle is very near one on the upper Part——

*Cleon.* I see it,—speak when it disappears——

*Euphros.* The Moon just touches it—'tis gone.——

*Cleon.* I observed it the Instant you spoke; from hence you see how truly every Thing in the Heavens is represented in the large Picture of the Sun, in the Focus of a proper Glass, when the Room is dark.

*Euphros.* Very finely, indeed; I never observed an Eclipse with so much Pleasure and Exactness before——  
But see, methinks it begins to appear somewhat darkish, or else 'tis my Fancy——

*Cleon.* The Sun is now about two thirds eclipsed, and the Day-light begins to be sensibly diminished, and will be so in a few Minutes.——

*Euphros.* 'Tis darker than it was—I'll view the Sun again—he appears horned like the Moon in her last Quarter;—a great Cluster of Spots will be hid by-and-by.—

*Cleon.* They will so—the Darkness increases very sensibly—the Air seems obscured, you will quickly see the Stars——

*Euphros.* The Stars! Will it be so dark as to make them visible?

*Cleon.* Visible! yes, for a considerable Time; you will see Day converted into Night——

*Euphros.* Bless me, you make me shudder at the Thought——  
The Spots are gone, *Cleonicus.*

*Cleon.* They are, I see, in the Image——see, from the Window, how the People stare and are surprized in the Street——

*Euphros.* Surpriz'd, and well they may; I believe they never saw it so dark in the Day-time before—How dark it is!

*Cleon.* It will be much darker by-and-by——in about three or four Minutes the Sun will be totally eclipsed——

*Euphros.* I find it cold too, as well as dark, *Cleonicus.*

*Cleon.* It is cold——see the Owl flying over yonder Meadow——she thinks 'tis Night.

*Euphros.* I see her——she halloos too——Hark! there's a general Murmur in the Streets—I heard one say he believed the World was going to be at an End——

*Cleon.* Very likely; they can't tell what to think of a Thing so very strange——See, yonder, a large Star appears——

*Euphros.* I see it——and many more——I believe the Sun is nearly quite eclipsed——The Birds chirrup, cry, and fly to the Hedges, as if very much frightened——

*Cleon.* They really are so——the Sun is now totally eclipsed.

*Euphros.* Look, see how the Beasts run under the Trees——what do the poor Creatures think!

*Cleon.* Think! they can't tell what the Matter is,——they know 'tis something very extraordinary——There has been many a Night not so dark as it is now.

*Euphros.* That I am sure of——well 'tis very surprizing——

*Cleon.* So it is, to see the *two great Lights* of Heaven in a Manner both extinguished!

*Euphros.* The greatest Darkness is over I see——Pray, was it ever so dark in an Eclipse before?

*Cleon.* Yes, and sometimes of longer Continuance.

*Euphros.* Do there often happen such very great and total Eclipses of the Sun?

*Cleon.* To some Part of the Earth or other there does; but not in any one Place; for in *England* I know not of

above two total Eclipses that have happened in this or the last Century, *viz.* one in 1652, on *Monday March 29*; and the other in 1715, 21st of *April*, when it was total about two Minutes of Time. The next great Eclipse happened in 1737, *Feb.* 18. Another pretty large one happened in 1748 on the 13th of *July*; besides these, we have no other to happen 'till the Year 1764, when more than five Parts out of six of the Sun's Diameter will be eclipsed\*.

*Euphros.* The Thing would not be so strange if it happened often.—The Sun recovers his Splendor apace—the Stars begin to disappear; and the Beasts retreat from their Coverts to the open Fields again.

*Cleon.* Yes, 'twill soon be Day once more; these ecliptic Nights last but a little Time; they are scarce sufficient for a Nap——

*Euphros.* Pray, how large may the dark Shadow of the Moon be on the Part of the Earth which it sweeps?

*Cleon.* When at a mean, it takes in the Compass of about 150 Miles; and when greatest it extends to 220 Miles.

*Euphros.* But what you call the Penumbral Shadow, I see, is vastly larger——

*Cleon.* Yes, it is so; it involves a Part of the Earth's Surface, no less than about *four thousand three hundred and ninety-seven Miles* over, at a Mean; and when greatest, it takes in about 600 Miles more; and therefore all People about us, to the Distance of near two thousand five hundred Miles, will see the Sun eclipsed more or less.

*Euphros.* The Eclipse, I see, is nearly at an End; I do assure you, *Cleonicus*, I never spent  $2\frac{1}{2}$  Hours with more Pleasure and agreeable Surprize than now.—If you please, we will now go to drink Tea, and then I shall trouble you with a few more Questions about an Eclipse of the Moon.

*Cleon.* With all my Heart, my *Euphrosyne*; you know nothing gives me a greater Pleasure than to satisfy your Enquiries about natural Things.

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\* This proved a most beautiful *Annular Eclipse*, for the Moon's Disk being at that Time less than the Sun's, left a Ring on the Sun's Limb not eclipsed.

DIALOGUE VI.  
Of an ECLIPSE of the MOON.

*Euphrosyne.*

**A**S the Eclipses of the Sun which are visible to us must always happen in the Day-time, so those of the Moon must ever be in the Night, I conceive, *Cleonicus*.

*Cleon.* And very justly, Sister; for since an Eclipse of the Moon can never happen, but when the Moon is at Full; and since the Moon is then in Opposition to the Sun, she will rise when the Sun sets; therefore no Eclipse of the Moon can be seen by us till after Sun-set. But the Moon may, and often does, rise and set eclipsed as well as the Sun.

*Euphros.* As I said before, I need not ask how an Eclipse of the Moon happens, for 'tis plain from the Scheme, that it is by the Moon's passing through the dark Shadow of the Earth FGLN.

*Cleon.* It is so; for the Earth at that Time coming between the Sun and Moon, and being much larger than the Moon, does cast so large a Shadow as often involves the Moon a considerable Time therein. According to *Lucretius*:

*So whilst the Moons their monthly Courses run  
Within the Reach of Earth's dark shadowing Cone,  
The Earth, revengeful, stops the streaming Light,  
And hides the sick'ning Moon in Gloom of Night.*

*Euphros.* The sick'ning Moon. I think it is a very beautiful Metaphor on that Occasion.

*Cleon.* It is so; and it is only a Metaphor in the Poet; but the Vulgar among the Ancients did indeed believe that the Moon was actually sick, and laboured as in an Agony, and suffered a Kind of Death.

*Euphros.* Indeed! Pray, how came they by such a Notion?

*Cleon.* Their Superstition taught them to look on the Moon as the Goddess who presided over the Earth; and their Credulity (for the Ignorant believe any Thing) made them fit Fools for Magicians and Inchanters to work upon; for these deceitful Wretches made them believe that

that it was in their Power to bring the Goddess down from her Sphere, and to torture her by muttering over some Charms and Incantations in Verse; to which Milton thus ironically alludes,

*Not uglier follow'd the Night Hag, when call'd  
In secret Riding thro' the Air, she comes  
Lur'd by the Smell of Infant Blood to dance.  
With Lapland Witches, while the lab'ring Moon  
Eclipses at their Charms.—*

And also Butler;

*Or putting Tricks upon the Moon,  
Which by Confederacy are done.  
Your antient Conjurers were wont  
To make her from her Sphere dismount;  
And to their Incantations stoop.—*

Yea, so great was the Stupidity and Ignorance of the Ancients, that even *Stesichorus* and *Pindar*, two Poets of great Name, were of this ridiculous Opinion, if we believe *Pliny* the Historian.

*Euphras.* And, pray, what did the poor deluded Mortals do in Behalf of their Deity, in such a disastrous Case?

*Cleon.* Do! You'll smile to hear what they did; they endeavoured to relieve her by ringing of Bells, sounding Trumpets, beating of brass Vessels, and making great Noises by hallooing, hooting, &c. to drown the muttering of Witches that the Moon might not hear them, and so receive no Harm. According to *Lee's* Imitation in his *Oedipus*—

*—The silver Moon is all o'er Blood:  
A setting Crimson stains her beauteous Face;  
Sound there, sound all our Instruments of War,  
Clarions, and Trumpets, silver, brass, and iron,  
And beat a thousand Drums to help her Labour.*

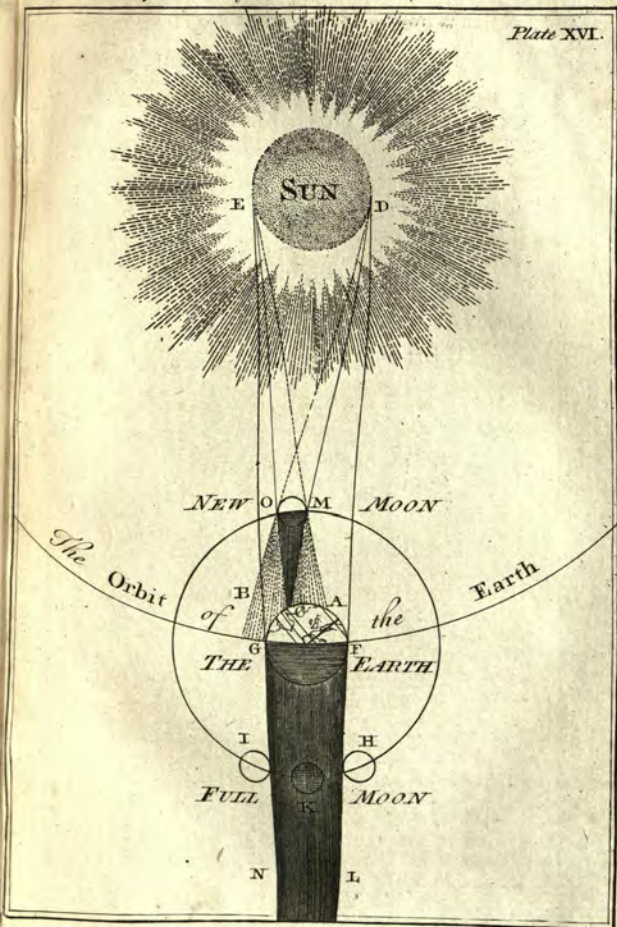
And *Medea*, boasting of her enchanting Power in *Ovid*, says,

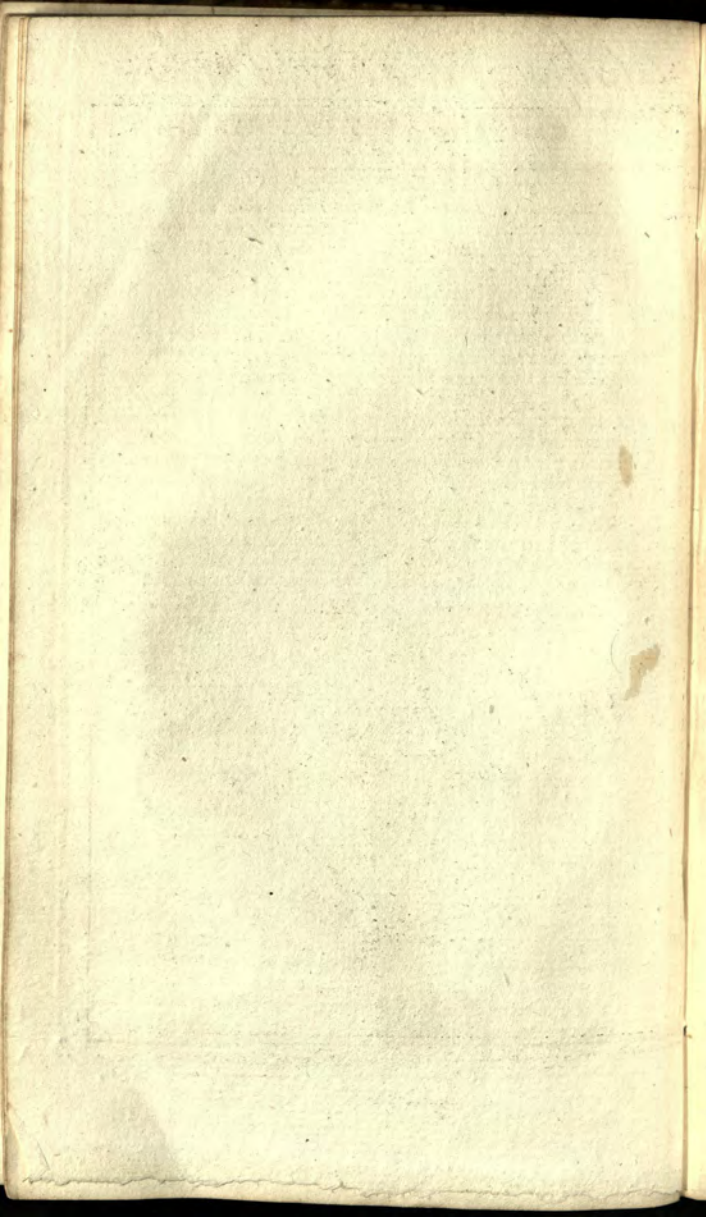
*I cleave the Rocks, the knotted Oaks I break,  
Remove the Forests, and the Mountains shake;  
Force Earth to groan through all her hollow Caves,  
And call the slumb'ring Ghosts, from silent Graves.  
Thee too, O Luna! from thy Sphere I call,  
Tho' Brass relieves thee, and obstructs thy Fall.*

METAM. Lib. VII.

*An Eclipse of the SUN and MOON.*

*Plate XVI.*





And thus *Tibullus*;

*Whene'er the Moon is forc'd from wand'ring Stars,  
The Midwife Nations sound from far the Brass.*

And lastly, *Juvenal*, speaking of a loud scolding Woman, says pleasantly, that she alone was able to relieve the Moon out of the Labour of an Eclipse—

*Forbear your Drums and Trumpets, if you please,  
Her Voice alone the lab'ring Moon can ease.*

And this strange and absurd Piece of Superstition is practis'd to this Day among the *Turks* and *Heathen Nations* with many and various ridiculous Ceremonies more than I have related, as *Historians* inform us.

*Euphras.* Well, you have entertained me with a pleasant Digression, which thoroughly convinces me how necessary it is for every one to study Philosophy who would have but a tolerable Notion of Things, and not be absurd and ridiculous in his Sentiments. But to return to the Matter—Pray, in how many Particulars does an *Eclipse of the Moon* differ from an *Eclipse of the Sun*?

*Cleon.* In the following, *viz.* First, The Moon is really and truly eclipsed by the Shadow of the Earth; whereas in a *Solar Eclipse* the Sun is not eclipsed, but the Earth by the Shadow of the Moon.

Secondly; An Eclipse of the Moon begins on the East Side or Limb, and ends on the West; but the contrary happens in a *Solar Eclipse*.

Thirdly; The *Lunar Eclipses* are more frequent to any one Place than *Solar Eclipses*. Because,

Fourthly; An Eclipse of the Moon appears from all Parts of the Earth to be the same as it really is; whereas an Eclipse of the Sun does not; but may be total in one Part, partial in another, and none at all to others, at the same Time.

Fifthly; But *Solar Eclipses* are more frequent with respect to the whole Earth than the *Lunar ones*; because the large *Penumbra* of the Moon can oftener fall on the broad Surface of the Earth than the small *Globe* of the Moon can fall into the conical Shadow of the Earth.

Sixthly; The total Darkness of a *Lunar Eclipse* lasteth  $1\frac{1}{2}$  Hour, sometimes more; but that of a *Solar Eclipse* not above two Minutes.

These



These are the principal Differences of Eclipses, Solar and Lunar.

*Euphros.* I thank you, *Cleonicus*; you take a great deal of Pains with me; but one Question more. Pray, do you know the Dimensions of the Earth's Shadow at the Distance of the Moon?

*Cleon.* Yes; the Shadow of the Earth, where the Moon passes through it, is about 5900 Miles in Diameter, which is almost three Times the Diameter of the Moon.

*Euphros.* How long may an Eclipse of the Moon continue from first to last when greatest?

*Cleon.* From the Time of the Moon's Immersion into the Shadow at I, to the Time of her Emerision at H, is sometimes  $3\frac{1}{2}$  Hours, and sometimes more; and the Time of total Darknes is generally  $1\frac{1}{2}$  Hour, as I told you before.

*Euphros.* I have a few more Questions concerning Eclipses that I want resolved; but on Account of the Visit we are to make this Evening, must refer them to another Season.

## DIALOGUE VII.

*Of the Boundaries, and Number of Eclipses, and the Times of the Year when they happen.*

*Cleonicus.*

I Remember, *Euphrosyne*, you told me, when we last discoursed of Eclipses, you had several Questions more to ask concerning them; if you'll now propose them I'll endeavour to give you Satisfaction in each Particular.

*Euphros.* One thing I have often wanted to know, why our Almanacks of several Years present us with different Numbers of Eclipses, sometimes they tell us we shall have *two*, sometimes *four*, and at other Times *six*: Also, why they happen at some certain *new* and *full Moons* and not at others; and other such like Matters,

*Cleon.* That I may give you a good Idea of such Things, it is necessary you should conceive it by a little easy Instrument of two circular Pieces of Pafteboard which I have here prepared, and contrived to fhew the Nature of the Thing. One of these Pieces AFMP is to represent the Plane of the Moon's Orbit.—

*Euphros.* Very good! and what is the other design'd for?

*Cleon.* The other Piece UFLP, represents the Plane in which the Sun, or the Earth's Shadow appears to move in at the Distance of the Moon. For in the Firmament, the Sun seems to go in the same Tract very nearly with the Moon; and if the conical Shadow of the Earth were cut through, at the Distance of the Moon, that Section would appear a dark circular Space, and to move in the same Tract with the Sun.

*Euphros.* Well; and how then?

*Cleon.* Then the Edge of the circular Piece AFMP will represent the Orbit of the Moon, and that of the other Piece the Orbit of the Sun, or (in other Words) the Ecliptic, at the Distance of the Moon.

*Euphros.* So far I apprehend you pretty well; pray, proceed.

*Cleon.* In the last Place, you must know, that the Plane of the Moon's Orbit does not lie exactly level with the Plane of the Ecliptic, but one Half below it, and the other above it, just as you see me put these two Pieces of Pafteboard together.

*Euphros.* I see your Meaning plain; the Half FAP lies below the Ecliptic, and the other Half FMP above it.

*Cleon.* Well, then the Distance between these Planes is called the *Latitude of the Moon*; that below the Ecliptic is the *South Latitude*, the other above it the *North Latitude*; because the Moon in describing the lower Part FAP is Southward of the Sun; but in the o her Half FMP she is Northward of it.

*Euphros.* I understand you so far very well; pray go on.

*Cleon.* Also the Points F and P, where the Planes cross each other, are called the *Nodes*; and F the *Ascending Node*, because there the Moon rises above the

Ecliptic,

Ecliptic, and is thus marked  $\infty$ ; the other, P, is the *Descending Node*, marked thus  $\infty$ : And now having sufficiently explained the Instrument, it will be very easy to understand the Things you enquire farther of Eclipses.

*Euphros.* If so, I shall be very glad; and pray let me know when, or in what Part of the Moon's Orbit there may, and when there may not be an Eclipse?

*Cleon.* I shall satisfy your Enquiry first of *Solar Eclipses*; and therefore from what I have already said, you will easily conceive, that a Spectator at the Earth,  $a b c$ , will view the apparent Faces of the Sun and Moon very nearly equal at the Distance of the Moon; and consequently the Moon journeying round every Month in her Orbit AFMP, and the equal Solar Disk moving round the Ecliptic UFLP, which two Orbits intersect each other at F and P; it must happen that in the Course of a Year the Sun will be seen in the Nodes F and P, at two different, and almost opposite Seasons of the Year; and will be for some Time so near them on each Side, that when the Moon passes that Part of her Orbit, she must necessarily hide or cover either the Whole or Part of the Sun's Disk or Face, and so produce an *Eclipse of the Sun*, total or partial: For since the Inclination or Distance between the two Orbits grows less and less from AU, where it is greatest, towards the Nodes where it is nothing; so there must be a certain visible Latitude or Distance as at C, B, which is just equal to the Sum of half the Diameters of the Moon B, and Sun C; (because the greatest Latitude, AU or IM, far exceeds that Sum.) Again, since the visible Latitude BC is equal to the half Diameters of the Sun and Moon, the Moon in passing along will just touch the lower or Southern Limb of the Sun, but cover no Part of his Surface: Consequently any new Moon before the Point B, as at  $d$ , will have such a Latitude from the Sun at  $e$ , as will exceed the Sum of their half Diameters, and so will be seen to pass at some Distance below the Sun, and not touch it.—But if the new Moon appears nearer to the Node F, as at D, where her Latitude from the Sun at E is less than the said Sum of the half Diameters of the Sun and Moon, then the Moon will be seen to pass over a Part of the Sun's

Sun's Disk, and so cause a *partial Eclipse* of the Sun where it is visible.

Once more; if the new Moon happens in the very Node itself, as at P, the Sun being there also, the Moon then having no Latitude must necessarily pass over the whole Disk of the Sun, and so produce a *central and total Eclipse of the Sun*.

Lastly; New Moons on the other Side of the Node F, to the same Distance GH, will produce Eclipses, more or less, on the upper or northern Part of the Sun; but at H the Sum of the half Diameters and visible Latitude being again equal, the Luminaries will there but just touch each other; and in all Parts farther from the Node, as at K, there will be no Eclipse possible; for the Moon will then pass above the Disk of the Sun.

*Euphros.* It is all very evident; and therefore I presume the Points B and H in the Moon's Orbit are what you call the *ecliptic Boundaries, or Limits of Solar Eclipses*.

*Cleon.* Yes, they are so; and now with Respect to *Lunar Eclipses*, we must turn our Eye to the opposite Parts of the Orbits on each Side the Node P, where we shall view the *Full-Moon* in her Orbit, and the Section of the Earth's Shadow at the Distance of the Moon's Orbit in the Points O, P, Q, S.

Now, in the first Place, let us consider that if the *Full-Moon* happens at N or R, where the Earth's Shadow passing by, just touches it, then in any Point between N and R, the said Shadow will more or less involve the Moon, and so cause a *Lunar Eclipse* in a greater or lesser Degree; and therefore those two Points, N and R, in the Lunar Orbit, where the Sum of the half Diameters of the Moon and Earth's Shadow is equal to the true Latitude of the Moon, are the *Boundaries or Limits of Lunar Eclipses*, on each Side the Node P.

Again, in the second Place; the nearer the Moon is to the Node P, the greater will be the Eclipse, and therefore greatest of all, and central, in the Node itself, where the Shadow of the Earth is near three Times greater than the Moon, as I formerly told you.

*Euphros.* The Manner of explaining the Boundaries of a *Lunar Eclipse* I see is the same nearly as that of the Solar

Solar ones, and as easily understood. But unless I could tell which were greatest, the *Sum of the half Diameters of the Sun and Moon*, or of the *Shadow and Moon*, I can't tell which would be greatest, the Limits of a *Solar or Lunar Eclipse*.

*Cleon.* Though the latter Sum be in itself greater than the former, yet the former, with Respect to the *visible Latitude* of the Moon, is greater than the latter, in Regard of her true *Latitude*; and therefore the *Limits of a Solar Eclipse exceed those of a Lunar one*.

*Euphros.* I should be glad to know in what Time the Sun moves over the ecliptic Limit CG.

*Cleon.* These Limits are somewhat variable; but when CG is least, the Sun takes up about 28 Days in passing over it, and 32 Days when greatest.

*Euphros.* And pray what is the Time between one new Moon and another?

*Cleon.* Twenty-nine Days and an half.

*Euphros.* Why then, when the Limit CG is greatest, there must necessarily be an Eclipse of the Sun during his Stay within that Limit; but when it is least, I perceive it is possible there may be no Eclipse of the Sun that Node.

*Cleon.* 'Tis indeed possible there may not; but the Chance there will not is so very great, that it was never known to happen, I believe. On the other Hand, when the Limit is least there is *one* Eclipse very certain, and there may be *two* when greatest; and this sometimes happens, as in the Year 1736, 1743, &c. But these twin Eclipses are very small, and almost always to us invisible.

*Euphros.* Of all this I conceive the Reason pretty well; and now for the other Node: Pray how long is the Shadow of the Earth within the *Lunar Limit OQ*?

*Cleon.* This Limit is also variable; and when greatest, the Shadow passeth it in 24 Days; and when least, in 19 Days.

*Euphros.* Then since from Full Moon to Full Moon there is 29 Days and an half, if the Full Moon should happen in the Beginning of the Limit, as at N, before the Moon could again return to the same Node, the Shadow would be past the other Limit Q; and so there would

would be no Eclipse of the Moon, in such a Case, at that Node, even when the Limit is the greatest of all.

*Cleon.* Very well observed, *Euphrosyne*; nor can there ever be two Lunar Eclipses together at the same Node, when the Limit is greatest; so that upon the whole you see there can be but one Eclipse of the Moon within the Lunar Limits, and sometimes none at all.

*Euphros.* Then I see 'tis possible, that in some Years there may be no Lunar Eclipse at all.

*Cleon.* Yes, it is; and thus it happened in the Years 1734, 1738, 1745, 1752, and in the present Year 1756, and will again happen in 1763; for in these Years there was no Eclipse of the Moon; and but two of the Sun, and both invisible to us, except that of *August* the 3d, 1738.

*Euphros.* We find by Experience that the Solar and Lunar Eclipses happen both at the same Times of the Year, which is also evident from the Instrument.

*Cleon.* It is so; for the new Moon, which obscures the Sun in the Solar Limit, is itself eclipsed by the Shadow of the Earth at the Lunar Limit, when it is next at Full.

*Euphros.* I understand you very well; and I farther observe, that as the Nodes F and P are in opposite Points of the Orbit, so after half a Year, the Nodes will change their Nature, and that which is now the *Solar Node* will then become the *Lunar*; and the *Lunar Node* that now is, will then become the *Solar Node*, and will be the Season of Eclipses again.

*Cleon.* It will not be quite half a Year between, because the Sun, for Instance, may be eclipsed at the End of one Limit, as at G, (as in the Year 1732, *December* 6) and at the Beginning of the other at O, (as *May* 2, 1733) in which Time there intervened not above 147 Days, which is short of half a Year by 35 Days. Yea, the Sun may leave one Limit, and arrive to the next in about four Months and an half, as in the Year 1740 the Sun was eclipsed *Jan.* 17, and again in *June* 12; and another Reason for this is, that the Nodes F and P are not fixed, but move in a retrograde Manner, so as that the distant Node is carried towards the Sun, and they meet near ten Days sooner than if the Node were fixed.

*Euphros.* Well, I am not now so much at a Loss to guess the Reason why we have in different Years a different Number of Eclipses; why one Year *four*, another *two*, and a third Year *five* or *six*; and also the Reason why they happen at such and such Intervals and Seasons of the Year: This Doctrine of Nodes and Limits has given me the *Rationale* of Eclipses beyond whatever I expected; and now to be plain with you, I am got to a *ne plus ultra*, for I know not what further to ask or say on the Subject of Eclipses.

*Cleon.* We have pretty well exhausted the Subject, indeed, *Euphrosyne*, and I shall only observe to you next, that the Year 1740 had six Eclipses in a very peculiar Manner; for in those Years wherein six Eclipses happen, there are generally *two of the Sun and one of the Moon* at each ecliptic Season; but in that Year there were three ecliptic Seasons, or the Luminaries came three Times within the ecliptic Limits, and each of them suffered an Eclipse each Time; so that in that Year there were three Eclipses of the Sun, and three of the Moon; a Thing which very rarely happens. But Eclipses, like all other Things, in a long Course of Time, undergo a great Variety of Mutations and Changes, in the Circumstances we have now been considering.

*Thus I've the Motions taught of STARS above,  
Of SUN, and MOON, and by what Cause they move;  
And how eclips'd they lose their gaudy Light,  
And spread o'er all an unexpected Night,  
As if they wink'd, and then with open Eyes  
View'd all again, and clear'd the lower Skies.*

Creech's Lucretius, Book V.

## DIALOGUE VIII.

*Reflections on the Immensity of the Universe, and of the Plurality of Worlds.*

*Euphrosyne.*

THE Conversations which have passed between us of late, have opened a new and strange Scene of Things to my Mind, and given quite a new turn to my Thoughts;