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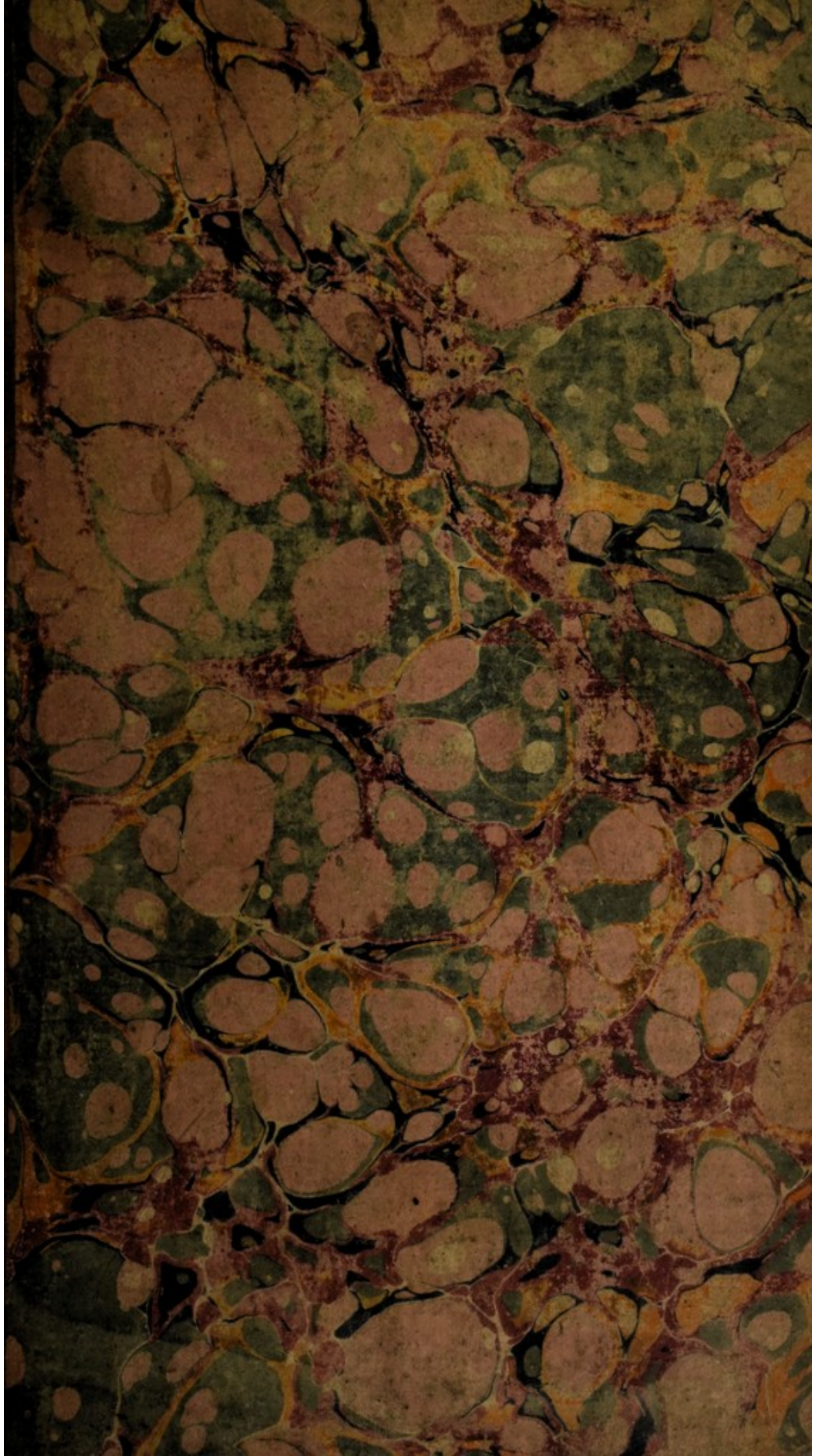
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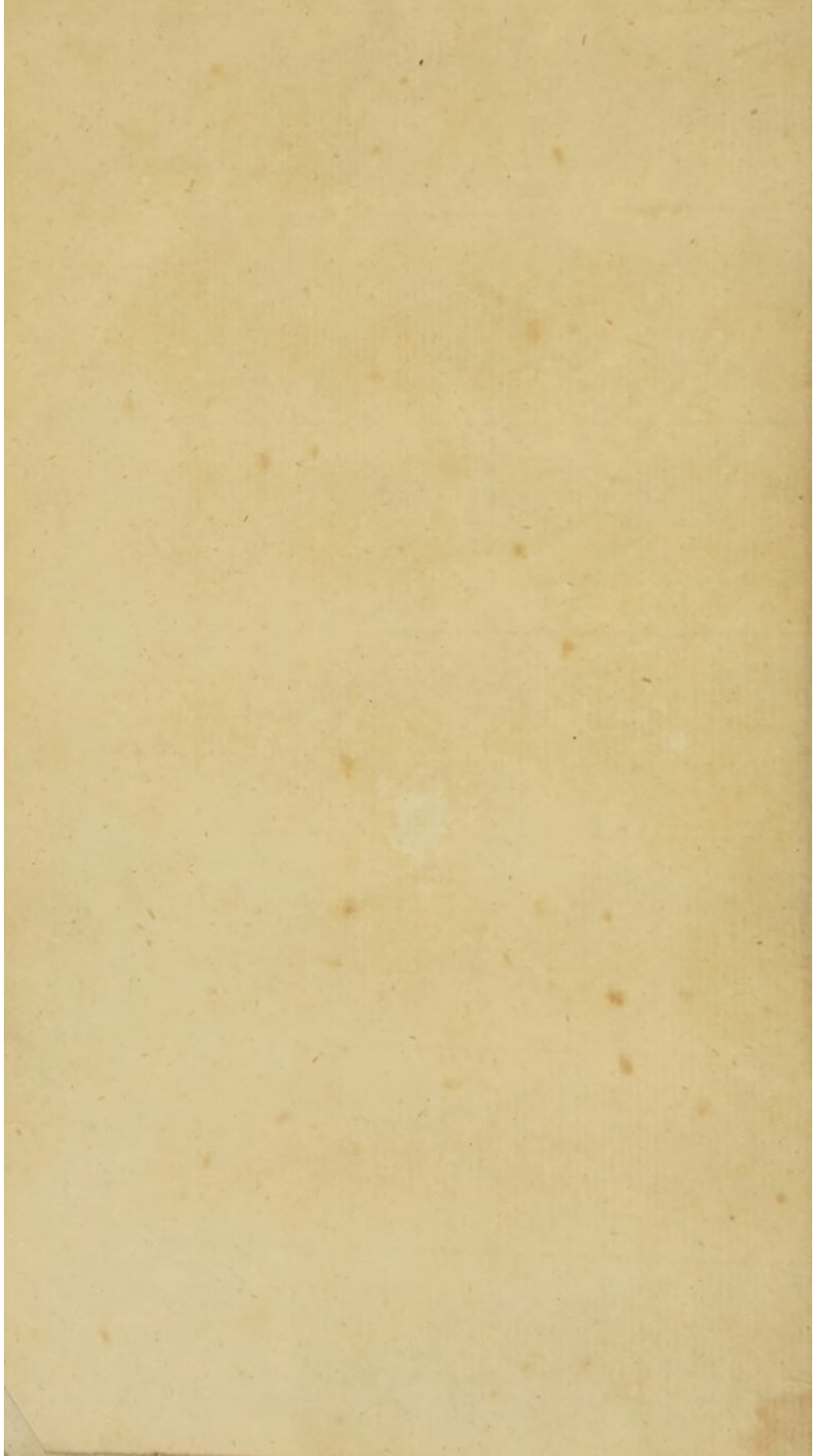


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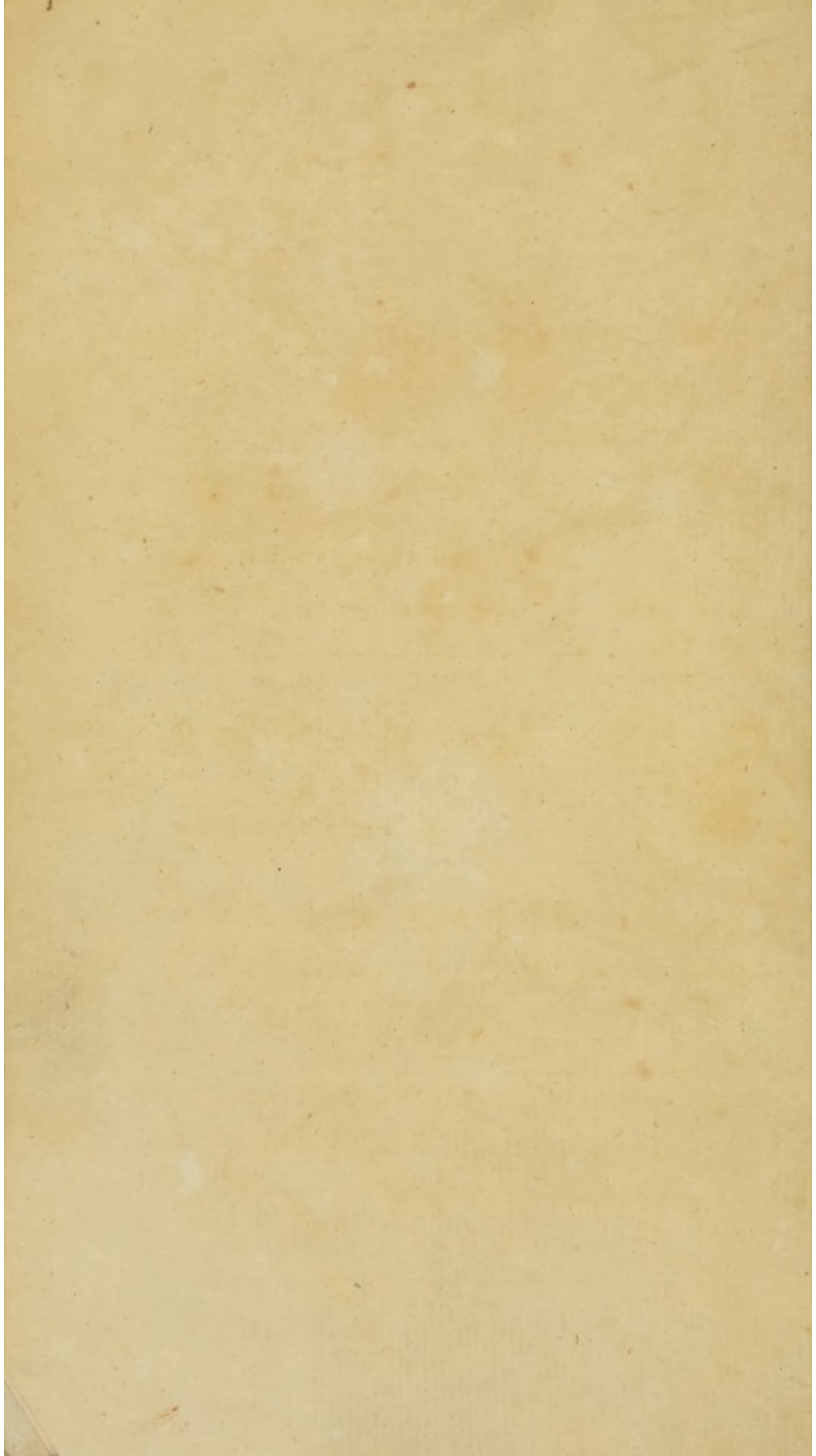
THE

ECONOMY

OF


THE METS

1844



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ASTRONOMY
OF
COMETS.

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T H E
A S T R O N O M Y
O F
C O M E T S.
I N T W O P A R T S.

PART I. Containing a Physical Account of the SOLAR SYSTEM; the whole THEORY of COMETS, with the Rationale, or Physical Causes of these Phænomena, from the earliest Ages to the present Time.

PART II. Containing the Practical Methods of Calculation. First, by the Properties of the Parabola without Tables; and secondly, by Tables prefixed to the Work, with the Construction of the Tables, whereby the PLACE and DISTANCE of a Comet from the Earth, together with its Latitude and Longitude in the Ecliptic, may, for any Time, be known, by any one who has but a common Skill in Plane Trigonometry. The whole Process of Calculation exemplified in the Comet which is expected to make its Appearance in the Year 1789.

B Y B L Y T H H A N C O C K,
TEACHER OF THE MATHEMATICS.

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M D C C L X X X V I .



(v)

TO THE

Fraternity of United Friars;

OR,

SOCIETY *for the* PARTICIPATION
of USEFUL KNOWLEDGE,

IN

N O R W I C H.

GENTLEMEN,

THE social principle in man is of such an expansive nature, that it cannot be confined to a family, a few friends, or to a neighbourhood, but spreads into wider systems, and draws men into larger communities and commonwealths; in which only the sublime powers of our nature attain the highest improvement and perfection of which they are capable. In society, the mutual aids which men give and receive from each other,

shorten the labours of each; and the combined strength and reason of individuals give security and protection to the whole body.

Your laudable design in encouraging and promoting the sciences, is a sufficient apology for my desiring the honour of inscribing the following sheets to you; not doubting but that your goodness will pardon the liberty I have taken, as it will afford me an opportunity of testifying the high respect and esteem with which I am,

GENTLEMEN,

Your most devoted,

most obedient, and

most humble Servant,

NORWICH,
June 20, 1786.

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E C L I P S E S.

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P R E F A C E.

IN the following Treatise of Cometary Astronomy, I have endeavoured to illustrate the THEORY OF COMETS, so far as I judged any thing of that kind could be desired or expected by the Public: for, as the time is approaching, when that part of astronomical knowledge, which, as yet, is but in its infancy, may receive considerable improvement; or, possibly, may be brought to as great perfection as it is capable of receiving for an age or two to come; I concluded it would be deemed an acceptable piece of service to the younger students in the science of Astronomy, to have the theory of those wonderful bodies in our system, called

called Comets, and their motions, illustrated by *Practical Rules*, containing an easy solution of all the principal problems relating thereto, and applied to that very Comet on which they will soon have an opportunity of making their observations, and proving the same by experiments.

To this purpose, I have premised as much concerning the *Natural History* and *Philosophy* of Comets, as I thought could be of any use, having consulted the best writers on that subject.

But, as the Theory of Comets, in the writings of those learned Authors, is chiefly speculative, and interwoven with great difficulties, I have selected those parts only, which I thought would be easy and useful to such readers as are but moderately versed in trigonometry. To make such ready in cometary calculations, I have added all the necessary tables, and shewn the operation in every part.

I have also given proper directions how to proceed in representing the visible path of a Comet on the celestial globe, whenever it appears; and have endeavoured altogether, as far as my abilities extended, to render the study of Cometary Astronomy easy, familiar, and entertaining.

THE direful Comets urge,
 Glaring tremendous through the vast expanse,
 Threat'ning destruction, and the wrecks of worlds;
 But that strict bounds direct and guide their course,
 Set, when th' ALMIGHTY, in creating hour,
 From Chaos call'd the glorious Universe,
 And fix'd the Stars, and bid the Planets move.
 Where Æther's space immense eludes our view,
 And Planets in their orbs in order range,
 There, free as air, the fiery Comets rove,
 And direful orbs their rapid course extend:
 Nor are their ways confus'd or intricate;
 Irregular, in winding mazes lost,
 Eccentric Error, constant to itself,
 To one law subject, one unerring rule
 Of force attractive; thus, unweary'd, they
 Now sweep the utmost confines of the world,
 Now basking in the neighb'r'ood of the Sun,
 Then swiftly flying his too piercing heat,
 Rejoicing, they ascend, their labours to resume.
 Long tracts of light attend their dreadful course,
 (But trust not to thy view a foreign light)
 And spurious honours deck their glowing mass;
 Dense atmospheres emit their furtive beams,
 Frequent and thick, by heat intense exhal'd:
 The Moon thus, with fraternal lustre bright,
 Darts borrow'd rays, and glories not her own.

INTRODUCTION.

THE ensuing Treatise is not intended to explain any thing new in the Theory of Comets, but rather, to render the practice of computing the returns of such Comets as have been taken notice of by Astronomers, and to calculate their places in the Heavens, both in respect of longitude and latitude, where they will appear at any required or given time, either before or after their perihelion; and although several more learned, and by far more able men, have professedly written thereon, yet are their works too complex and abstruse for the comprehension of learners. My sole purpose is therefore to render the process of calculation plain and easy to such capacities as may not have made so much progress in mathematical studies, as to comprehend what has been
written

written by more eminent authors: and this I shall endeavour by two methods; first, by the properties of the parabola, without tables; and secondly, by the method shewn by the celebrated Doctor Halley, by the help of tables, prefixed to this work; and, as an introduction to the work, shall give the following physical account of the Planetary System, and of the Theory of Comets, containing so much of the rationale, or physical causes of these phænomena, as may be consistent with my design.

T H E
A S T R O N O M Y
O F
C O M E T S.

P A R T I.

ASTRONOMY is justly acknowledged by all men to be the most ancient, the most sublime, the most interesting, and the most useful, of all the sciences cultivated by mankind; since, by the knowledge derived from this science, not only the true magnitude of the Earth is discovered, the situation and extent of the countries and kingdoms upon it ascertained, trade and commerce carried on to the remotest

B

parts,

parts of the world, and the various products of several countries distributed for the health, comfort, and conveniency of it's inhabitants; but our very faculties are enlarged with the grandeur of the ideas it conveys, our minds exalted above the low contracted prejudices of the vulgar, and our understandings clearly convinced, and affected with the conviction, of the existence, wisdom, power, goodness, and superintendency of the Supreme Being! Also from this branch of knowledge we learn by what means or laws the Almighty carries on and continues the admirable harmony, order, and connection observable throughout the planetary system; and are led, by very powerful arguments, to form the pleasing deduction, that minds capable of such deep researches not only derive their origin from that all-wise and adorable Being, but are also incited to aspire after a more perfect knowledge of his nature, and a stricter conformity to his will.

By Astronomy we are enabled to discover that the Earth is at so great a distance from
the

the Sun, that, if seen from thence, it would appear no bigger than a point, although it's circumference is known to be 25,020 miles : yet that distance is so small, compared with the distance of the fixed Stars, that, if the orbit in which the Earth moves round the Sun were solid, and seen from the nearest fixed Star, it would likewise appear no bigger than a point, although it is at least 162 millions of miles in diameter : for the Earth, in going round the Sun, is 162 millions of miles nearer to some of the Stars at one time of the year than at another ; and yet their apparent magnitudes, situations, and distances from one another, still remain the same, and a telescope which magnifies 200 times, does not sensibly magnify them ; which proves them to be at least four hundred thousand times farther from us than we are from the Sun.

This inconceivable distance of the fixed Stars does wholly divest them of all parallaxes ; for I know not of any one fixed Star in the Heavens, the Great Dog Star only

excepted, that has any parallax, and he a parallax of only two seconds, which places him at the amazing distance of two billions, or two millions of millions of miles from the centre of the system; so that if a cannon ball was projected from the surface of our Earth, and travelling with the same velocity with which it leaves the mouth of the cannon, it would not reach the nearest fixed Star in five hundred thousand years: I say the nearest fixed Star; for we are not to imagine or suppose that all the Stars are placed in one concave surface, so as to be equally distant from us, but that they are scattered at immense distances from one another through infinite and unlimited space; so that there may be as great a distance between any two neighbouring Stars, as between our Sun and those which are nearest to him: therefore an observer, who is nearest any fixed Star, will look upon it alone as a real Sun, and consider the rest as so many shining points, placed at equal distances from him in the firmament. By the help of telescopes we discover thousands of Stars, which are
invisible

invisible to the naked eye; and the better our glasses are, still the more become visible: so that we can set no limits, either to their number or their distances; nor can we reasonably suppose that the different apparent magnitudes of the Stars is in anywise owing to one Star being less or bigger than another, but wholly to their being at a less or greater distance from us; as it is most proveable, that they are all nearly of the same size one with another, and all nearly of the same magnitude with the Sun. The Sun appears very bright and large, in comparison of the fixed Stars, because we keep constantly near the Sun, in comparison of our immense distance from the Stars: for a spectator, placed as near to any Star as we are to the Sun, would see that Star a body as large and bright as the Sun appears to us; and a spectator, as far distant from the Sun as we are from the Stars, would see the Sun as small as we see a Star, divested of all it's circumvolving Planets, and would reckon it one of the Stars in numbering them.

The Stars being at such immense distances from the Sun, cannot possibly receive from him so strong a light as they seem to have, nor any brightness sufficient to make them visible to us; for the Sun's rays must be so scattered and dissipated before they reach such remote objects, that they can never be transmitted back to our eyes, so as to render these objects visible by reflection. The Stars therefore shine with their own native and unborrowed lustre, as the Sun does; and since each particular Star, as well as the Sun, is confined to a particular portion of space, it is plain that the Stars are of the same nature with the Sun. It is no ways probable, nor is it reasonable for any man to think, that the Almighty, who always acts with infinite wisdom, and does nothing in vain, should create so many glorious Suns, fit for so many important purposes, and place them at such distances from one another, without proper objects near enough to be benefited by their influences: whoever therefore should be weak enough to imagine they were created only to give a faint glimmering light to the

inhabitants

inhabitants of this globe, must have a very superficial knowledge of Astronomy, and a mean and contracted opinion of the Divine wisdom; since, by an infinitely less exertion of creating power, the Deity could have given our Earth much more light by one single additional Moon. Instead then of one Sun and one World only in the universe, as the unskilful in Astronomy imagine, that science discovers to us such an inconceivable number of Suns, Systems, and Worlds, dispersed through boundless space, that if our Sun, with all the Planets, Moons, and Comets belonging to it, were annihilated, they would be no more missed out of the creation, than a grain of sand from the sea shore; the space they possess being comparatively so small that it would scarce be a sensible blank in the universe; although Saturn, the outermost of our Planets, revolves about the Sun in an orbit of 4,884 millions of miles in circumference, and some of our comets make excursions upwards of 10,000 millions of miles beyond Saturn's orbit; and yet, at that amazing distance, they are incomparably nearer

nearer to the Sun than to any of the Stars, as is evident from their keeping clear of the attractive power of all the Stars, and returning periodically by virtue of the Sun's attraction. From what we know of our System, it may be reasonably concluded, that all the rest are with equal wisdom contrived, situated, and provided with accommodations for rational inhabitants.

To him who attentively considers, it will appear highly probable, that the Planets, together with their attendants, called Satellites or Moons, are much of the same nature with our Earth, and destined for the like purposes; for they are solid opaque globes, capable of supporting animals and vegetables. Some of them are bigger, some less, and some much about the size of our Earth. They all circulate round the Sun, as the Earth does, in a shorter or longer time, according to their respective distances from him; and have, where it would not be inconvenient, regular returns of summer and winter, spring and autumn. They have
warmer

warmer and colder climates, as the various productions of our Earth require ; and in such as afford a possibility of discovering it, we observe a regular motion round their axis, like that of our Earth, causing an alternate return of day and night, which is necessary for labour, rest, and vegetation ; and that all parts of their surfaces may be exposed to the rays of the Sun. Such of the Planets as are farthest from the Sun, and therefore enjoy least of his light, have that deficiency made up by several Moons, which constantly accompany and revolve round about them, as our Moon revolves about the Earth. The remotest Planet has, over and above, a broad ring encompassing it, which, like a lucid zone in the Heavens, reflects the Sun's light very copiously on that Planet ; so that if the remoter Planets have the Sun's light fainter by day than we, they have an addition made to it morning and evening by one or more of their Moons, and a greater quantity of light in the night time.

By

By reason of the vicinity of the Moon to our Earth, we discover a nearer resemblance to our Earth ; for by the assistance of telescopes we observe the Moon's surface to be full of high mountains, large valleys, and deep cavities. These similarities leave us no room to doubt, but that all the Planets and Moons in the system are designed as commodious habitations for creatures endowed with capacities of knowing and adoring their beneficent Creator.

Since then the fixed Stars are prodigious spheres of fire, like our Sun, and placed at such immense and inconceivable distance from us and from one another, how can we reasonably conclude but that they are made for the same purposes that the Sun is ; each to bestow light, heat, and vegetation, on a certain number of inhabited Planets, kept by gravitation within the sphere of its activity.

But what makes the most wonderful and most surprising part of the Solar System, are those

those bodies called Comets, whose number is very great; near forty have already been observed, with so much accuracy as to leave little room to doubt, that they are all different from each other. And a much greater number still are recorded in history, for one author has reckoned no less than 415 in number, to the year 1665 inclusive; but though the number be certainly very great, it may require many ages to determine what the number really is.

Diodorus Siculus tells us, that the Chaldeans, by a long course of observations, were able to predict the appearance of Comets: and Seneca says, that Apollonius the Myndian, who was very skilful in natural sciences, affirmed, that Comets were by the Chaldeans reckoned among the Planets, and had their periods or courses like them. Seneca further tells us, that Apollonius used to say, that a Comet was a Star or Celestial body like the Sun or Moon; but that he did not know its course, because it ranges through higher parts of the world, and then at last
 appears

appears, when it comes to the bottom of its course. Of which opinion Seneca himself professes himself to be, in these words: "I don't think a Comet to be a sudden fire, but one of the eternal works of Nature;" he also gives the sole and only method by which this question may be solved, saying, "that there ought to be a collection of former rises or appearances of Comets; because by reason of their seldom appearing, their courses cannot yet be understood, neither can it be discovered whether they return or no; and that they appear or are produced in order at their settled time. *A time*, says he, will come when those things, which are now hid, will at last be brought to light, by length of time and the diligence of posterity. One age is not sufficient to make such great discoveries. A time will come when those that come after us will wonder that we were ignorant of things so plain." And farther on he says, "Somebody will demonstrate, which way Comets wander, why they go so far from the rest of the celestial bodies, how big, and what sort of bodies they are." All these predictions have
been

been accurately fulfilled and compleated in Sir Ifaac Newton.

Notwithstanding Seneca has fo clearly difcoursed on the nature of Comets in that dark age, yet few of the fucceeding astronomers were of his opinion, for they generally esteemed them as meteors kindled in the air, and defigned as prefages, or unlucky omens of fome difaftrous catastrophe, that was fhortly to befall the people or nations to whom they appeared. Nor did Seneca himfelf think fit to fet down thofe phænomena of the cometary motions, by which he was enabled to maintain his opinion, nor the times of thofe appearances which might have been of ufe to pofterity, in order to the determining thefe things. Afterwards, the whole fchool of Peripateticks, to keep up their doctrine concerning the Heavens, which they fupposed not capable of being generated or corrupted, did not look upon the Comets as eternal or permanent bodies of the world, but as bodies newly produced, and in a fhort time to perish again, and affirmed them to be

be sublunary, and made of exhalations in the terrestrial regions ; which was the more believed after solid orbs were introduced, because Comets could not pass through them. But at last, Tycho Brahe and Kepler, finding by observation, that Comets had no diurnal parallax, restored them to places above the Moon. All which has been fully and clearly demonstrated by Sir Isaac Newton, who says, that Comets are higher than the Moon, and are moved in the region of the primary Planets ; and that they move in conic sections, having their focus in the center of the Sun ; and by rays drawn to the Sun, describe equal areas in equal times, and in general, areas proportional to the times. Thus following the steps of so great a man, we may venture to affirm, that Comets are opaque, spherical, and solid bodies like the Planets, and like them perform their revolutions about the Sun in elliptical orbits, having the Sun in one of their foci. The particulars in which Comets differ from the Planets are, that they move in various directions, some the same way with the Planets, others the
 contrary ;

contrary ; neither are their motions confined within the zodiac, their orbits admitting of any inclination to the ecliptic whatever : and the eccentricity of their orbits is so very great, that some of the Comets perform the greatest part of their motion almost in right lines, tending, in their approach to the Sun, almost directly towards it, after which they pass by it, and when they leave it, move off again nearly in a right line, till they are out of sight, as if they were hastening back to the fixed Stars, and return not till after a period of many years.

Comets were looked upon by the ancients in general, as nothing more than sublunary vapours, or fiery meteors, as has before been remarked, and consequently little notice was taken of them, till the year 1577, when Tycho Brahe, seriously pursuing the study of the Stars, and being provided with large instruments fit for making celestial observations, with far greater care and certainty than the ancients could ever hope for, there appeared a very remarkable Comet ; to the ob-
 servation

fervation of which Tycho vigorously applied himself; and found by many just and faithful trials, that it had not a diurnal parallax that was at all perceptible, and consequently was not only no aerial vapour, but also much higher than the Moon; nay might be placed amongst the Planets, for any thing that appeared to the contrary; the cavilling opposition made by some of the school-men in the mean time, being to no purpose. Next to Tycho came the sagacious Kepler, who, with the advantage of Tycho's labours, and by his own observation, found out the true physical system of the world, and greatly improved the science of Astronomy. This great Astronomer had an opportunity of observing two Comets, one of which was a very remarkable one, and from the observations of these (which afforded sufficient indications of an annual parallax) he concluded, that the Comets moved freely through the planetary orbs, with a motion not much different from a rectilinear one; but of what kind he could not then precisely determine. Next Hevelius (a noble

emulator

emulator of Tycho Brahe) following Kepler's steps, embraced the same hypothesis of the rectilinear motion of Comets, himself accurately observing many of them, yet he complained that his calculations did not perfectly agree to the matter of fact in the Heavens; and was aware that the path of a Comet was bent into a curve line towards the Sun: at length came that prodigious Comet of the year 1680, which descending as it were from an infinite distance, perpendicularly towards the Sun, arose from him again with as great a velocity. This Comet, which was seen for four months successively, by the very remarkable and peculiar curvity of its orbit, above all others, gave the fittest occasion for investigating the theory of its motion. And the royal observatories at Greenwich and Paris having been for some time founded, and committed to the care of most excellent astronomers, the apparent motion of this Comet was most accurately (perhaps as far as human skill could extend) observed by Mr. Flamsteed and Mr. Cassini. Not long after, the illustrious Newton, writing

ting his Mathematical Principles of Natural Philosophy, demonstrated, not only that what Kepler had found did necessarily obtain in the planetary system; but also, that all the phænomena of Comets would naturally follow from the same principles: which he abundantly illustrated by the example of the aforesaid Comet of the year 1680, shewing at the same time a method of delineating the orbits of Comets geometrically.

That Comets are not aerial vapours, or even formed by exhalations from the Sun and Planets, Sir Isaac Newton has clearly shewed; by proving that the Comet of 1680, in its passage through the solar regions, would have been dissipated, had it consisted of such; for the heat of the Sun, it is allowed, is as the density of his rays, *i. e.* reciprocally, as the squares of the distances of places from the Sun; wherefore, since the distance of that Comet in its perihelion, December the 8th, was observed to be to the distance of the Earth from the Sun, nearly as 6 to 1000, the Sun's heat in the
Comet,

Comet, at that time, was to his heat with us at Midsummer, as 1,000,000 to 36, or 28,000 to 1. It is found by experiment, that the heat of boiling water is little more than three times the heat of our dry Earth, when exposed to the Midsummer Sun; and assuming the heat of red hot iron to be about three or four times as great as that of boiling water, he thence concludes, that the heat of the dried earth, or body of the Comet in its perihelion, must be near 2000 times as great as that of red hot iron. Such an immense heat once acquired in its perihelion, the Comet must be a long time in cooling again. Sir Isaac Newton also computes, that a globe of red hot iron, of the dimensions of our Earth, would scarce be cool in 50,000 years. If then the Comet be supposed to cool 100 times as fast as red hot iron; yet since its heat was 2000 times greater, supposing it of the bigness of the Earth, it would not cool in a million of years.

There is one remarkable phænomenon, which sometimes, though very seldom, ac-

companies the passage of Comets in their orbits, and that is, what may be called Cometary Eclipses; for when a Comet comes in the syzigial line of the Sun and the Earth, it must very much abate the solar light, though its visual diameter may not equal it: but if it should equal, or exceed it (and such have made their appearance) if their course be not exceedingly rapid, the Sun will be darkened through a much greater extent of Earth, for a much longer duration, and attended with a more remarkable obscurity, than any circumstances of a solar eclipse ever can be; such possibly might be the Egyptian darkness in the Jewish history, that of Jupiter and Alcmena in the Grecian, and of Augustus in the Roman; besides others, unrecorded in the annals of history. With respect to the tail of a Comet, Sir Isaac infers, that it is nothing else but a very fine vapour, which the head or nucleus of the Comet emits by its heat; and that the magnitude of the tail depends principally upon the degree of heat it receives from the Sun, as is evident from observation: for, till the Comet comes within a certain

certain

certain distance of the Sun, it is not seen with any train at all; as it approaches nearer, and the heat increases, the tail begins to arise, and grows longer about the perihelion, and a little distance after it is largest of all; then, as the heat of the Sun decreases, the length of the tail decreases also, till at last it no more appears: therefore the tail of a Comet is caused by heat, and is always proportional to it. Thus also the Comets which are nearest the Sun have, generally speaking, the longest tails; and those which are more remote, the shortest. But it may seem wonderful to some, how those prodigious tails are, or can be supplied from the atmosphere of a Comet: Sir Isaac has removed that wonder, by a computation which he had made on the expansive power, or force of an elastic fluid, such as our air, which is more dense near the surface of the Earth, where it is pressed upon by the whole weight of the air above, than it is at a distance from the Earth, where it has a less weight to compress it; the density of the air being always proportioned to the force which compresses

it, and consequently the air will expand itself, and become more rare in proportion as it becomes less compressed. From hence, Sir Isaac computes to what degree of rarity the air must be expanded, according to this rule, at an height equal to that of the semidiameter of the Earth (which is about 4000 miles); and he finds that a globe of such air as we breathe here on the surface of the Earth, which is only one inch in diameter, if it were expanded to a degree of rarity, which the air must have at the height of one semidiameter of the Earth, would fill all the planetary regions, even to the very sphere of Saturn, and much farther. Wherefore, seeing the air at a greater height is still immensely more rarefied, and the surface of the atmospheres of Comets' tails is usually about ten times the distance from the center of the Comet, as the surface of the Comet itself, and the tails rise yet to vastly greater heights, therefore they must be exceedingly rare; and though, on account of the much denser atmospheres of Comets, and the greater gravitation of their bodies towards the Sun, as
well

well as of the particles of their air and vapours mutually one towards another, it may happen that the air in the celestial spaces, and in the tails of the Comets, is not so vastly rarefied, yet, from such a computation, it is plain that a very small quantity of air and vapour is abundantly sufficient to produce all the appearances of the tails of Comets; and that the tails of Comets are very rare indeed, is evidently proved by the shining of Stars through them, without the least diminution of their splendour. The light reflected from the tail of a Comet is not near what we are usually prone to think it to be: Sir Isaac says, it is not greater than that of our air, determined by the Sunbeams let into a darkened room through a hole in the window-shutter, an inch or two in diameter. This also fully appears from viewing the tail of a Comet with a telescope, which always to the observer appears very faint and languid, even in the denser parts of it, and the extreme parts of the tail make no appearance at all through a telescope.

As to the cause of the ascent of the tail, Kepler ascribes it to the rarefaction of the Comet's atmosphere by the heat of the Sun, and the impulsive force of the Sun-beams carrying along with them the matter of the Comet's tail; which also accounts, at the same time, for the direction or position of the Comet's tail, which is always towards those parts opposite to the Sun. Since the phenomena of a Comet's tail depend upon the heat of the Sun, as has been observed, and since the nucleus or body of a Comet is heated to that prodigious degree as before-mentioned, it is but reasonable to suppose, that the action of the Sun's light upon those ignited particles of the Comet, and its heated atmosphere, should carry them away in their own directions, and so cause that appearance of a train of light, or the blazing tail of a Comet. Now, if we rightly consider the nature of things, the particles of light agitate and put all the parts of bodies in motion, particularly the parts of fluid bodies; and those parts of bodies, whether solid or fluid, that are ignited, or real fire, evidently

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lose their ignited particles, and by degrees become extinct, only by the action of the Sun's rays. Thus a fire, exposed to the Sun-beams, appears immediately to be divested of its ignited parts; the flame gradually lessens, the glowing coals by degrees become wholly extinct, and the fire goes out: also the flame of a spirit-lamp loses all its light in the Sun-beams, and the denser flame of a candle burns languid in the Sun; and many phenomena of a similar nature have been frequently observed by the curious. Nay, some philosophers, who have had the advantage of very large burning-glasses, four or five or more feet in diameter, have told us, that they have rendered this impulsive force of the rays of light upon bodies sensible to the eye; for by several experiments, which they have favoured us with an account of their having tried on light bodies suspended by a fine thread, and then throwing the dense rays of light near the focus of the glass upon them, it has manifestly put them in motion, and they have been observed to vibrate backward and forward like the pen-
dulum

dulum of a clock : whence there can be no dispute but that the parts of bodies may be propelled and carried forward by the particles of light in their own direction ; and though such effects of the Sun's rays are very small, and almost insensible, here with us, where the parts of matter are very gross, and confined in a dense atmosphere, yet the case is undoubtedly far otherwise in those free spaces through which the Comets move, where scarcely any resisting medium can be supposed, and where the matter of a Comet's tail is very fine, and liable to be put in motion with the least degree of force, much more by the prodigious impetus of a particle of light moving with a velocity not to be expressed or conceived. Agreeably to this notion of the cause of the ascent of a Comet's tail, we find the general form of the tail is that of a dilating vapour, growing wider towards the extreme parts, especially when they attain to their full degree of heat, and greatest magnitude. That the tail does or should lie in a right line direction from the Sun, we have no reason to suppose, unless

less it were to move in a real vacuum, or empty space; for though the medium through which the Comet moves may be exceeding rare and fine, yet some degree of resistance will arise to so large a moving body as the tail of a Comet, and the more rare the tail is, the greater resistance it will meet with from the medium; therefore the tail must be in some degree incurvated, or left a little behind the Comet in its motion, somewhat like the flame of a candle when it is moved gently forward through the medium of air; and hence it is that we see all the tails of the Comets deviating from a right line passing through the Sun and the Comet, but mostly so towards the extreme part.

Sir Isaac has also, in the strongest light imaginable, represented the extensive providence of the Supreme Creator of the Universe, who, besides the furnishing our Earth, and, without doubt, the rest of the Planets, so abundantly with every necessary for the support and continuance of the numerous
races

racés of plants and animals they are stocked with, has over and above provided a numerous train of Comets, far exceeding the number of Planets, to rectify continually and restore their gradual decay. For since the Comets are subject to such very unequal degrees of heat, being sometimes scorched with the most intense degree of it, at other times scarce receiving any sensible influence from the Sun, it can scarcely be supposed that they are designed for any such constant use as the Planets. As to the tails which they emit, they must, like all other kinds of vapour, dilate themselves as they ascend, and consequently are gradually scattered and dispersed through all the planetary regions, and therefore cannot but mix with the atmospheres of the Planets; for it is well known the Planets have one and all an attractive power, by which they cause all bodies to gravitate towards them; and therefore, in process of time, these vapours will be drawn into one or other of the Planets, whichever happens to be nearest, and acts the strongest upon them; and by entering
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the atmospheres of the Earth, or other Planets, may very naturally be supposed to contribute to the renovation of the face of things, in particular to supply the diminution caused in the humid parts by vegetation and putrefaction; since vegetables are nourished by moisture, and are also by putrefaction turned in a considerable part into dry earth: for it is well known that earthy substances will always subside in fermenting liquors; whence, by the same means, it is very reasonable to conclude that the dry parts of the Planets are continually increasing, and the fluid parts diminishing, and in a sufficient length of time may be exhausted, if they are not supplied by some other means.

Sir Isaac is also of opinion, that the most subtle and active parts of our air, upon which the life of animals and vegetables do chiefly depend, is derived to us and supplied by the Comets; so far are they from portending any hurt or mischief to us, which the natural fears of some men are too apt to surmise,
from

from the appearance of any thing uncommon and astonishing.

Sir Isaac also supposes, that the resistance which Comets meet with from the atmosphere of the Sun and of the medium of the planetary regions, must occasion a retardation of their motion in some small degree, which may be also further promoted by the attraction of the larger Planets; the consequence of which will be, that the central force will bring them nearer and nearer the Sun in each revolution, till at length they fall into him, and supply fuel to that immense body of fire. Sir Isaac has carried this supposition so far as to say, that fixed Stars (or Suns of other systems) that had been gradually wasted by light and vapours emitted from them for a long time, may be re-kindled by the Comets of their systems falling upon them, and from this fresh supply of new fuel, those old Stars acquiring new splendour, make those new Stars which we often observe suddenly appear in the Heavens, and shine with wonderful brightness

ness at first, and afterwards vanish by little and little, of which he enumerates many instances.

Nay, further still, Sir Isaac thinks it not unreasonable to imagine, that the exhalations that arise from the Sun, the fixed Stars, and the tails of Comets, may at last meet with and fall into the atmospheres of the Planets, by their gravity, and there be condensed and turned into water and humid spirits; and from thence, by a slow heat, pass gradually into the form of salts, sulphurs, and tinctures, and mud, and clay, and sands, and stones, and coral, and other terrestrial substances.

The near approach of some Comets to the Earth's orbit at particular times, may afford very good opportunities of determining the parallax of the Sun, as their parallaxes are very much larger than that of the Sun, in their perigeums. Dr. Halley says, that he found by calculation the Comet of 1680, on November 11 d. 1 h. 6 m. was not above
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the femidiameter of the Sun to the northward of the Earth's path; and had the Earth been there then, he thinks the parallax of the Comet would have equalled that of the Moon.

Some other uses may be made of the doctrine of Comets; as, that they entirely destroy the arbitrary hypothesis of Cartesian Vortices, by their regular and free motions in all directions, through every part of the Heavens; as also of the solid orbs in which the Planets were supposed to move by the vain imagination of ignorant schoolmen; and lastly, the argument against the eternity of the universe, drawn from the gradual decay of the Sun, still subsists, and receives new force from this theory of the Comets.

How far the fate of the planetary system may be affected by Comets, or particularly what may happen in process of time to our Earth, I cannot take upon me to say; since, among such a number revolving Comets, with such prodigious tails attending them
through

should touch the atmosphere of our Earth, (or if a part of this matter, scattered and diffused about the Heavens, should fall into it) the exhalations of it mixed with our atmosphere (one fluid with another) may cause very sensible changes in our air, especially in the animals and vegetables; for vapours brought from strange and distant regions, and excited by a very intense heat, may be prejudicial to the inhabitants or products of the Earth: wherefore, says the Doctor, those things which have been observed by all nations, and in all ages, to follow the apparition of Comets, may happen; and it is a thing unworthy a philosopher to look upon them as false and ridiculous.

Comets are not comprehended within the limits of a Zodiac, as the Planets are; but being confined to no bounds, are with various motions dispersed all over the Heavens, namely, to this purpose, that in their aphe-
 lions, where their motions are exceeding slow, receding to greater distances one from another, they may suffer less disturbance
 from

from their mutual gravitations. And hence it is, that the Comets which descend the lowest, and therefore move the slowest in their aphelions, ought also to ascend the highest. Neither are the planes of the Comets' motions in the planes of the Ecliptic, or any of the planetary orbits; for had this been the case, it would have been impossible for the Earth, or any of the Planets, to have been out of the way of the Comets' tails. Nay, the possibility of an immediate rencounter or shock of the body of a Comet would then have been too frequent; and considering how great the velocity of a Comet is at such a time, the collision of two such bodies must necessarily be destructive of each other; nor perhaps could the inhabitants of Planets long survive those frequent immersions in the tails of Comets, as they would be liable to in such a situation, not to mention any thing of the irregularities and confusion that must happen in the motion of Planets and Comets, if their orbits were all disposed in the same plane.

The reason why Comets are so very numerous is, that a very few could not answer those very great purposes before mentioned; for setting aside the constant supply of planetary moisture, an estimate of which cannot properly be formed, it is well known by experience, that the fire of the Sun is renewed and recruited very frequently; for the maculæ or spots in the Sun are only the parts burnt out, or a dead calx without fire; and these spots, after many years appearance and increase, will oftentimes disappear on a sudden, and will not be seen again for some years; which, I think, plainly shews that something has happened to the Sun, by which those dark or extinct parts are rekindled and burn again afresh; and why may not this arise from Comets falling into the Sun? though we are well assured from observations, that Nature has provided some other means to answer this purpose, besides the bodies of Comets.

Thus have I delivered as much concerning the natural history and philosophy of
Comets,

Comets, as I think can be of any use to my readers; for besides what Hevelius, Flamsted, Newton, and Halley have said on the subject, I can find nothing worth relating from others.

(7)

Correct, as I think can be of any use to my
 readers, for the sake of which, I have
 not hesitated, and I hope that you will
 think, I can find nothing more to say

on this subject.

I am, Sir, your obedient servant,

J. G. [Name]

[Address]

[City]

[State]

[Country]

[Date]

[Signature]

[Name]

[Address]

[City]

[State]

[Country]

[Date]

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[Name]

[Address]

[City]

P A R T II.

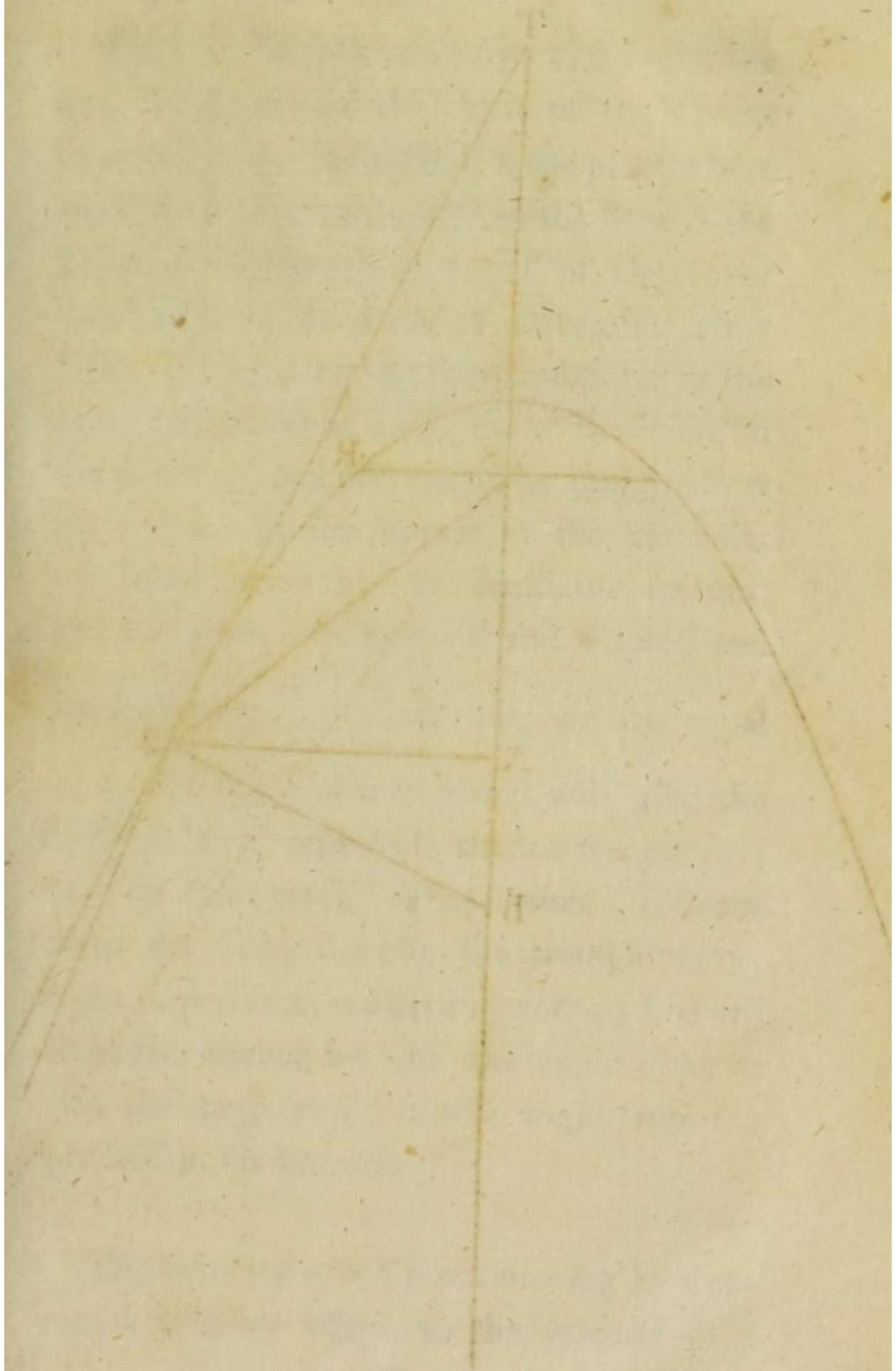
The whole Process of COMETARY CALCULATION, and Tables of the Elements of the Theory of a COMET'S MOTION, with their Construction and Use, exemplified in the Comet of 1661, which will again visit us in the latter End of the Year 1789, as we have great Reason to expect.

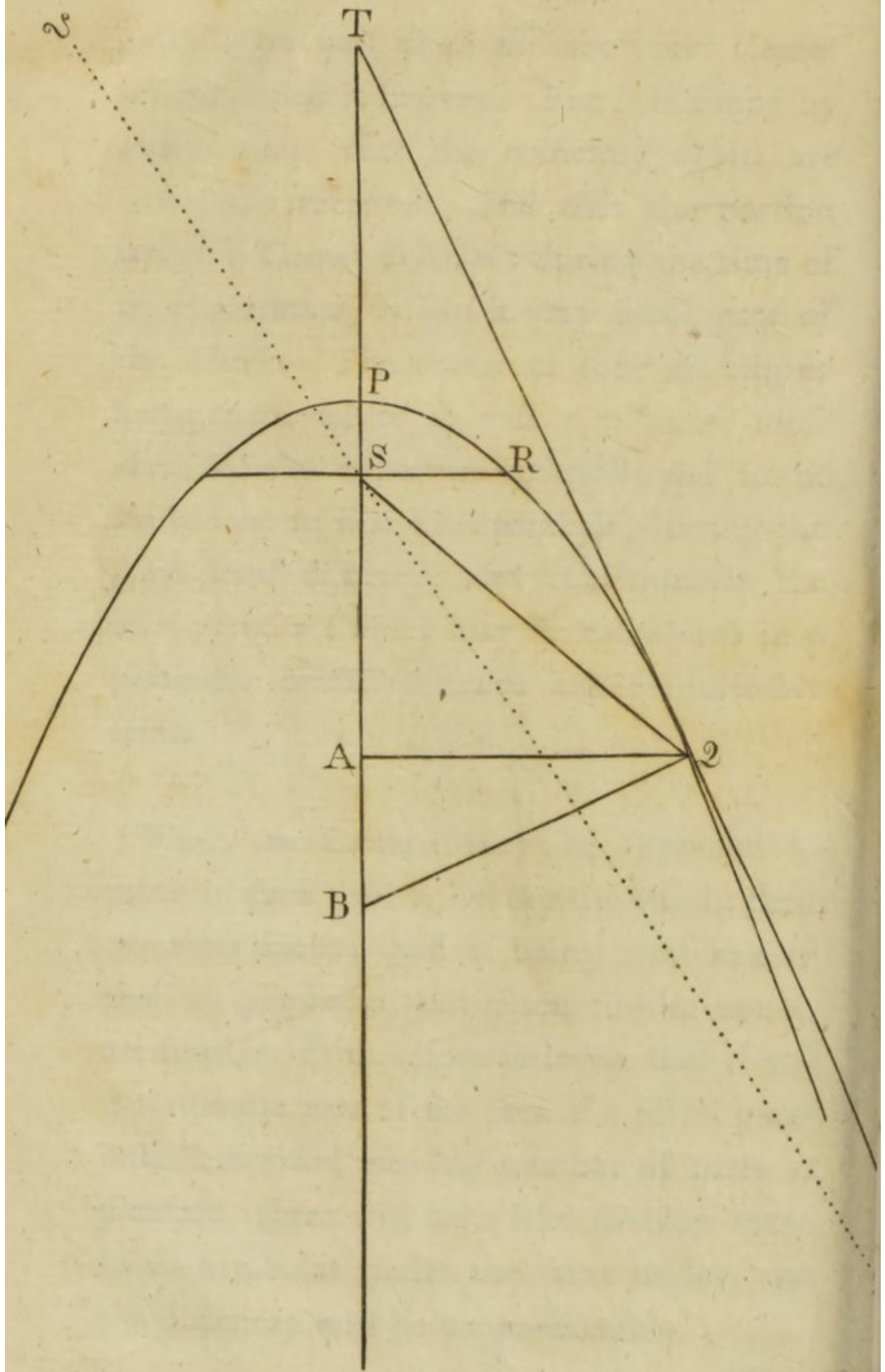
I JUDGE it will be an agreeable amusement for my readers, to be instructed in a plain and practical method, requiring no more than a moderate skill in plane trigonometry, of calculating the place and distance of this Comet, both from the Sun and from the Earth, with its latitude and longitude in the Ecliptic for any given time during the Comet's appearance; and the same mode of calculation

calculation will serve for any other Comet whose period is known. For it is found by observation, that the cometary orbits are extremely eccentric; and that the portion which a Comet describes during the time of its appearance, is but a very small part of the whole. The center of such an ellipsis being removed to so vast a distance, must occasion the curvature at each end to be vastly near to that of a parabola, having the same focal distance; and consequently the motion of a Comet may be calculated in a parabolic orbit, without any considerable error.

Now, as Comets may be supposed to move in such orbits, having the Sun in their common focus; and it being well known that all parabolas, cut from similar cones, are similar; it therefore follows, that if any determinate part of the area of a given parabola be divided into any number of parts at pleasure, there will be a like division made in all parabolas under the same angles, and the distances will be proportionable.

Thus





Thus in the following figure, let s be the Sun, pqr part of the orbit of the Comet expected, p the perihelion, r the place where the Comet is 90° distant from the Sun, q the place of the Comet on the 1st of December Old Stile, or the 12th of December New Stile, 1789; draw qa perpendicular to the axis, and let ab be a tangent to the curve in the point q , and perpendicular thereto draw bq ; then, by the nature of the parabola, we have $ab = sr$, the semilatus rectum. Put the given area $pqs = a$, and $AQ = x$, and we shall have $\frac{x^3}{12} + \frac{x}{4} = 12a$, or its equal $x^3 + 3x = 12a$, which solved will give the ordinate AQ , and from thence we get PA ; but $PA + ps = sq$, the Comet's distance from the Sun; then in the triangle SAQ , right angled at A , we have sq and AQ known, and from thence we find the angle QSA , as also the angle PSQ , or the angle from the perihelion, is known.

The velocity of a Comet moving in a parabola is every where to the velocity of a

E Planet

Planet describing a circle about the Sun, at the same distance from the Sun as $\sqrt{2}$ to 1, that is, as the square root of 2 to 1, by Cor. 77, prop. 16, lib. i. of the Principia.

If therefore a Comet in its perihelion were supposed to be as far distant from the Sun as the Earth is, then the diurnal area which the Comet would describe, would be to the diurnal area of the Earth as $\sqrt{2}$ to 1; and consequently, the time of the annual revolution of the Earth is, to the time in which such a Comet would describe a quadrant of its orbit from the perihelion, as 3.14159, &c. to $\sqrt{\frac{8}{9}}$, viz. as 3.14159, the circumference of a circle whose diameter is unity, is to 365.25 days, the time of one revolution of the Earth, so is .94281, the square root of $\frac{8}{9}$, to 109 days 14 hours 46 minutes, the time in which a Comet would describe a quadrant of its orbit from the perihelion. Now, seeing the Comet would describe that quadrant in 109 days 14 hours 46 minutes, and so the parabolic area analagous to the area PRS, being divided into 100 parts, to
each

each day there would be allotted 0.912280 of those parts, whose log. 9.960128 is to be reserved for constant use. But the time in which a Comet at a greater distance, or a less distance, would describe a similar quadrant, will be as the times of the revolutions in circles; that is, in the sesquiplimate ratio of the distances, and so the diurnal areas estimated in 100 parts of the quadrant, (which parts are to be put for measures of the mean motion, like degrees) are in each in the sesquialtera proportion of the distance from the Sun in the perihelion.

For the Comet expected in 1789, whose mean anomaly, or diurnal area, is first to be determined, thus: Put $ps=1$ the semidiameter of the Earth's orbit $= \frac{100}{109 \text{ d. } 14 \text{ h. } 46 \text{ m.}}$
 $= 0.912280$. The perihelion distance ps of this Comet, was observed to be ,44851, whence the diurnal area will be thus found, either by the logs, or numbers; but the logarithm being the most expeditious method, shall give an example by them. In order
 E 2 thereto,

thereto, I must premise this rule:—Take the square root of the cube of the Comet's perihelion distance, and divide unity thereby; multiply the quotient by the constant factor 0.912280, or its log. 9.960128, the product will give the diurnal area required.

Comet's perihelion distance, .44851, log.	—	—	6.348228
Multiply by	—	—	3
			<hr style="width: 100%;"/>
Cube of the perihelion distance	—	—	2)19.044684
			<hr style="width: 100%;"/>
Divide by 2, gives the square root	—	—	=9.522342
Constant log.	—	—	9.960128
			<hr style="width: 100%;"/>
Log. of the diurnal area 3.037	—	—	9.482470
			<hr style="width: 100%;"/>

Multiply this diurnal area 3.037, by the number of days and decimal parts of a day, if any, the product will be the area PRQS, or mean anomaly for the given time.—

Thus:

			d. h. m.
Time of perihelion, January Old Stile, 1661			16 23 41
Given time, December 1, Old Stile, 1789	—		1 23 41
			<hr style="width: 100%;"/>
Before perihelion	—	—	46 0 0
			<hr style="width: 100%;"/>

Then

Then 3.037, multiplied by 46, gives 139.702, the diurnal area or mean anomaly. Having therefore the area $PRSQ = 139.702$, we find $QA = x$ from the equation $x^3 + 3x = 12a$; for when the quadrantal area PSR is 100, if we put $SR = x = 1$, we get $x^3 + 3x = 4 = 12a$; and therefore, when the mean anomaly is but $\frac{1}{100}$ part of this, we shall have $x^3 + 3x = \frac{4}{100} = .04$, a constant multiplier for reducing any anomaly to fit it for the equation. Thus .04 multiplied into 139.702, gives 5.588, but $x^3 + 3x = 5.588$. Now it appears that x is somewhat more than 1, but considerably less than 2. Put $r = 1$, then $r + z = x$, from whence we get $r^3 + 3r^2z + 3r + 3z = 5.588$. — . . . $z = \frac{5.588 - r^3 - 3r}{3r^2 + 3}$. $= \frac{1.588}{6} = .264$, then $r + z = 1.264 = x$; this number being somewhat too great, I repeat the operation, by assuming $r = 1.264$, and the value of x comes out $1.23507 = AQ$, extremely near,

Then,

Then, by the property of the parabola, we shall have $\frac{AQ^2}{4PS} = 0.76269 = AP$, but $AP + PS = QS = 1.26269$, the distance of the Comet from the Sun for the given time: but to express this distance in the same parts, the Sun's mean distance from the Earth contains 100000, we must consider that the perihelion distance of the Comet PS is equal to $.44851$, whence $SK = .89702 = 2PS$, then say, as $1 : .89702 :: 1.26269 : 1.13266 = SQ$, reduced; and as $1 : .89702 :: .26269 : .23564 = AS$; reduced also as $1 : .89702 :: 1.23507 : 1.10788 = AQ$, reduced; which are the expressions required. For $AP = .76269 + PS = .5 = 1.26269 = SQ$. And $SQ = 1.26269 - SR = 1 = .26269 = AS$. Then in the right-angled triangle QAS , we have all the sides given, viz. $AS, .23564$ $SQ, 1.13266$ and $AQ, 1.10788$. To find the angle QSA .

As $SQ, 1.13266$	—	—	—	<u>0.054099</u>
To Radius	—	—	—	<u>10.000000</u>
So is $AQ, 1.10788$	—	—	—	<u>0.044493</u>
To s. angle $QSA 78^\circ$	—	—	—	<u>9.990394</u>

From

From 180° take the angle QSA 78° , there will remain 102° , the angle PSQ , the heliocentric distance of the Comet from the perihelion. And since the Comet's perihelion is in Cancer, 25 degrees 58 minutes 41 seconds; if therefore we now take

	S.	°	'	"
From — — —	3	25	58	41
The angle PSQ , $102^\circ =$ — —	3	12	00	00
There will remain the Comet's place in its orb.	0	13	58	41
Comet's ascending node — —	2	22	30	30
Comet from its ascending node —	2	8	31	49

For the reduction of the Comet from its orbit to the Ecliptic, say,

As Radius — — —	10.000000
To sc. $32^\circ 35' 50''$ inclination Comet's orbit —	9.925693
So is t. $68^\circ 31' 49''$ Comet from its node —	10.405275
To t. $64^\circ 58' 55''$ reduction — —	10.330968

	S.	°	'	"
Comet's ascending node — —	2	22	30	30
Reduction subtract — —	2	4	58	55
Comet's heliocentric longitude in the Ecliptic	0	17	31	35

For

For the Comet's heliocentric latitude :

As Radius	—	—	—	10.000000
To f. $68^{\circ} 31' 49''$ Comet from its node	—	—	—	9.968768
So is f. $32^{\circ} 35' 50''$ inclination	—	—	—	9.731371
To f. $30^{\circ} 5' 21''$ heliocentric lat. Comet	—	—	—	9.700139

For the log. of the true distance of the Comet from the Sun :

Log. of the proper dist. Comet from the Sun	—	—	—	0.402255
Log. of the Comet's perihelion distance	—	—	—	9.651772
Sum of the two logarithms	—	—	—	0.054027
As Radius	—	—	—	10.000000
To the sum of the 2 logs.	—	—	—	0.054027
So is fc. $30^{\circ} 5' 21''$ heliocen. lat.	—	—	—	9.937191
To log. of the Comet's curtate distance	—	—	—	9.991218

REMARK. If the curtate distance of the Comet from the Sun be greater than the distance of the Earth from the Sun, we must work in the calculation as is done in the calculation of the places of the superior Planets; but if the curtate distance of the Comet

met

met from the Sun be less than the distance of the Earth from the Sun, the operations are to be performed as in the calculations of the inferior Planets.

To find the geocentric longitude of the Comet, or it's true place in the Heavens, as seen from the Earth: in order to which, we must compute the true place of the Sun, and the place of the Earth, together with the log. of the Earth's distance from the Sun, to the given time.

		S. ° ' "	S. ° ' "
December O. S. 1700	—	8 20 10 25	— 3 7 44 25
Comp. years	{ 88	— 40 4	— 1 30 12
	{ 1	— 11 29 45 40	— 1 1
Days	— 1 —	59 8	<u>3 9 15 38</u>
Hours	— 23 —	56 40	
Minutes	— 1 —	1 41	
Sun's mean motion	—	<u>8 22 33 38</u>	
Apogee	—	<u>3 9 15 38</u>	
Sun's mean anomaly	—	<u>5 13 18 00</u>	
Equa. Sun's center	—	<u>34 00</u>	
Sun's place	—	<u>8 21 59 38</u>	
True place of the Earth	—	<u>2 21 59 38</u>	

Log. of the Earth from the Sun.	—	—	—	9.992935		
Log. of the Comet's curtate distance	—	—	—	9.991218		
		0	'	"	<hr/>	
Tangent of	—	44	53	12	—	9.998283
Add	—	45	—	—		
		<hr/>				
Sum	—	89	53	12		
		<hr/>				

As Radius	—	—	—	—	10.000000		
		0	'	"	<hr/>		
To tc.	—	89	53	12	—	7.285435	
So is t.	—	57	45	58	Half ang. commut.	10.200273	
						<hr/>	
To t.	—	0	10	28	An arc	—	7.485708
							<hr/>

					S.	0	'	"
Heliocentric longitude of the Comet	—	—	—	—	0	17	31	35
Sun's longitude	—	—	—	—	8	21	59	38
								<hr/>
Anomaly of commutation	—	—	—	—	3	25	31	57
Its half	—	—	—	—	1	27	45	58
Fourth arc, add and subtract	—	—	—	—	0	0	10	28
Parallax of the Comet's orb	—	—	—	—	1	27	56	26
Elongation	—	—	—	—	1	27	35	30
Heliocentric longitude of the Comet	—	—	—	—	0	17	31	35
Parallax of its orb, subtract	—	—	—	—	1	27	56	26
Comet's geocentric longitude	—	—	—	—	10	19	35	9
								<hr/>

For the geocentric latitude of the Comet :

	—	°	'	"	Co. ar.	
As f. commutation	—	64	28	3		0.044629
To f. elongation	—	57	35	30		9.926471
So is t. heliocentric latitude		30	5	21		9.762999
To t. geocentric latitude		28	27	48		<u>9.734099</u>

By this calculation it appears, that on the 13th of December 1789, New Stile, the Comet will be in the sign Aquarius, 19 degrees 35 minutes 9 seconds, with 28 degrees 27 minutes 48 seconds N. latitude; and at eight o'clock that evening may be seen, if the air be clear, near the small Star in the head of Aquarius, about 25 degrees above the western horizon.

For the latitude and longitude of the Comet on the 11th of December, 23 h. 41 m. 1789, Old Stile, assume another point Q, and draw AQ perpendicular to the axis; then, by rule page 44, the Comet's diurnal area was 3.037, and the above time 36 days before perihelion: whence 3.037 multiplied

by 36, gives the mean anomaly or area PRSQ, equal to 109.332; this multiplied by the common multiplier .04, we shall have $4.37328 = x^3 + 3x$, which solved as in page 39, gives $x = 1.0604 = AQ$, and $\frac{AQ^2}{4PS} = 0.56222 = AP$; then $AP + PS = QS = 1.06222$, the distance of the Comet from the Sun at the given time; which distance, expressed in the same parts as the Sun's mean distance from the Earth, contains 100000 (see p. 40) we get $QS = 0.95283$, $AS = .05581$, and $AQ = 0.95120$.

In the right-angled triangle QAS, are given the sides SQ 0.25283, and AQ .95120. To find the angle QSA :

As SQ 0.95283	—	—	9.979015
To Radius	—	—	10.000000
So is AQ 0.95120	—	—	9.978272
To f. ang. QSA, 86° 39'	—	—	9.999257

From 180° take the angle QSA, $86^\circ 39'$, and there will remain the angle PSQ, $93^\circ 21'$,
the

the heliocentric distance of the Comet from the perihelion. Thus :

	S.	°	'	"
The Comet's perihelion is in	3	25	58	41
The angle PSQ $93^{\circ} 21'$ in signs	3	3	21	00
<hr/>				
The Comet in its orb	0	22	37	41
<hr/>				
Comet's ascending node	2	22	30	30
Comet from its node	1	29	52	49
<hr/>				

For the reduction :

As Radius	-	-	-	-	10.000000			
	°	'	"		<hr/>			
To sc.	-	32	35	50	Inclination	-	-	9.925693
So t.	-	59	52	49	Comet from its node	-	10.236466	
<hr/>								
To t.	-	55	27	23	Reduction	-	10.162159	
<hr/>								

	S.	°	'	"
Comet's ascending node	2	22	30	30
Reduction subtract	1	25	27	23
<hr/>				
Comet's heliocentric ecliptic longitude	0	27	3	7
<hr/>				

Or the place in which the Comet would appear to an eye in the Sun.

For

For the Comet's heliocentric latitude :

As Radius	.	-	-	-	10.000000
To f. $59^{\circ} 52' 49''$	Comet from its node	-	-	-	9.937004
So is f. 32 35 50	Inclination	-	-	-	9.731371
To f. 27 46 11	Heliocentric latitude	-	-	-	9.668375

For the log. Comet's true distance from the Sun :

Log. proper distance of the Comet from the Sun					0.330461
Log. Comet's perihelion distance	-	-	-	-	9.651772
Sum	-	-	-	-	9.982233

As Radius	-	-	-	-	10.000000
To sum of the two logs.	-	-	-	-	9.982233
So is fc. $27^{\circ} 46' 11''$	heliocentric latitude	-	-	-	9.946858
Log. Comet's curtate distance	-	-	-	-	9.929091

For the geocentric longitude of the Comet, or its true place in the Heavens, as seen from the Earth :

Compute

Compute again the true place of the Sun, and the place of the Earth, with the log. of the Earth's distance from the Sun; as in page 49.

	S.	°	'	"
Heliocentric longitude of the Comet	-	0	27	3 7
Sun's longitude	-	9	2 10	58
<hr/>				
Anomaly of commutation	-	3	24	52 9
<hr/>				
Its half	-	1	27	26 4
<hr/>				

Log. of the Comet's curtate distance	-	9.929091
Log. of the Earth from the Sun	-	9.992679
<hr/>		
Tangent of $40^{\circ} 49' 11''$	-	9.936412
Add	-	45 00 00
<hr/>		
Sum	-	85 49 11
<hr/>		

As Radius	-	10.000000
<hr/>		
To tc. $85^{\circ} 49' 11''$	-	8.863853
So is t. 57 26 4 Half anom. commut.	-	10.194716
<hr/>		
To t. 6 31 17 An arc	-	9.058569
<hr/>		

		S.	o	'	"
Half anomaly of commutation	-	-	57	26	4
Fourth arc, add and subtract	-	-	6	31	17
Parallax of the Comet's orb	-	-	63	57	21
Heliocentric longitude of the Comet	-	-	0	27	3 7
Parallax of its orbit, subtract	-	-	2	3	57 21
Comet's geocentric longitude	-	-	10	23	5 46

For the geocentric latitude :

		o	'	"	Co. ar.	
As f. commutation	-	65	7	51	-	0.042264
To f. elongation	-	50	54	47	-	9.889967
So is t. heliocentric latitude		27	46	11	-	9.721452
To t. geocentric latitude		24	15	4	-	9.653683

Whence, on the 23d of December, New Style, 1789, the Comet will be in Aquarius, $23^{\circ} 5' 46''$, with $24^{\circ} 7' 4''$ North latitude, its right ascension then 328 degrees; and about eight o'clock that evening, if clear, will be seen in the jaw of Pegasus, near the Star Enif.

Thus

Thus having shewn the method of computation from the properties of the parabola, it now remains that I should shew the mode of calculation by the following Tables, which are constructed by the foregoing calculation, as in pages 41, 42, 43, 44, 45, and 46.

As, in the foregoing and following computations, I have made choice of the Comet of 1661, which is again expected in 1789, I think it will be expedient to shew the reasons why we expect its return, that it may appear we have sufficient grounds for our theory and computations. To this purpose I shall lay down the following criterions, or proofs of the same Comet returning, so that we may not be liable to mistake one for another :

1st. The intervals or periods of time in which the Comet appears, must be among themselves nearly equal, and determined from observations.

2d. The ascending node of the same Comet must be observed at each appearance to have nearly the same place in the Ecliptic.

3d. That the inclination of the plane of such a Comet's orbit be observed to be at each appearance nearly of the same quantity.

4th. The place of the perihelion must also be found to possess the same part of the Ecliptic nearly.

5th. The perihelion distance must also be very nearly the same at each return.

6th. The time of the year in which the perihelion happens, must be nearly the same at each return.

7th. The same Comet returning, must have always the same direction of motion :

tion : if it be direct at one time, it must be direct at another ; if retrograde at its first appearance, it must be so at every appearance.

TABLE I. ASTRONOMICAL ELEMENTS of the THEORY

Year of Appear.	Ascending Node.	Inclination.	Perihelion from Sun.	Log. Perihe. dist.
	° ' "	° ' "	° ' "	
1337	♄ 24 21 0	32 11 0	♄ 7 59 0	9.609236
1472	♃ 11 46 20	5 20 0	♄ 5 33 30	9.734584
1531	♄ 19 25 0	17 56 0	♃ 1 39 0	9.753583
1532	♄ 20 27 0	32 36 0	♃ 21 7 0	9.706803
1556	♃ 25 42 0	32 6 0	♃ 8 50 0	9.666424
1577	♃ 25 52 0	74 32 45	♃ 9 22 0	9.263447
1580	♃ 18 57 20	64 40 0	♃ 19 5 50	9.775450
1585	♄ 7 42 30	6 4 0	♃ 8 51 0	0.038850
1590	♃ 15 30 40	29 40 40	♄ 6 54 30	9.760882
1593	♃ 14 14 15	87 58 0	♃ 26 19 0	8.949940
1596	♃ 12 12 30	55 12 0	♄ 18 16 0	9.710058
1607	♄ 20 21 0	17 2 0	♃ 2 16 0	9.768490
1618	♄ 16 1 0	37 34 0	♃ 2 14 0	9.579498
1652	♄ 28 10 0	79 28 0	♃ 28 18 40	9.928140
1661	♄ 22 30 30	32 35 50	♃ 25 58 41	9.651772
1664	♄ 21 14 0	21 18 30	♃ 10 41 25	10.011044
1665	♄ 18 2 0	76 5 0	♄ 11 54 30	9.027309
1672	♃ 27 30 30	83 22 10	♄ 16 59 30	9.843476
1677	♄ 26 49 10	79 3 15	♃ 17 37 5	9.448072
1680	♃ 2 2 0	60 56 0	♃ 22 39 30	7.787106
1682	♄ 21 16 30	17 56 0	♃ 2 52 45	9.765877
1683	♃ 23 23 0	83 11 0	♄ 25 29 30	9.748343
1684	♃ 28 15 0	65 48 40	♄ 28 52 0	9.982339
1686	♃ 20 34 40	31 21 40	♄ 17 0 30	9.511883
1698	♃ 27 44 15	11 46 0	♃ 00 51 15	9.839660
1699	♃ 21 45 35	69 20 0	♄ 2 31 6	9.871570
1702	♃ 9 25 15	4 30 0	♃ 18 41 3	9.810165
1706	♃ 13 11 40	55 14 10	♄ 12 29 10	9.629218
1707	♄ 22 46 35	88 36 0	♄ 19 54 56	9.934368
1718	♃ 8 43 0	30 20 0	♃ 1 30 0	10.011380
1723	♃ 14 16 0	49 59 0	♄ 12 52 20	9.999414
1729	♃ 10 32 37	76 58 4	♃ 22 40 0	10.629552
1737	♄ 16 22 0	18 20 45	♃ 25 55 0	9.347960
1739	♃ 27 25 14	55 42 44	♃ 12 38 40	9.828388
1742	♃ 5 38 29	66 59 14	♄ 7 35 13	9.884049
1743	♄ 18 21 15	2 19 33	♃ 2 41 45	9.921690
1744	♄ 15 46 11	47 5 18	♃ 17 10 0	9.347325
1747	♃ 27 18 50	79 6 20	♃ 7 2 0	10.342128
1748	♄ 22 52 15	85 27 0	♄ 5 0 50	9.924624

of all the PRINCIPAL COMETS, to the Year 1748.

Dist. Perih. from the Sun.	Time of Perihelion.	Perihelion from the Node.	Direction of Motion.
	d. h. m.	° ' "	
40666	June - - 2 6 25	46 22 0	Retrograde.
54273	February - 28 22 23	123 47 10	Retrograde.
56700	August - 24 21 18½	107 46 10	Retrograde.
50910	October - 19 22 12	30 40 0	Direct.
66390	April - - 21 20 3	103 8 0	Direct.
18342	October - 26 18 45	103 30 0	Retrograde.
59628	November 28 15 0	90 80 30	Direct.
109358	September 27 19 20	28 51 30	Direct.
57661	January - 29 3 45	51 23 50	Retrograde.
89113	July - - 18 13 48	12 4 45	Direct.
51293	July - - 31 19 55	83 56 30	Retrograde.
58680	October - 16 3 50	108 5 0	Retrograde.
37975	October - 29 12 23	73 47 0	Direct.
84750	November 2 15 40	59 51 20	Direct.
44851	January - 16 23 41	33 28 10	Direct.
102575½	November 24 11 52	49 27 25	Retrograde.
10649	April - - 14 5 15½	156 7 30	Retrograde.
69739	February - 20 8 37	109 29 0	Direct.
28059	April - - 26 0 37½	99 12 5	Retrograde.
00612½	December 8 0 6	9 22 30	Direct.
58328	September 4 7 39	108 23 45	Retrograde.
56020	July - - 3 2 50	87 53 30	Retrograde.
96015	May - - 29 10 16	29 23 0	Direct.
32500	September 6 14 33	86 25 50	Direct.
69129	October - 8 16 57	3 7 0	Retrograde.
74400	January - 13 8 32	70 45 31	Retrograde.
64590	March - 13 14 22	50 44 12	Retrograde.
42581	January - 30 4 32	59 17 30	Direct.
85974	December 11 23 39	27 8 31	Direct.
102655	January - 14 23 48	7 13 0	Retrograde.
99865	September 27 16 20	28 36 20	Retrograde.
426141	June - - 25 11 6	12 7 23	Direct.
22283	January - 30 8 40	99 33 0	Direct.
67358	June - - 17 10 9	75 13 26	Retrograde.
76568	February - 8 4 48	31 56 44	Retrograde.
83501	January - 10 20 35	14 10 30	Direct.
22249½	March - 1 8 13	151 23 49	Direct.
219851	March - 3 7 20	50 16 50	Retrograde.
84067	April - - 28 19 35	17 51 25	Retrograde.

TABLE II. For calculating the MOTION and

Perih. dift. in Days.	True Anomaly.	Log. pro. dift. a' Sun.	Perih. dift. in Days.	True Anomaly.	Log. pro. dift. a' Sun.
	0' "			0' "	
1	1 31 40	0.000077	39	51 31 8	0.090910
2	3 3 15	0.000309	40	52 30 56	0.094596
3	4 34 43	0.000694	41	53 29 44	0.098300
4	6 6 0	0.001231	42	54 27 32	0.102019
5	7 37 1	0.001921	43	55 24 21	0.105752
6	9 7 43	0.002759	44	56 20 12	0.109490
7	10 38 2	0.003745	45	57 15 6	0.113240
8	12 7 54	0.004876	46	58 9 3	0.116995
9	13 37 17	0.006151	47	59 2 4	0.120756
10	15 6 7	0.007564	48	59 54 11	0.124518
11	16 34 20	0.009115	49	60 45 25	0.128278
12	18 1 54	0.010798	50	61 35 45	0.132035
13	19 28 47	0.012609	51	62 25 14	0.135792
14	20 54 54	0.014550	52	63 13 52	0.139544
15	22 20 14	0.016607	53	64 1 40	0.143291
16	23 44 44	0.018783	54	64 48 38	0.147029
17	25 8 22	0.021072	55	65 34 50	0.150762
18	26 31 8	0.023470	56	66 20 13	0.154482
19	27 52 55	0.025969	57	67 4 50	0.158192
20	29 13 47	0.028570	58	67 48 42	0.161890
21	30 33 40	0.031263	59	68 31 50	0.165578
22	31 52 32	0.034045	60	69 14 16	0.169254
23	33 10 23	0.036916	61	69 55 58	0.172914
24	34 27 12	0.039864	62	70 36 56	0.176527
25	35 42 59	0.042892	63	71 17 16	0.180188
26	36 57 41	0.045989	64	71 56 56	0.183803
27	38 11 20	0.049154	65	72 35 57	0.187404
28	39 23 54	0.052382	66	73 14 15	0.190978
29	40 35 23	0.055668	67	73 51 59	0.194540
30	41 45 47	0.059009	68	74 29 6	0.198085
31	42 55 6	0.062400	69	75 5 38	0.201614
32	44 3 20	0.065838	70	75 41 35	0.205122
33	45 10 29	0.069319	71	76 16 36	0.208612
34	46 16 35	0.072839	72	76 51 43	0.212080
35	47 21 36	0.076396	73	77 25 57	0.215529
36	48 25 33	0.079984	74	77 59 41	0.218963
37	49 28 27	0.083600	75	78 32 54	0.222378
38	50 30 19	0.087244	76	79 5 35	0.225769

PLACES of COMETS in a PARABOLIC ORBIT.

Perih. dist. in Days.	True Anomaly.	Log. pro. dist. a' Sun.	Perih. dist. in Days.	True Anomaly.	Log. pro. dist. a' Sun.
77	° ' "		130	° ' "	
78	79 37 45	0.229142	132	99 33 11	0.379842
79	80 9 23	0.232488	134	100 4 43	0.384576
80	80 40 34	0.235809	136	100 35 45	0.389252
81	81 11 16	0.239127	138	101 5 48	0.393868
	81 41 31	0.242416		101 35 22	0.398428
82	82 11 19	0.245684	140	102 4 19	0.402930
83	82 40 40	0.248933	142	102 32 41	0.407380
84	83 9 34	0.252159	144	103 00 31	0.411784
85	83 38 4	0.255366	146	103 27 47	0.416132
86	84 6 8	0.258552	148	103 54 31	0.420430
87	84 33 49	0.261720	150	104 20 43	0.424676
88	85 1 5	0.264865	152	104 46 22	0.428866
89	85 27 58	0.267989	154	105 11 33	0.433012
90	85 54 27	0.271092	156	105 36 16	0.437110
91	86 20 34	0.274176	158	106 00 32	0.441164
92	86 46 20	0.277239	160	106 24 23	0.445178
93	87 11 43	0.280284	162	106 47 47	0.449144
94	87 36 45	0.283306	164	107 10 44	0.453060
95	88 1 27	0.286308	166	107 33 17	0.456936
96	88 25 49	0.289293	168	107 55 27	0.460772
97	88 49 48	0.292252	170	108 17 14	0.464208
98	89 13 32	0.295201	172	108 38 37	0.468318
99	89 36 54	0.298122	174	108 59 39	0.472030
100	90 0 0	0.301030	176	109 20 20	0.475705
102	90 45 14	0.306782	178	109 40 40	0.479340
104	91 29 18	0.312469	180	110 00 40	0.482937
106	92 12 14	0.318060	182	110 20 20	0.486498
108	92 54 4	0.323587	184	110 39 41	0.490022
110	93 34 52	0.329042	186	110 58 44	0.493512
112	94 14 40	0.334424	188	111 17 28	0.496965
114	94 53 30	0.339736	190	111 35 55	0.500384
116	95 31 22	0.344979	192	111 54 5	0.503769
118	96 8 22	0.350153	194	112 11 58	0.507121
120	96 44 30	0.355262	196	112 29 34	0.510441
122	97 19 48	0.360306	198	112 46 55	0.513729
124	97 54 17	0.365284	200	113 4 0	0.516984
126	98 28 00	0.370200			
128	99 00 57	0.375052			

TABLE III. Of the RADICAL MEAN PLACES and MOTIONS of the SUN, for Years and Months, Old Stile, Greenwich Latitude $51^{\circ} 28' 30''$ N. Longitude $00^{\circ} 00'$.

1700. JULIAN, OF OLD STILE.									
MONTHS.		ME. PLACE SUN.				M. PL. SUN'S APO.			
		S.	°	'	"	S.	°	'	"
January	I.	9	20	58	3	3	7	43	29
February	I.	10	21	31	21	3	7	43	31
March	O.	11	19	7	14	3	7	43	39
April	O.	0	19	40	33	3	7	43	44
May	O.	1	19	14	43	3	7	43	49
June	O.	2	19	43	1	3	7	43	51
July	O.	3	19	22	11	3	7	43	59
August	O.	4	19	55	29	3	7	44	5
September	O.	5	20	28	47	3	7	44	10
October	O.	6	20	2	57	3	7	44	15
November	O.	7	20	36	15	3	7	44	20
December	O.	8	20	10	25	3	7	44	25
YEARS JULIAN.		MEAN MOT. SUN.				M. Mo. SUN'S APO.			
100		0	0	45	32	0	1	42	30
200		0	1	31	4	0	3	25	0
300		0	2	16	36	0	5	7	30
400		0	3	2	8	0	6	50	0
500		0	3	47	40	0	8	32	30

TABLE IV. MEAN MOTION of the SUN
for 99 Julian Years.

Jul. Years	MEAN MOT. OF SUN.				MEAN MO. OF APOGEE			
	S.	°	'	"	S.	°	'	"
4	0	0	1	49	0	0	4	46
8		+	3	39		+	8	12
12			5	28			12	18
16			7	17			16	24
20			9	6			20	30
24			10	56			24	36
28			12	45			28	42
32			14	34			32	48
36			16	24			36	54
40			18	13			41	0
44			20	2			45	6
48			21	51			49	12
52			23	41			53	18
56			25	30			57	24
60			27	19	1		1	30
64			29	8	1		5	36
68			30	58	1		9	42
72			32	47	1		13	48
76			34	37	1		17	54
80			36	26	1		22	0
84			38	15	1		26	6
88			40	4	1		30	12
92			41	53	1		34	18
96			43	43	1		38	24
1	11	29	45	40	1		1	1
2	11	29	31	20	2		2	3
3	11	29	17	1	3		3	4

TABLE V. MEAN MOTION of the SUN for DAYS, HOURS, MINUTES, and SECONDS.

Days	Mean Motion of Sun.	Sun's Apo.	H. Min. Sec.	° ' "			H. Min. Sec.	° ' "		
				°	'	"		°	'	"
	S. ° ' "									
1	59 8	0	1	0	2	28	31	1	16	23
2	1 58 17	0	2		4	56	32	1	18	51
3	2 57 25	0	3		7	24	33	1	21	19
4	3 56 33	1	4		9	51	34	1	23	47
5	4 55 42	1	5		12	19	35	1	26	14
6	5 54 50	1	6		14	47	36	1	28	42
7	6 53 58	1	7		17	25	37	1	31	10
8	7 53 7	1	8		19	43	38	1	33	38
9	8 52 15	1	9		22	11	39	1	36	6
10	9 51 23	2	10		24	38	40	1	38	34
11	10 50 32	2	11		27	6	41	1	41	1
12	11 49 40	2	12		29	34	42	1	43	29
13	12 48 48	2	13		32	2	43	1	45	57
14	13 47 57	2	14		34	30	44	1	48	25
15	14 47 5	2	15		36	58	45	1	50	53
16	15 46 13	3	16		39	20	46	1	53	21
17	16 45 22	3	17		41	53	47	1	55	48
18	17 44 30	3	18		44	21	48	1	58	16
19	18 43 38	3	19		46	49	49	2	0	44
20	19 42 47	3	20		49	17	50	2	3	12
21	20 41 55	3	21		51	45	51	2	5	40
22	21 41 3	4	22		54	13	52	2	8	8
23	22 40 12	4	23		56	40	53	2	10	36
24	23 39 20	4	24		59	8	54	2	13	3
25	24 38 28	4	25	1	1	36	55	2	15	31
26	25 37 37	4	26	1	4	4	56	2	17	59
27	26 36 45	4	27	1	6	32	57	2	20	27
28	27 35 53	5	28	1	9	0	58	2	22	55
29	28 35 2	5	29	1	11	27	59	2	25	23
30	29 34 10	5	30	1	13	55	60	2	27	50
31	1 0 33 18	5								

TABLE VI. EQUATION of the SUN'S CENTER.

ARGUMENT SUN'S MEAN ANOMALY.																			
☉'s M. A.	Signs 0. Subt.		Signs 1. Subt.		Signs 2. Subt.		Signs 3. Subt.		Signs 4. Subt.		Signs 5. Subt.		☉'s M. A.						
0	0	0	0	56	52	1	39	15	1	55	49	1	41	22	0	59	0	30	
1		1	59	0	58	36	1	40	16	1	55	50	1	40	22		57	12	29
2		3	58	1	0	18	1	41	15	1	55	49	1	39	20		55	23	28
3		5	57	1	1	59	1	42	13	1	55	46	1	38	16		53	34	27
4		7	56	1	3	39	1	43	8	1	55	42	1	37	10		51	44	26
5		9	54	1	5	18	1	44	2	1	55	35	1	36	3		49	53	25
6		11	52	1	6	57	1	44	54	1	55	26	1	34	53		48	1	24
7		13	50	1	8	33	1	45	44	1	55	15	1	33	41		46	8	23
8		15	48	1	10	9	1	46	33	1	55	1	1	32	28		44	14	22
9		17	45	1	11	43	1	47	19	1	54	45	1	31	13		42	19	21
10		19	42	1	13	16	1	48	3	1	54	29	1	29	57		40	23	20
11		21	39	1	14	48	1	48	45	1	54	9	1	28	38		38	27	19
12		23	36	1	16	19	1	49	25	1	53	47	1	27	19		36	31	18
13		25	32	1	17	47	1	50	4	1	53	23	1	25	57		34	33	17
14		27	28	1	19	16	1	50	41	1	52	57	1	24	34		32	34	16
15		29	23	1	20	42	1	51	15	1	52	9	1	23	9		30	35	15
16		31	17	1	22	7	1	51	48	1	51	58	1	21	42		28	36	14
17		33	11	1	23	30	1	52	19	1	51	26	1	20	14		26	36	13
18		35	5	1	24	52	1	52	47	1	50	52	1	18	45		24	35	12
19		36	58	1	26	13	1	53	14	1	50	16	1	17	13		22	34	11
20		38	51	1	27	33	1	53	38	1	49	38	1	15	41		20	32	10
21		40	43	1	28	50	1	54	1	1	48	56	1	14	7		18	29	9
22		42	34	1	30	6	1	54	21	1	48	13	1	12	31		16	26	8
23		44	24	1	31	20	1	54	39	1	47	29	1	10	55		14	23	7
24		46	13	1	32	33	1	54	55	1	46	43	1	9	16		12	20	6
25		48	2	1	33	34	1	55	9	1	45	55	1	7	37		10	17	5
26		49	50	1	34	54	1	55	21	1	45	4	1	5	56		8	14	4
27		51	37	1	36	2	1	55	31	1	44	11	1	4	14		6	11	3
28		53	23	1	37	8	1	55	39	1	43	16	1	2	31		4	8	2
29		55	8	1	38	13	1	55	45	1	42	20	1	0	46		2	4	1
30		56	52	1	39	15	1	55	49	1	41	22	0	59	0	0	0	0	0
☉'s M. A.	Add Signs 11.		Add Signs 10.		Add Signs 9.		Add Signs 8.		Add Signs 7.		Add Signs 6.		☉'s M. A.						

TABLE VII. LOGS. of SUN'S DIST. from the EARTH
ECCENTRICITY 1685.

ARGUMENT SUN'S MEAN ANOMALY.							
☉'s M. A.	Signs 0. ☉ a' ⊕.	Signs 1. ☉ a' ⊕.	Signs 2. ☉ a' ⊕.	Signs 3. ☉ a' ⊕.	Signs 4. ☉ a' ⊕.	Signs 5. ☉ a' ⊕.	☉'s M. A.
0	5.007257	5.006320	5.003736	5.000122	4.996424	4.993656	30
1	5.007257	5.006260	5.003628	4.999991	4.996310	4.993590	29
2	5.007252	5.006196	5.003520	4.999861	4.996201	4.993524	28
3	5.007248	5.006132	5.003409	4.999735	4.996091	4.993463	27
4	5.007240	5.006063	5.003297	4.999609	4.995981	4.993401	26
5	5.007231	5.005990	5.003185	4.999483	4.995872	4.993343	25
6	5.007218	5.005918	5.003068	4.999357	4.995762	4.993286	24
7	5.007205	5.005845	5.002952	4.999230	4.995653	4.993233	23
8	5.007188	5.005772	5.002835	4.999104	4.995547	4.993180	22
9	5.007171	5.005695	5.002719	4.998978	4.995442	4.993132	21
10	5.007150	5.005618	5.002602	4.998852	4.995341	4.993088	20
11	5.007128	5.005540	5.002486	4.998725	4.995244	4.993043	19
12	5.007103	5.005459	5.002369	4.998599	4.995148	4.992999	18
13	5.007077	5.005378	5.002248	4.998473	4.995051	4.992960	17
14	5.007047	5.005292	5.002127	4.998346	4.994955	4.992920	16
15	5.007017	5.005206	5.002006	4.998220	4.994862	4.992885	15
16	5.006987	5.005120	5.001885	4.998093	4.994770	4.992849	14
17	5.006953	5.005030	5.001764	4.997971	4.994678	4.992818	13
18	5.006919	5.004940	5.001643	4.997848	4.994590	4.992787	12
19	5.006881	5.004845	5.001517	4.997727	4.994502	4.992761	11
20	5.006838	5.004751	5.001392	4.997605	4.994414	4.992739	10
21	5.006795	5.004652	5.001266	4.997482	4.994330	4.992717	9
22	5.006748	5.004553	5.001141	4.997360	4.994247	4.992699	8
23	5.006701	5.004454	5.001015	4.997238	4.994167	4.992681	7
24	5.006650	5.004356	5.000889	4.997120	4.994088	4.992664	6
25	5.006598	5.004257	5.000764	4.997002	4.994013	4.992651	5
26	5.006547	5.004158	5.000638	4.996883	4.993938	4.992637	4
27	5.006491	5.004055	5.000512	4.996770	4.993864	4.992628	3
28	5.006436	5.003951	5.000382	4.996652	4.993793	4.992624	2
29	5.006380	5.003844	5.000252	4.996538	4.993722	4.992620	1
30	5.006320	5.003736	5.000122	4.996424	4.993656	4.992620	0
☉'s M. A.	☉ a' ⊕. Signs 11.	☉ a' ⊕ Signs 10.	☉ a' ⊕ Signs 9.	☉ a' ⊕ Signs 8.	☉ a' ⊕ Signs 7.	☉ a' ⊕ Signs 6.	☉'s M. A.

THE foregoing Tables will serve to represent the motions of all our Comets; of which hitherto there has been none observed, but those that come within the laws of the parabola.

These necessary things being premised, it now remains that I shew rules and examples for computing the apparent place of any one of the beforementioned Comets for any given time, and in particular for the Comet of 1661, which will appear again in 1789. Therefore,

1. Let the Sun's place be had, and the logarithm of its distance from the Earth for the given time.
2. Let the difference between the time of the perihelion and the time given be gotten, in days and decimal parts of days. To the logarithm of this number let there be added the constant logarithm 9.960128, and the arithmetical complement of $\frac{3}{2}$ of the logarithm
of

of the perihelion distance of the Comet from the Sun: the sum will be the logarithm of the mean motion, to be sought in the first column of the general table, viz. table ii. p. 62.

3. With the mean motion let there be taken the correspondent angle from the perihelion in the same table, and the logarithm for the distance from the Sun: then in Comets that are direct, add, and in retrograde ones subtract (if the time be after the perihelion) the angle thus found to or from the perihelion; or in direct Comets subtract, and in retrograde ones add (if the time be before the perihelion) the aforesaid angle to or from the place of the perihelion, so shall we have the place of the Comet in its orb: and to the logarithm for the distance found, add the logarithm of the distance at the perihelion; the sum will be the logarithm of the true distance of the Comet from the Sun.

4. The

4. The place of the node, together with the place of a Comet in its orb, being had, let the distance of the Comet from the node be taken; then the inclination of the orbit being known from table i. p. 60, we by the common rules of trigonometry may compute the Comet's place reduced to the ecliptic, the inclination, or heliocentric latitude; and the logarithm of its curtate distance.

From the foregoing elements being determined, we may, by the same rules that we compute a Planet's place from the Sun's place and distance given, find the geocentric place both in latitude and longitude of a Comet, as I shall shew at large further on; in the mean time shall, in order to remove every obstacle or apparent difficulty, premise a few necessary remarks.

The logarithm of days is added to the given logarithm of one day, that the motion of one day may be understood to be multiplied by the number of days; for it is well known

known that the addition of logarithms doth infer the multiplication of numbers corresponding to those logarithms; and these things may suffice, if so be the Comet be supposed to pass in its perihelion at a distance equal to a radius of the orbis magnus. But if, which commonly is the case, the Comet doth not pass at that distance, but at a greater, as it is sometimes; or at a less, as oftener happens, that area proportional to the time is to be increased, or diminished, and this in the sub-fesquialteral proportion of that least distance from the Sun; so that at length that area may rightly represent the mean anomaly: from whence the logarithm of that fesquiplicate distance is to be added to the former sum of the logarithms, and the radius to be subtracted according to the exigence of the golden rule to be practised in logarithms; or, which is the same, the arithmetical complement only of that fesquialteral logarithm is to be added. Now it ought not to seem strange, that in lesser distances we, by adding the logarithm, obtain the true proportion increased, and the

same

same greater distances diminished: for multiplication by a fraction, vulgar or decimal, doth no less diminish the sum than multiplication by whole numbers doth increase it, and the thing is the same in logarithmetical addition. Also it must be observed, that the logarithms set down in the third column of table ii. p. 62, are not the logarithms of the numbers of the distances from the Sun, to be added over and above the radius to the mean distances; but of numbers, by the multiplication of which that true distance were to be obtained: from whence the logarithms of the same being superadded to one another, will easily give us the logarithm of that whole distance from the Sun.

These things being well understood, we shall be able to undertake and perform the whole process of calculation, not only of this Comet, which is expected to make its appearance in 1789, but also of any other Comet, inserted in the first or general table, p. 60.

A CALCULATION of the LONGITUDE and LATITUDE of the COMET which is expected to make its appearance in the latter end of the year 1789, for the 21st day of December, 23 h. 41 m. P. M. Old Stile, or the 2d of January, about noon, 1790, New Stile.

	d.	h.	m.
Comet's perihelion, 1661, January O. S.	—	16	23 41
Given time, December 1789, N. S.	—	21	23 41
Preceding the perihelion	—	26	00 00
Sun's true longitude then	—	9	12 22 37
<hr/>			
Logarithm of the Earth from the Sun	—	9.992629	
Log. of the Comet's perihelion from the Sun	—	9.651772	
Mult. by 3, gives the cube of the perih. dist.	—	8.955316	
Divide by 2, gives the log. sesquialtrate	—	9.477658	
Its arithmetical complement is	—	0.522342	
Constant log. (see p. 43)	—	9.960128	
Log. of the given time, 26 days	—	1.414973	
Log. of the Comet's mean motion, 78.97	—	1.897443	
<hr/>			
Comet's mean anomaly answering thereto	—	80 39 38	
Comet's proper distance from the Sun, log.	—	0.235709	

			S.	°	'	"
Comet's perihelion place	—	—	3	25	58	41
Anomaly of the Comet above is	—	—	2	20	39	28
<hr/>						
Comet in its orbit	—	—	1	5	19	3
<hr/>						
Comet's ascending node	—	—	2	22	30	30
Comet's orbit place, subtract	—	—	1	5	19	3
<hr/>						
Comet's distance from its node	—	—	1	17	11	27
<hr/>						
Comet's ascending node	-	-	2	22	30	30
Reduction subtract	-	-	1	12	17	43
<hr/>						
Comet's heliocentric ecliptic place	-	-	1	10	12	47
<hr/>						

For the reduction :

As Radius	-	-	-	-	10.000000	
<hr/>						
To f.	-	32	35	50	Comet's inclination, tab. 1.	9.925693
So is t.	-	47	11	27	Comet from its node	10.033244
<hr/>						
To t.	-	42	17	43	Reduction	9.958937
<hr/>						

For the Comet's heliocentric latitude :

As Radius	-	-	-	-	10.000000
<hr/>					
To f.	47°	11'	27"	Comet from its node	9.865471
So is f.	32	35	50	Comet's inclination	9.731371
<hr/>					
To f.	23	16	48	Comet's heliocentric latitude	9.596842
<hr/>					

For the logarithm of the Comet's true distance from the Sun :

Log. of the Comet's proper distance from the Sun	0.235709
Log. Comet's perihelion distance	9.651772
Sum of the two logarithms	<u>9.887481</u>
As Radius	10.000000
To the sum of the two logs.	9.887481
So is sc. $23^{\circ} 16' 48''$ Comet's heliocentric latitude	<u>9.963119</u>
To log. of the Comet's curtate distance	<u>9.850600</u>

For the geocentric longitude of the Comet :

	S.	°	'	''
Heliocentric longitude of the Comet	-	1	10	12 47
Sun's true longitude	-	9	12	22 37
Anomaly of commutation	-	3	27	50 19
Its half is	-	1	28	55 5

Log. of the Comet's curtate distance	9.850600
Log. of the Earth from the Sun	9.992629
Tangent of $35^{\circ} 47' 38''$	<u>9.857971</u>
Add	<u>45 00 00</u>
Sum	<u>80 47 38</u>

As

As Radius	10.000000
To tc.	80°	47'	38"	The sum	9.209714
So is t.	58	55	5	Half anom. commut.	10.219820
To t.	15	2	5	A fourth arc	9.429534
					S. ° ' "
Half anomaly of commutation	-	-	-	-	58 55 5
Fourth arc, add and subtract	-	-	-	-	15 2 35
Parallax of the Comet's orb, subtract	-	-	-	-	73 57 40
Elongation, add	-	-	-	-	43 52 30
Comet's heliocentric longitude	-	-	-	-	1 10 12 47
Parallax of the Comet's orb, subtract	-	-	-	-	2 13 57 40
Comet's geocentric longitude	-	-	-	-	10 26 15 7

For the Comet's geocentric latitude :

As f.	—	62	9	50	Commutation co. ar.	0.053407
To f.	—	43	52	30	Elongation	9.840787
So is t.	—	23	16	48	Heliocentric latitude	9.633725
To t.	—	18	38	7	Geocentric latitude	9.527919

Whence, on the 2d of January, 1790, the Comet will be near the eye of Pegasus, about 13° above the western horizon, right ascension 328° ,

I shall

I shall give another Example of Computation for the LATITUDE and LONGITUDE of this COMET, for the 1st of January, O. S. 1789-90, or January 13, near Noon, 1790, N. S. in which I shall note down each step.

	d.	h.	m.
Comet's perihelion, 1661, Jan. O. S. p. 60, tab. 1.	16	23	41
Given time, January — — —	1	23	41
Preceding the perihelion — — —	15	00	00

For the Sun's true longitude :

	Sun's Mean Mo.				Mean Mo. Apo.			
	S.	°	'	"	S.	°	'	"
January 1700, O. S.	9	20	58	3	3	7	43	29
Comp. years { 88 -			40	4			1	30
{ 1 -	11	29	45	40			1	1
Day - 1 -			59	8				0
Hours - 23 -			54	13				0
Minutes - 41 -			1	41				0
Sun's mean motion	9	23	18	49	3	9	14	42
Apo. subtr.			3	9				
Sun's mean anom.	6	14	4	7				
Equa. center add —			28	44				
Sun's longitude —	9	23	47	33				

Log. of the Earth from the Sun, 9.992851, tab. vii. p. 67.

Log. of the Comet's perihelion, tab. i. p. 60	—	—	9.651772
Multiply by	—	—	<u>3</u>
Log. cube of the perihelion	—	—	8.955316
Divide by 2 log. sesquialtrate	—	—	<u>9.477658</u>
Complement arithmetical	—	—	0.522342
Constant log. p. 43	—	—	9.960128
Log. of the time, viz. 15 days	—	—	<u>1.176091</u>
Log. of the Comet's mean motion, viz. 45.56	—	—	<u>1.658561</u>
			0 ' "
Comet's mean anom. answering thereto, tab. ii. p. 62.			<u>57 48 18</u>
			0.115341
Log. Comet's proper distance from the Sun, same p.			<u>0.115341</u>
			S. 0 ' "
Comet's perihelion place, tab. i. p. 60	—	—	3 25 58 41
Comet's mean anomaly above in signs, is	—	—	<u>1 27 48 18</u>
Comet in its orbit	—	—	1 28 10 23
Comet's ascending node, tab. i. p. 60	—	—	<u>2 22 30 30</u>
Comet from its node	—	—	<u>0 24 20 7</u>

For the reduction :

As Radius	—	—	10.000000
To sc. — 32 35 50	Comet's inclination, tab. 1.	—	9.925693
So is t. 24 20 7	Comet from its node	—	<u>9.655386</u>
To t. 20 51 49	Reduction	—	<u>9.581079</u>

Comet's

		S. 0' "
Comet's ascending node, tab. i. p. 60	—	2 21 30 30
Reduction subtract	—	20 51 49
		<hr/>
Heliocentric ecliptic longitude of the Comet	—	2 1 38 41
		<hr/>

For the Comet's heliocentric latitude :

As Radius	—	—	—	10.000000
To f. 24° 20' 7"	Comet from its node	—	—	9.614977
So is f. 32° 35' 50"	Comet's inclination	—	—	9.731371
				<hr/>
To f. 12° 49' 25"	Comet's heliocentric latitude			9.346348
				<hr/>

For the log. of the Comet's true distance from the Sun :

Log. of the Comet's proper distance from the Sun		0.115341
Log. of the Comet's perihelion distance	—	9.651772
		<hr/>
Sum of the 2 logs.	—	9.767113
		<hr/>

As Radius	—	—	—	10.000000
To the sum of the 2 logs.		—	—	9.767113
So is fc. 12° 49' 25"	Comet's heliocentric latitude			9.989030
				<hr/>
To log. of the Comet's curtate distance		—	—	9.756143
				<hr/>

For the geocentric longitude of the
Comet:

		S.	°	'	"
Heliocentric longitude of the Comet	—	2	1	38	41
Sun's true longitude	—	9	23	47	33
<hr/>					
Anomaly of commutation	—	4	7	51	8
Its half is	—	2	3	55	34
<hr/>					

Log. Comet's curtate distance	—	—	9.756143
Log. of the Earth from the Sun	—	—	9.992851
<hr/>			
Tangent of $30^{\circ} 6' 22''$	—	—	9.763292
Add — 45 0 0			<hr/>
Sum — 75 6 22			<hr/>

As Radius	—	—	10.000000
<hr/>			
To tc. $75^{\circ} 6' 22''$	The sum	—	9.424825
So is t. 63 55 34	Half anom. commut.	—	10.310398
<hr/>			
To t. 28 31 32	A fourth arc	—	9.735223
<hr/>			

		S.	°	'	"
Half anomaly of commutation	—	63	55	34	
Fourth arc, add and subtract	—	28	31	32	
Parallax of the Comet's orb, subtract	—	92	27	6	
Elongation, add	—	35	24	2	
Comet's heliocentric longitude	—	2	1	38	41
Parallax of the Comet's orb, subtract	—	3	2	27	6
<hr/>					
Comet's geocentric longitude	—	10	29	11	35
<hr/>					

For the Comet's geocentric latitude :

As f.	52 8 52	Commutation co. ar.	—	0.102594
To f.	35 24 2	Elongation	—	9.762895
So is t.	12 49 25	Comet's heliocentric latitude		<u>9.357225</u>
To t.	9 28 9	Comet's geocentric latitude		<u>9.222714</u>

To find the Comet's distance from the Earth in miles, on the 2d of December, Old Stile, at noon; the solar parallax 10 seconds.

As Radius	—	—	—	10.00000
To f. 68° 32'	Comet from its node	—	—	9.96878
So is s Q	0.8265	—	—	<u>9.91724</u>
To QN	0.7692	—	—	<u>9.88602</u>

As Radius	—	—	—	10.00000
To f. 32° 36'	Comet's inclination	—	—	9.73141
So is QN	0.7692	—	—	<u>9.88602</u>
To QP	0.4144	—	—	<u>9.61743</u>

As ℓ . $28^{\circ} 28'$ geocentric latitude	—	—	9.67821
To ρ 0.4144	—	—	9.61745
			<hr/>
So is Radius	—	—	10.00000
			<hr/>
To τ 0.8694, the Comet from the Earth	—	—	9.93924
			<hr/>

As 10000 to .8694, so is 81000000 mean
dist. of the Earth from the Sun.

81000000	
<hr/>	
8694000000	
69552	
<hr/>	

10000)704214000000(70421400 Miles the Comet from
the Earth, on the 13th of December, at noon, 1789, New
Stile.

How to delineate the VISIBLE PATH of a
COMET among the fixed STARS, on the
Surface of the CELESTIAL GLOBE.

THE method of drawing on a Globe the tract of a Comet, or its apparent path amongst the Stars in the Heavens, is both easy and diverting, as we may by so doing be able to foresee and shew what course the Comet will take during the time of its appearance, and also in what part of the Heavens it may be expected at any time assigned.

In order to the doing this, it will be necessary to make three observations on the place of the Comet at its first appearance, as correctly as we can at the distance of 24 or 48 hours from each other, as the state of the air, &c. will permit.

Astronomers make use of several methods for investigating the apparent place of a Comet; one of which is the method I am now
going

going to explain. Thus stretch a thread over the Comet, and two known fixed Stars, in a right line with the Comet; then moving the thread into another position so as may bring the Comet into a right line with two other known fixed Stars, which is easily done among such a vast number of Stars. Having thus got the position of the Comet in respect of these Stars in the Heavens, by finding the same Stars on the surface of the Globe, and laying the quadrant of altitude over each two respectively, and drawing lines between them with a pencil, those lines will intersect each other in the place of the Comet in each observation; and thus the places of the Comet may be assigned on the surface of the Globe for any number of observations, and a circle passing through two or more places, thus marked on the Globe, will be the future way of the Comet.

It remains now that I explain the method of drawing the great circle above-mentioned, which is thus done: having got two, three, or more places of the Comet marked on the
 Globe,

Globe, let one of the poles of the Globe be raised or depressed, and the Globe turned about till the places of the Comet marked thereon coincide with the horizon, or touch it all at the same time ; then, with a pencil, draw a great circle along the surface of the Globe by the horizon, and that will be the path of the Comet required, or its visible way in the Heavens.

In the points where this circle intersects the Ecliptic will be the nodes of the orbit of the Comet ; and the angle contained between this circle and the ecliptic, will be the inclination of the Comet's orbit to the plane of the Ecliptic ; the quantity of which is readily measured at the 90th degree from the node, on the quadrant of altitude fixed over the pole of the Ecliptic, and laid on the said 90th degree.

After this manner the place of the Comet for every night it can be seen, may be represented or protracted on the surface of the Globe ; and thereby its longitude, latitude, velocity

velocity of motion, and all things relative to it, may be easily defined.

Having all along considered the orbits of Comets as parabolic; upon which supposition it must follow, that Comets being impelled towards the Sun by a centripetal force, would descend as from spaces infinitely distant, and, by their so falling, acquire such a velocity as that they may again fly off into the remotest parts of the universe, moving upwards with a perpetual tendency, so as never to return again to the Sun. But since they appear frequently enough, and since none of them can be found to move with an hyperbolic motion, or a motion swifter than what a Comet might acquire by its gravity to the Sun, it is highly probable they rather move in very eccentric elliptic orbits, and make their returns after very long periods of time. One principal use, therefore, of the
table,

table, in page 60, of the Elements of the Cometary Motions, is, that whenever a new Comet shall appear, we may be able to know, by comparing together the Elements, whether it be any of those which have appeared before; and consequently, to determine its period, and the axis of its orbit; and also to foretell its return.

The Comet which Apian observed in the year 1531, was the same with that which Kepler and Longomontanus more accurately described in the year 1607, and which Dr. Halley observed in 1682; and, according to the prediction of the Doctor, the same Comet again visited the earth in 1758; and was observed by Mr. Benjamin Martin, Dr. Patrick Browne, and many others; which leaves no room to doubt but the rest may return also: for it is highly probable, that the Comet observed by Apian in the year 1532, was the same with that observed by Hevelius in the year 1661, which will again visit us in the year 1789. As a further proof, and as far as probability from the equality
of

of periods, and similar appearance of Comets may be urged as an argument, the wonderful Comet of 1680, was the same which was seen in the reign of Henry the First, anno 1106. As also in the consulate of Lampadius and Orestes, about the year of Christ 531, of which Malela relates, that it was a great and fearful Star; now it is plain, that the interval between this and that of 1106, is nearly equal to that between 1106 and 1680, viz. about 575 years. And if we reckon backward such another period, we shall come to the 44th year before Christ, in which Julius Cæsar was murdered, and in which there appeared a very remarkable Comet, mentioned by almost all the historians of those times, and by Pliny, in his Natural History, Book xi. chap. 24. who recites the words of Augustus Cæsar on this occasion, which leads us to the very time of its appearance, and its situation in the Heavens. Thus, it is probable, that this Comet has four times visited us, at intervals of about 575 years.

I shall now conclude with wishing that the lovers of Astronomy will never let a Comet pass without making necessary observations thereon, whenever it can be done with correctness.

F I N I S.

