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A CANON OF LUNAR ECLIPSES FOR THE YEARS -1500 TO -1000, ASTRONO--ETC(U)
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By R. R. NEWTON

THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY

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ABSTRACT

The Shang dynasty ruled China for more than two centuries during the period from -1500 to -1000. A number of observations of lunar eclipses that have been preserved from the Shang dynasty may be the oldest astronomical observations known that involve the moon. The dating of these eclipses would supply valuable data for determining the secular accelerations within the sun-earth-moon system. This report presents a canon of all lunar eclipses that occurred between -1500 and -1000 for use in the dating of the Shang eclipses. The canon includes the circumstances needed to determine the visibility of each eclipse at any point on earth.

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1. INTRODUCTION

The forces or effects that are slowly changing the number of days per month and the number of days per year are important in studying precise measurements of time. They are also important in many geophysical problems, including the behavior of the ocean tides, the body tides in the solid earth, core-mantle coupling, secular changes in the earth's magnetic field, and possibly other effects.

In the present state of knowledge, the best way to get quantitative values for the rates at which the number of days per month and per year are changing is to compare astronomical observations made in ancient and medieval times with the results that we calculate from a modern astronomical theory, that is, a theory that neglects all astronomical forces except gravitation.* Since the difference between the observations and the results thus calculated tends to increase as the square of the time, the oldest observations are the best, other things being equal.

With the possible exception of some marks on neolithic pottery, whose significance is a matter for considerable debate, the oldest Chinese writing known comes from the Shang dynasty, which ruled China for two centuries or more between -1500 and -1000. Fortunately this writing includes a number of observations of lunar eclipses. If these eclipses can be dated, they are of great potential value in astronomical research; they will be the oldest datable observations known that involve the moon.

Keightley (Ref. 1) has been studying many aspects of the history of the Shang dynasty, including the dating of the dynasty by means of the eclipses and other information. In order for him to use the eclipses, I have prepared a canon (included in this report) that gives the circumstances of all lunar eclipses for the period -1500 to -1000.

At present, not all lunar eclipse records in the Shang writing are useful for dating. Only certain clusters of records that can be dated relative to each other by means of the texts themselves

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*It is understood that a gravitational theory includes the effects of special and general relativity.

Ref. 1. David N. Keightley, Sources of Shang History: The Oracle-Bone Inscriptions of Bronze Age China, University of California Press, Berkeley, 1977.

are useful. The technique is to use the canon of eclipses in the search for a cluster of eclipses that have the same relative dating as a cluster of records. If there is only one such cluster, the records are dated uniquely. If there are several such clusters, there are several choices for the chronology of the records, but historical evidence may guide a choice between possible clusters.

With the eclipse records that are currently available, there is no rigorously unique choice of dating, although Appendix 4 of Keightley's work (Ref. 1) shows that there is a most probable choice. Luckily, new inscriptions from the Shang dynasty continue to be found fairly frequently; for example, more than 4800 specimens were found in 1973 alone (Ref. 2). Eclipse observations are not common, but we have good reason to hope that new eclipse observations will be found that can resolve the problem of dating, thus making them useful both for history and for astronomy. The purpose of this report is to make the canon of lunar eclipses available to scholars who may study such observations.

It is useful at this point to explain the notations and conventions used in writing dates and similar matters.

Dates are given in the so-called astronomical style, in which the year appears first, then the month, and then the day of the month, without using commas to separate the components of the date. Since all of the dates involved are earlier than the time of Julius Caesar, they are in the proleptic Julian calendar.

In the astronomical style, a year that is preceded by a plus sign (if no sign is given, a plus sign is understood) is the same as a year of the common era. Thus, for example, the Battle of Hastings took place on 1066 October 14. The year before the year 1 is called 0, the preceding year is called -1, and so on back. This style contrasts with the so-called historical style, in which the year before 1 is called 1 before the common era (1 BCE). When the number of the year is negative, then the number is not the same as the year BCE.

The time that is called noon is the time when the sun is directly south of the observer. Thus noon can be observed directly by astronomers, while midnight cannot be. For this reason, astronomers for many centuries took the astronomical day to begin at noon, and many earlier astronomical tables, including some earlier canons of eclipses, are presented in terms of this convention. However, by international agreement, astronomers dropped this practice at the

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Ref. 2. David N. Keightley, private communication, 3 January 1977.

beginning of 1925. In astronomical work since then, the astronomical day is considered to begin at midnight, just as the day of ordinary usage in the United States does. Specifically, in this report, a calendar day runs from midnight to midnight.

The time of day is given in terms of hours and decimal fractions, not hours, minutes, and seconds. The time runs from 0 hours to 24 hours. The phrases "0 hours" and "24 hours" both denote midnights, and the distinction is most easily explained by an example. The time 0 hours on 1066 October 14 is the midnight that begins the calendar day 1066 October 14. That is, it is the midnight that separates 1066 October 13 from 1066 October 14. The time 24 hours on 1066 October 14 is the next midnight, the one that separates 1066 October 14 from 1066 October 15; it is the same as 0 hours on 1066 October 15.

The time of day can also be given in terms of a fraction of a day, and this was actually done in some ancient and medieval writing on astronomy. For example, we could write a time as 1066 October 14.718 75. This is the time 17.25 hours, or 5:15 p.m., on 1066 October 14.

Because different calendar months have different numbers of days, and because different calendar years have different numbers of days, a calendar based upon months and years is not convenient for making precise astronomical calculations. In astronomy, we need a time variable that runs continuously and uniformly. Throughout the centuries, astronomers have adopted various devices for achieving such a time variable. One that has had considerable use during the past four centuries is the Julian day number.*

The term "Julian" in Julian day number has nothing to do with "Julian" in the Julian Calendar. The Julian day number was devised in the sixteenth century by Josephus Justus Scaliger, who named it after his father, Julius Caesar Scaliger. The Julian day number is often called the Julian date. This is probably not a desirable usage because the term is easily confused with a Julian calendar date.

The Julian day number is a time variable that is measured in units of days. Since Scaliger worked at a time when the astronomical day began at noon, he began the Julian day number (henceforth abbreviated JDN) at noon. Specifically, JDN = 0 at noon on the calendar date -4712 January 1. JDN is therefore always an integer at noon.

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*The Julian day number, as well as most calendrical matters involved in this report, is explained in Chapter 14 of Ref. 3.

Ref. 3. Explanatory Supplement to the Astronomical Ephemeris and to the American Ephemeris and Nautical Almanac, Her Majesty's Stationery Office, London, 1961.

There are various ways of finding the JDN from the calendar date, and vice versa. When one is dealing with only a few dates, the easiest way probably is to use the tables on pp. 436-439 of Ref. 3. For a large number of dates, it probably is easiest to write a computer program to carry out the transformation. Writing such a program is tedious but straightforward.

To continue the earlier example, the JDN was 2 110 701 at noon on 1066 October 14. At 5:15 p.m. on that day, it was 2 110 701.218 75, and at 5:15 a.m., 2 110 700.718 75.

In this report, only integral values of JDN will be used. For a given calendar date, the corresponding value of the JDN will be the value at noon on that date. Thus the JDN, as used here, changes at midnight, just as the calendar date does. We can put the matter another way. As we have seen, we can write a time in terms of calendar days and fractions. When we write a calendar date, we write the truncated form; that is, we leave off the fraction and write only the integral part. For example, we write the time 1066 October 14.718 75 as 17.25 hours on 1066 October 14. In this report, in contrast, the JDN will be rounded to the nearest integer. Thus JDN 2 110 701.218 75 will be written as 17.25 hours (5:15 p.m.) on JDN 2 110 701, and JDN 2 110 700.718 75 will be written as 5.25 hours (5:15 a.m.), also on JDN 2 110 701.

Since midnight occurs at different times in different places, and since the calendar date changes at midnight, the calendar date and the JDN at any instant are not necessarily the same in all places. In giving a date or a JDN, it is necessary to specify the place to which they apply. In this report, dates and times apply to the meridian of Anyang,* which is 114°20' east of Greenwich. Anyang time** is thus 7.62 hours greater than Greenwich time. When it is 17.25 hours on 1066 October 14, JDN 2 110 701, in Greenwich time, it is 0.87 hours on 1066 October 15, JDN 2 110 701, in Anyang.

Beginning at least as early as the Shang dynasty and continuing at least into the time that we call the medieval period, the Chinese numbered the days in a cycle of 60 days. Beginning with some arbitrarily chosen day, they numbered the days from 1 to 60 and then numbered the next day 1 again, and so on. This cycle will

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*The Shang eclipse observations that have been used up to the present time were all made in Anyang.

**Specifically, time used in this report is Anyang mean time, which is 7.62 hours greater than Greenwich mean time. Mean time is the kind of time that the reader lives by; it is the time kept by an accurate timepiece properly adjusted for the place in question.

be called the 60-day cycle, and the number of the day within the cycle will be called the cycle number, designated C.

Records such as eclipse records from later times that can be dated exactly in our calendar (Ref. 4) enable us to devise a way to calculate C from the JDN. We simply add 50 to the JDN and divide the result by 60. The remainder is equal to C with one exception: when the remainder is 0, we say that C = 60.

We have no documents that can tell us if the cycle count used in Shang times continued unbroken into later times; that is, we have no documentary proof that the rule just stated gives C in Shang times; see Keightley (Ref. 1) for an extensive discussion of the point. It is assumed in the report that the rule does apply to Shang times, and the assumption agrees with the preponderance of the evidence.

Since the JDN changes at midnight in the usage of this report, the rule makes C change at midnight also. This usage is not intended to prejudge the question of when the Shang actually considered the day to change. It is adopted because it is necessary to have a precise usage in the canon of eclipses, and the adopted usage seems to be the most convenient for present purposes.

Ref. 4. H. H. Dubs, "Solar Eclipses During the Former Han Period," Osiris, Vol. 5, 1938, pp. 499-522.

2. THE LUNATION

In all earlier canons of eclipses that I know of, the eclipses appearing in a canon have been numbered serially. This practice means that the number applied to an eclipse is arbitrary, and if the same eclipse appears in different canons, it probably has a different identifying number in each. There is no direct relation between numbers in different canons, and there is no clear relation of the numbers to chronology.

It is desirable for many reasons to use identifying numbers that can be applied to all canons. I have adopted such a system of numbers in this report, and I would be interested in the reader's reaction.

The identifying number used in this canon is called the lunation. A lunation is the interval of time from one new moon to the next. In most current national ephemeris publications, the reference epoch adopted is noon, Greenwich time, on 1899 December 31, when the JDN was 2 415 020. As it happens, there was a new moon on the following morning, on 1900 January 1, Greenwich time. I take lunation 1 to be the lunar month that began on the morning of 1900 January 1, Greenwich time. Other lunations are then counted from that one. In particular, lunation 0 is the one that began on 1899 December 3, lunation -1 is the one that preceded lunation 0, and so on.

There was a solar eclipse on 1899 December 3. This is the beginning of lunation 0, and the eclipse would be identified as lunation 0 in a canon of solar eclipses. There was a lunar eclipse on 1899 December 17, also within lunation 0. That eclipse would therefore be identified as lunation 0 in a canon of lunar eclipses.

The lunation does not depend upon the place for which a canon of eclipses is prepared.

3. MAGNITUDE: UMBRAL AND PENUMBRAL ECLIPSES

An eclipse of the moon is produced by the earth's shadow, which is illustrated in Fig. 1. (The figure is not to scale.) The shadow consists of two parts. The part called the umbra is shown in black in the figure; no light from the sun directly reaches any point within the umbra.* The part called the penumbra is shaded in the figure; light from part but not all of the sun reaches any point within the penumbra.

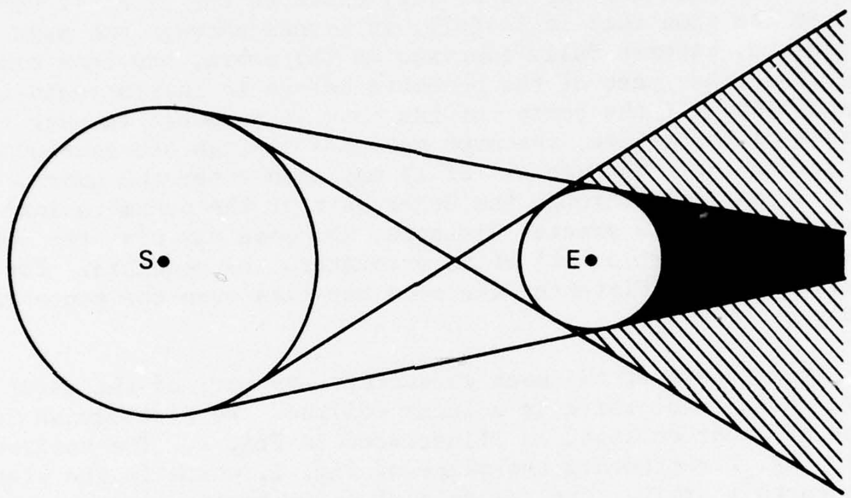

Fig. 1 The Geometry of the Earth's Shadow. No light from the sun directly penetrates to any point in the black region, which is called the umbra. Some but not all of the light from the sun reaches any point within the shaded region, which is called the penumbra. Actually, the atmosphere that surrounds the earth refracts or scatters a small amount of sunlight, and some of this light penetrates into the umbra. Thus it is not completely dark inside the umbra, even aside from the starlight that can be seen there.

*Some sunlight is scattered or refracted by the earth's atmosphere, and some of the light that is scattered or refracted gets into the umbra. Thus the umbra is not completely dark, even aside from the starlight that can be seen within it. This accounts for the fact that the moon frequently appears reddish during a total eclipse.

The sun and earth are not actually circles as the figure represents them. To the accuracy needed in this discussion, the sun and earth are solid spheres. The earth's shadow thus is not a plane figure either. The reader should be able to imagine that both the umbra and penumbra are conical regions of space, extending above and below the plane of the figure.

We may consider that the center of the earth is traveling around the sun in the plane of Fig. 1. The center of the moon is traveling around the earth, but not in the plane of the figure. Instead, the moon is sometimes in front of the plane of the figure and sometimes behind it.

If the moon happens to be very close to the plane of the figure at the time that it is full, it passes through one part of the penumbra, becomes fully immersed in the umbra, and then passes through the other part of the penumbra before it enters again into full sunlight. If the center of the moon is somewhat farther from the plane of the figure, the moon may pass through one section of the penumbra, part but not all of it may then enter the umbra, and finally it may pass through the other part of the penumbra into full sunlight. At a greater distance, the moon may miss the umbra entirely, while part or all of it encounters the penumbra. Finally, at a still greater distance, the moon may miss even the penumbra entirely.

If any part of the moon encounters any part of the earth's shadow, we say that there is a lunar eclipse. We distinguish four classes of lunar eclipse, as illustrated in Fig. 2. The horizontal line in Fig. 2 represents the plane of Fig. 1, which is the plane of the earth's orbit. For the sake of definiteness, we take the center of the moon to be above the horizontal line at the instant it is closest to the center of the earth's shadow. The circle marked M in each part of the figure represents the moon. Of the remaining pair of concentric circles, the inner one marks the edge of the umbra and the outer one the edge of the penumbra.

In case (a) of Fig. 2 the moon partly enters the penumbra, and in case (b) it totally enters it. These types of eclipse are called penumbral, but they are not given names to distinguish them from each other. The eclipses in cases (c) and (d) are called umbral, that in (c) being partial and that in (d) total. When the adjectives partial and total are used, it is understood that an eclipse is umbral.

In order to define the magnitude of an eclipse, let x denote the vertical distance from the upper edge of the umbra to the lower edge of the moon; this distance is explicitly marked only in

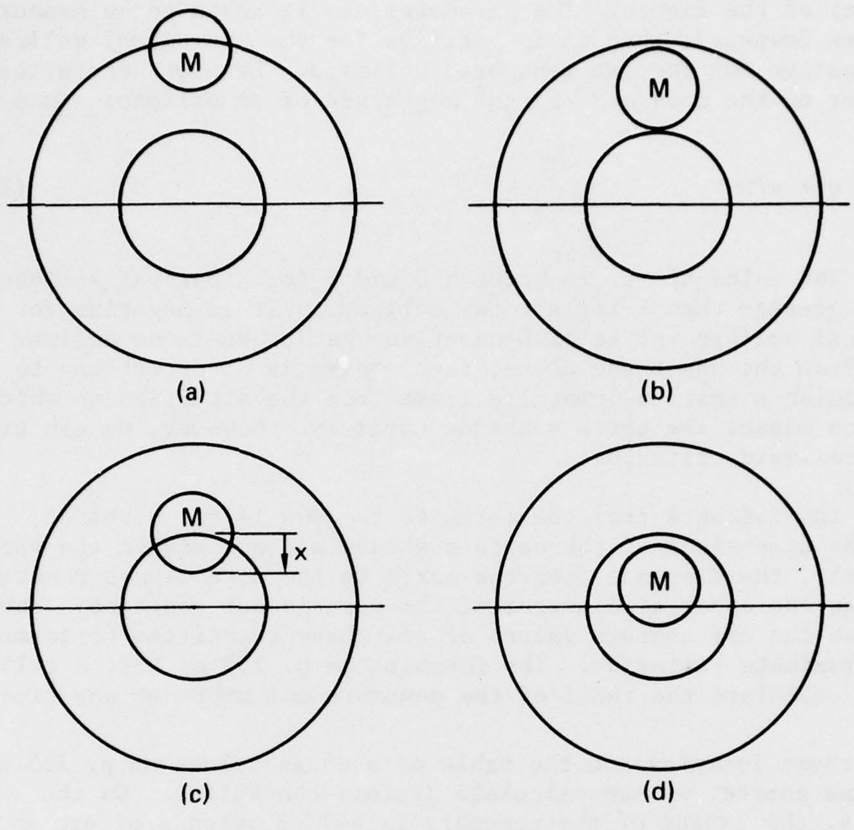

Fig. 2 **Four Possible Types of Lunar Eclipse. The horizontal line represents the plane of the earth's orbit, and the center of the moon is considered to be above this orbit when it is closest to the center of the earth's shadow. The inner circle outlines the umbra and the outer circle outlines the penumbra. The circle M represents the moon. In (a), part of the moon enters the penumbra. In (b), all of the moon enters the penumbra but none of it enters the umbra. In (c), part of the moon enters the umbra, while in (d) all of it enters the umbra. The eclipse in (c) is called partial and the eclipse in (d) is called total; it is understood that partial and total refer to immersion in the umbra. Eclipses (c) and (d) are also called *umbral*, while eclipses (a) and (b) are called penumbral. Eclipses (a) and (b) are not given separate designations.**

case (c) of the figure. The parameter x is taken to be measured positive downward; thus it is positive for the two umbral eclipses and negative for the two penumbral eclipses. Let D denote the diameter of the moon and μ the magnitude of an eclipse. Then

$$\mu = x/D \quad . \tag{1}$$

The value of μ is between 0 and 1 for a partial eclipse and is greater than 1 for a total eclipse. It is negative for a penumbral eclipse and is also negative when there is no eclipse at all. From the magnitude alone, then, there is no direct way to distinguish a small penumbral eclipse from the situation in which the moon misses the earth's shadow entirely. However, we can give an approximate criterion.

The distance from the earth to the sun is not constant; thus the dimensions of the earth's shadow are not always the same. Similarly, the distance from the earth to the moon is not constant, and thus the apparent diameter of the moon is not constant. However, we can use average values of all these quantities to formulate an approximate criterion. The formulas on p. 257 of Ref. 3 tell us how to calculate the radii of the penumbra and umbra at any time.

Using these formulas and the table of average values on p. 215 of the same source, we can calculate average conditions. On the average, the radius of the penumbra is 4473.8 seconds of arc and the radius of the umbra is 2515.4 seconds. Thus, if the lower edge of the moon just touches the upper edge of the penumbra, the distance x is $2515.4 - 4473.8 = -1958.4$ seconds. The average diameter of the moon is 1865.2 seconds. Under these conditions, $\mu = -1.05$. If μ is algebraically much smaller than -1.05, there is no eclipse at all, while if it is algebraically much larger than -1.05, say larger than about -1, there is a small penumbral eclipse. When the magnitude is close to -1.05, we cannot tell from μ alone whether or not there is an eclipse.

The greatest possible value of μ occurs when the center of the moon coincides with the center of the shadow. Under this circumstance and at the average distances, $x = 3448.0$ seconds and $\mu = 1.85$. The greatest possible magnitude when all circumstances are considered is about 1.88.

Figure 2 has been drawn under the assumption that the center of the moon is above the horizontal line (the plane of the earth's orbit). If it is below the horizontal, we obtain the required figures by inverting Fig. 2. Clearly, we have the same types of eclipse, and we have the same considerations about the magnitude.

4. THE VISIBILITY OF UMBRAL AND PENUMBRAL ECLIPSES

Even if sunlight traveled in straight lines past the earth, there would be no sharp division between full sunlight and the penumbra, or between the penumbra and the umbra. The reader can see this with the aid of Fig. 1. Light from almost all of the sun reaches a point just inside the penumbra. Thus a point on the moon just inside the penumbra is almost as bright as a point in full sunlight. Similarly, almost no light reaches a point in the penumbra just outside the umbra, while no light (on the assumption of linear propagation) reaches a point inside the umbra. Again, there is little difference in illumination between points just inside and just outside the umbra. The earth's atmosphere smoothes out even the small degrees of contrast that exist as we cross the geometric boundaries of the shadow.

A small change in illumination makes a large change in the response of the eye when the illumination is weak, but it makes little change in response when the illumination is strong. When the umbral phase of an eclipse begins, the illumination is already weak because one edge of the moon has already been deep within the penumbra. When the penumbral phase begins, however, the illumination is strong because most of the moon is in full sunlight and the moon is full.

Probably for this reason, the beginning of an umbral eclipse seems fairly sharp to the unaided eye. During the partial phase of an eclipse, the boundary of the earth's shadow seems to be well defined. Even an untrained observer using only the unaided eye can determine the beginning or ending of the umbral phase with fair accuracy, probably within about 10 minutes. The beginning or ending of the penumbral phase is not well marked, and it is doubtful if anyone has ever seen the beginning or ending of the penumbral phase with the unaided eye.

When the moon is completely within the penumbra, there is a considerable difference in illumination from one side to the other. However, there is no sharp line, and the difference in illumination does not greatly affect the eye because the total illumination is still fairly strong. In order to know that a penumbral eclipse is happening, the observer has only two things to help him: (a) there is a difference in illumination between one edge of the lunar disk and the other, and (b) the total level of illumination is less than when the moon was in full sunlight. Only a practiced observer can determine either effect.

In other words, almost anyone will see a partial eclipse, even down to rather small magnitudes. In contrast, almost no one will see a penumbral eclipse, even when the moon is totally immersed in the penumbra.

For this reason, much of the literature on lunar eclipses considers an eclipse to be synonymous with an umbral eclipse. For example, the largest canon of eclipses (Ref. 5) refers only to umbral eclipses. In all ancient and medieval literature that I have seen, only the umbral phase of a lunar eclipse is considered. al-Biruni (Ref. 6, p. 130) discusses the question of when a lunar eclipse first becomes visible. According to him, most astronomers think that it cannot be seen until the magnitude is about 0.083. He, however, thinks that it can be seen somewhat sooner. From his silence, it is clear that al-Biruni does not even contemplate the possibility of seeing an eclipse at a magnitude of zero, much less while the eclipse is still penumbral and the magnitude is negative. To al-Biruni, a lunar eclipse is clearly an umbral eclipse.

The writing of Ptolemy (Ref. 7) furnishes another example. In Chapter 5 of his Book VI, Ptolemy discusses the limiting conditions under which eclipses of the sun and moon are possible. For lunar eclipses, he finds that the limiting condition occurs when the center of the moon is 1°3'36" from the center of the earth's shadow. This is almost exactly the limiting condition given in Ref. 3 for umbral eclipses. In other words, for Ptolemy as for al-Biruni, a lunar eclipse is an umbral eclipse, and he does not seem even to contemplate any other possibility.

This report will deal with both umbral and penumbral eclipses, but it will deal with them separately.

Ref. 5. T. R. von Oppolzer, Canon der Finsternisse, Kaiserlich-Königlichen Hof- und Staatsdruckerei, Vienna, 1887. (There is a reprint, with the explanation of the tables translated into English by O. Gingerich, Dover Publishing Co., New York, 1962.)

Ref. 6. al-Biruni, Abu al-Raihan Muhammad bin Ahmad, Kitab Tahdid Nihayat al-Amakin Litashih Masafat al-Masakin, 1025. (There is a translation into English by Jamil Ali, with the title translated as The Determination of the Coordinates of Positions for the Correction of Distances Between Cities, published by the American University of Beirut, Beirut, Lebanon, 1967.)

Ref. 7. C. Ptolemy, 'E Mathematike Syntaxis, ca. 142. (There is an edition by J. L. Heiberg in C. Ptolemaei Opera Quae Exstant Omnia, B. G. Teubner, Leipzig, 1898. There is a translation of this edition into German by K. Manitius, B. G. Teubner, Leipzig, 1913. There is an edition with a parallel French translation by N. B. Halma, Henri Grand Libraire, Paris, 1813.)

5. THE CANON OF UMBRAL ECLIPSES

The first canon at the end of this report presents all umbral eclipses (781) between the dates -1500 August 27 and -1000 September 18. The canon is arranged so that we may easily tell which eclipses were visible at Anyang. However, all eclipses within the stated time interval* are listed, whether they were visible at Anyang or not. With the aid of simple computations that will be described later, the visibility of any eclipse can be determined for any point on earth.

The canon contains 14 columns:

1. The L column gives the lunation, which has already been defined.

2. The JDN column gives the Julian day number based upon Anyang time.

3. The Y column gives the year.

4. The M column gives the month. A month is identified by the first three letters of its name in English, without a period following. For some purposes, it would have been more convenient to number the months. However, the table is more readable when the string of numbers in a line is broken by letters. This was taken to be the most important consideration, since it lessens the chance of error in reading the canon.

5. The D column gives the day of the month. Y, M, and D are based upon Anyang time.

6. The C column gives the cycle number, also based upon Anyang time.

7. The MS column gives the time when the moon set at Anyang. It is almost the same time as sunrise. MS and all times in the remaining columns are in hours and decimal fractions at Anyang.

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*The canon actually gives all umbral eclipses between -1500 January 1 and -1000 December 31. As it happens, the first eclipse in -1500 came in August and the last eclipse in -1000 came in September.

8. The MR column gives the time when the moon rose at Anyang. It is almost the same time as sunset. More accurately, the reader may use MR and MS as if they were the times of moonrise and moonset for the purpose of determining the visibility of the eclipse. The precise definitions of these times will be given in Section 7 of this report in connection with determining visibility at places other than Anyang.

9. The BT column gives the time when the umbral phase of the eclipse began, i.e., when the magnitude became equal to zero. BT is sometimes negative, as will be explained in connection with column 11.

10. The GT column gives the time when the magnitude of the eclipse was greatest.

11. The ET column gives the time when the umbral phase of the eclipse ended, that is, when the magnitude again became zero as the eclipse was coming to its end. ET is sometimes greater than 24 hours, just as BT is sometimes negative. Such values of BT or ET occur only when the duration of an eclipse spans midnight. When that happens, we must make an arbitrary choice of the date to assign to an eclipse. In this canon, the date is chosen on the basis of the day at Anyang when the magnitude was greatest. Thus GT is always between 0 and 24 hours.

    If an eclipse crosses midnight, it actually occurs on two different dates. In order to have a unique date to assign to it, the canon uses the date when GT occurred and applies it to all other phases of the eclipse. Thus, for example, the eclipse of -1500 August 27, which is the first eclipse in the canon, had its greatest magnitude at 0.11 hours in the morning, Anyang time. It began at 23.31 hours on -1500 August 26. In order to keep the date -1500 August 27 for all phases, we say that BT = 23.31 - 24 = -0.69 hours on that date. Similarly, the eclipse of -1498 July 7 had its greatest magnitude at 22.64 hours on that date, and it ended at 0.37 hours on July 8, Anyang time. In order to keep the same date for all phases, we say that its ET was 24.37 hours on -1498 July 7.

12,13, and 14. These columns will be explained together since they all have the same purpose, which is to allow the user to estimate the magnitude of the eclipse at any time between BT and ET. The GM column gives the greatest magnitude of the eclipse, a magnitude that came at the time GT. Besides this magnitude, the canon gives, either explicitly or implicitly, the values of four other magnitudes, M1, M2, M3, and M4, at stated times. The values M1 and M4 are taken to be the magnitudes at the times BT and ET. Since these values are zero by the definitions of BT and ET, it is not necessary to list them. The remaining magnitudes are given in columns M2 and M3, respectively. M2 occurred at the average of BT and GT while M3 occurred at the average of GT and ET.

Since the user is given five values of magnitude and the corresponding times, he can use a general polynomial of the fourth degree in interpolating to find the magnitude at any other time. However, the eclipse is symmetrical about the time GT, to the accuracy of any observations with which the canon is likely to be used. Thus the user can do something simpler. He can replace GT by the average of BT and ET, and replace both M2 and M3 by the average of the values listed in the canon. The magnitude is now a function of time that is symmetrical about the new value of GT, and the user can fit it to a fourth-degree polynomial of the form $A + Bt^2 + Ct^4$. He can then find the magnitude at any time by substituting the value of time, t, into the polynomial.

Between MS and MR, the moon was below the horizon at Anyang and therefore could not be seen there. If any of the times BT, GT, or ET comes between MS and MR, the corresponding phase of the eclipse was not visible at Anyang.

Comparison of BT and ET with MS and MR tells us whether an eclipse was visible at Anyang. If both of these times lie between MS and MR, all the eclipse happened while the moon was below the horizon and none of it was visible at Anyang. If both times are before MS, the eclipse was in the morning and its entire duration was visible at Anyang. Similarly, if both times are after MR, the eclipse was in the evening (that is, the maximum eclipse came before midnight) and the entire duration was again visible at Anyang.

6. THE CANON OF PENUMBRAL ECLIPSES

Skilled modern observers equipped with careful predictions of the circumstances of a lunar eclipse can see an eclipse while it is still in the penumbral phase. However, for reasons that were mentioned earlier, it is doubtful that any ancient observers ever saw a penumbral eclipse. Nonetheless, some modern scholars feel that penumbral eclipses should be considered among the possibilities when we are studying ancient eclipse observations. For this reason, this report also includes a canon of 112 penumbral eclipses for the period -1500 to -1000.

In preparing the canon, it is necessary to decide upon the minimum magnitude of eclipse that will be included. Pogo (Ref. 8) used a large body of observations of the eclipse of 1936 December 28 in order to estimate the least magnitude "which can be noticed by the average naked-eye observer." The greatest magnitude of this eclipse was -0.15. According to Pogo's study, the "typical" observer first saw the eclipse when the magnitude reached -0.37, and he last saw it when the magnitude fell to -0.27. Pogo notes that there was a period of hesitation between the first time an observer thought he saw the eclipse and the time when he was sure of it. Similarly, there was a period of hesitation at last visibility. By combining these considerations, Pogo concludes that the smallest eclipse that would be seen by the "average naked-eye observer" has a magnitude of about -0.33.

On this basis, Dubs (Ref. 9) included penumbral eclipses in his canon of lunar eclipses visible in China. Instead of using -0.33 as the limiting magnitude, Dubs used -0.34 for a reason that I do not know; I shall use -0.34 to be consistent with him.

We should note that the people whose observations were used in Pogo's study were not "average naked-eye observers" at all. They were people who were competing to be the first to see the eclipse of 1936 December 28 whether they realized it or not. Many and perhaps all of them had a great deal of experience, they knew that a penumbral eclipse was about to occur, and many knew the precise times of the eclipse. They certainly cannot be considered

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Ref. 8. A. Pogo, "On the Visibility of Lunar Eclipses," Popular Astronomy, Vol. 45, 1937, pp. 126-129.

Ref. 9. H. H. Dubs, "A Canon of Lunar Eclipses for Anyang and China, -1400 to -1000," Harvard Journal of Asiatic Studies, Vol. 10, 1947, pp. 162-178.

typical Shang observers. Finally it is doubtful that Pogo's study is relevant to the study of the Shang eclipses.

The canon of penumbral eclipses follows immediately after the canon of umbral eclipses, and it has the same format. One point should be noted, however. In the canon of umbral eclipses, BT and ET are the times when the magnitude of the eclipse reaches 0. For the penumbral eclipses, these are the times when the magnitude reaches -0.34.

7. VISIBILITY OF ECLIPSES AT PLACES OTHER THAN ANYANG

We determine the visibility of an eclipse at Anyang by comparing the eclipse times BT, GT, and ET with the times of moonset and moonrise, MS and MR. Between MS and MR, the moon is below the horizon. Thus it is not visible between those times, and a lunar eclipse that occurs then is invisible. I have already explained how to use the canons to determine which eclipses were visible at Anyang.

We must now turn to the visibility at any point other than Anyang. We do this by using the times listed in the canons in order to determine the corresponding times at any other place. Once we have done this, we determine the visibility at any other place just as we do at Anyang.

We want to consider any point whose latitude is ϕ and whose longitude is λ. We take ϕ to be positive for points in the Northern Hemisphere and negative for points in the Southern Hemisphere. We take λ to be positive if it is measured east of Greenwich and negative west of Greenwich.

A lunar eclipse begins when the leading edge of the moon touches the earth's shadow. This event has nothing to do with the way that the earth happens to be oriented in space at that same instant. That is, in a measure of time that is worldwide in application, the time when an eclipse begins is the same for any observer, regardless of his latitude and longitude. The same principle applies to the times associated with any other phase of an eclipse. In other words, it applies to the times BT, GT, and ET in the canons of eclipses.

The time that is most commonly used on a worldwide basis is Greenwich mean solar time, which is often called universal time. Greenwich or universal time is 7.62 hours less than Anyang time, so we get the Greenwich values of BT, GT, and ET by subtracting 7.62 hours from the corresponding times listed in the canons. To get the corresponding times at any other place, we add the difference between Greenwich time and local time at that place. In recent years, most of the world has observed time zones, so we would add the difference between local zone time and Greenwich time. In the times to which the canons of this report apply, however, every observer implicitly used the time corresponding to his longitude. Since time increases by 1 hour when the longitude increases by 15°, local time is $\lambda/15°$ greater than Greenwich or universal time.

In sum, to change BT, GT, and ET to any other longitude, add the quantity ΔH, defined by

$$\Delta H = \lambda/15° - 7.62 \text{ hours}, \quad (2)$$

to the corresponding times listed in the canons. When doing this, watch for changes in date and JDN, and also be careful to use the correct sign of λ.

For example, the times BT, GT, and ET for the eclipse of -1494 April 25, lunation -41 974, are 7.45, 9.30, and 11.15 hours, respectively, in Anyang time. In Greenwich time, the respective hours are -0.17, 1.68, and 3.53. Since GT is still positive, the date in Greenwich time is still -1494 April 25, even though the eclipse began before midnight there.

To give another example, the same times for the eclipse of -1494 October 20, lunation -41 968, are 2.38, 4.20, and 6.02 in Anyang time. In Greenwich time, these become -5.24, -3.42, and -1.60. Since GT is now negative, we probably prefer to consider that the eclipse came on the preceding day, namely -1494 October 19, in Greenwich time, and that the hours are 18.76, 20.58, and 22.40.

It is extremely unlikely that the problem will ever arise, but I feel that I should caution the user not to cross the International Date Line by implication when he assigns the longitude, if he wants to adhere to the conventional system of assigning dates. For example, suppose he wants the times of an eclipse as seen on the island of Attu. The longitude of Attu is usually written as 173° east of Greenwich (+173°). However, the date line is deliberately indented in the Bering Sea to let Attu be considered part of North America rather than Asia. Hence, if we want to apply Eq. (2) to Attu, we should take the longitude to be -187° rather than +173°.

Before we consider the times of moonrise and moonset, let us take up an easier problem. Suppose that the sun sets at 17.62 hours, Anyang time, on some particular day. At what time does it set at any other point that is at the same latitude? When we have answered this question, we shall find it easier to handle the times of moonrise and moonset.

Let us suppose that the city of Oran is on the meridian of Greenwich and that it has the same latitude as Anyang. Under these suppositions, which are fairly accurate, what is the Oran time of sunset on a day when sunset comes at 17.62 hours in Anyang? At

17.62 hours in Anyang, the local time in Oran is 10.00 hours, and the sun is far from setting in Oran. In fact, since Oran is 114°20' (114°.333) west of Anyang, the sun sets at Oran at a time 114.333/15 = 7.62 hours later than it does at Anyang. Hence sunset at Oran on the day in question is 17.62 hours local time, the same as it is in Anyang in local time.

In other words, the local times of sunset and sunrise on a given day are the same at all points with the same latitude. In making this statement, I am ignoring some small effects that cannot change the times by more than 2 minutes. I shall take up what happens at different latitudes in a moment.

The corresponding statement about the times of moonrise and moonset is not as accurate, because the moon moves by a large amount during the course of a day. The point that is setting when it is moonset in Anyang, for example, is not the same point in the heavens that is setting when it is moonset in Greenwich. The error in saying that moonrise and moonset occur at the same local time on a given day (for points at the same latitude) can reach 25 minutes or more.

Partly for this reason, and partly for technical reasons connected with the processes of computation, the times that I have calculated and called MS and MR are not actually the times of moonset and moonrise at Anyang. In order to define these times, let M denote the point in the heavens that the moon occupies at the time of greatest eclipse, that is, GT in the canons. MS and MR are the times in Anyang when point M sets and rises. With this definition, we can take MS and MR to be the same at all points having the same latitude. The maximum error in doing so is about 4 minutes.

Although MS and MR are the setting and rising times of point M rather than of the moon, we can use them as if they were the true times of moonset and moonrise, provided that we use them only to determine whether an eclipse is visible or not. Consider a time of moonset, for example. If the median time of an eclipse is far from the time of moonset, the fact that MS may differ from the time of moonset by 25 minutes does not matter. Conversely, if the median time of an eclipse is close to the time of moonset, point M is close to the true position of the moon when it sets, and the difference between true moonset and MS is quite small.

In other words, the error in taking MS to be the time of moonset is automatically small whenever the error can be important. It can be large only when a large error does not matter. The same statement applies to taking MR as the time of moonrise.

BT, GT, and ET depend upon the longitude of the observer (Eq. (2)) but not upon his latitude. MS and MR behave in just the opposite way. As we have just seen, they do not depend upon the observer's longitude but they do depend upon his latitude. It remains to calculate MS and MR for any latitude other than that of Anyang. An explanation of the method by which this is done is very lengthy. Reference 3 (p. 26) gives an explanation aimed at the professional astronomer. Newton (Ref. 10) gives a simplified explanation aimed at a person who is not an astronomer. Here I shall merely summarize the calculations to be performed.

Let R denote the time called MR for any point other than Anyang, and let R_A denote MR for Anyang. In other words, R_A is the same as MR tabulated in the canons. Similarly, let S denote the time MS for any point other than Anyang and let S_A denote this time for Anyang. Let ϕ_A denote the latitude of Anyang and let ϕ denote the latitude of any other point; then $\phi_A = 36°04' = +36°.0667$. In order to find R and S, we evaluate the quantities N, h_A, and h by using the following formulas:

$$N = \tfrac{1}{2}(R_A + S_A) \qquad \text{hours},$$

$$h_A = 15(R_A - N) \qquad \text{degrees},$$

and

$$h = \arccos\,(\cos h_A \tan\phi/\tan\phi_A) \qquad \text{degrees.} \qquad (3)$$

After we have found the quantities N and h by the use of Eq. (3), we find R and S from

$$R = N + (h/15) \qquad \text{hours}$$

and

$$S = N - (h/15) \qquad \text{hours.} \qquad (4)$$

As an example of the use of Eqs. (3) and (4), consider the eclipse of -1497 June 27, lunation -42 009. For this eclipse,

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Ref. 10. R. R. Newton, "Introduction to Some Basic Astronomical Concepts," Astronomy in Ancient Literate Societies, Vol. 276A of Philosophical Transactions of the Royal Society of London, 1974, pp. 5-20.

S_A = 4.61 hours and R_A = 19.13 hours. Since the latitude of Anyang is 36°.0667, tan ϕ_A = 0.728 322. The calculations for latitude +51°, which is approximately the latitude of Greenwich, and for latitude -33°, which is approximately the latitude of Capetown, South Africa, are summarized in Table 1. The first column in the table gives the symbol for the quantity involved, the second and third columns give the values of these quantities for Greenwich and Capetown, and the fourth column gives the units of the quantity involved. The quantities cos h_A and cos h are dimensionless.

Table 1

The Times R and S for the Eclipse of -1497 June 27, Calculated for Greenwich and for Capetown, South Africa

Quantity Symbol	Value for Greenwich	Value for Capetown	Units
ϕ	51	-33	degrees
N	11.87	11.87	hours
h_A	108.9	108.9	degrees
cos h_A	-0.323 917	-0.323 917	
cos h	-0.549 214	+0.288 820	
h	123.3	73.2	degrees
R	20.09	16.75	hours
S	3.65	6.99	hours

8. UNCERTAINTIES IN THE CANONS

The major ephemeris publications, such as the American Ephemeris and Nautical Almanac, give ephemerides of the sun and moon that are based upon certain detailed solutions of the equations of motion of the solar system. The canons of eclipses in this report are based upon the same solutions. There are two types of possible error in the canons. First, certain approximations have been made in order to simplify the calculations, and second, the basic solutions themselves contain errors.

The complete solutions for the motions of the sun and moon can be put into the form of sums of periodic functions (sines and cosines). The correct solutions must have infinite numbers of terms, but only a finite number can be used in actual computations. The major ephemeris publications use about 130 terms for the motion of the sun and about 1500 for the motion of the moon. In preparing the canons, I kept only about the 70 largest terms for the sun and about 350 for the moon. The result of using the shortened solutions can be expressed by the effect upon BT, GT, and ET. I estimate that the average effect is about 20 seconds of time, but in rare cases the error might amount to 1 minute.

Finding the greatest magnitude would take an infinite number of computations if it were done exactly. Therefore I adopt a criterion of accuracy and terminate the computations when this criterion is satisfied. The criterion that I use can lead to an error in the greatest magnitude that does not exceed about 0.002. This means that an eclipse with a magnitude between 0 and 0.002 could have been transferred from the canon of umbral eclipses to the canon of penumbral eclipses. It also means that an eclipse with a magnitude between -0.34 and -0.338 could have been missed entirely.

Finding BT and ET also requires an infinite number of computations to do exactly. In preparing the canons, the computer program searches for the first time the magnitude is within 0.005 of 0 for umbral eclipses and of -0.34 for penumbral ones. It calls this time BT. The next time that the magnitude is within the specified range is called ET. The resulting errors in BT and ET depend somewhat upon the circumstances, but they are usually less than 20 seconds.

The errors in the basic solutions for the motions of the sun and moon come almost entirely from unknown forces that affect their motions. The best known is the force of friction in the tides, but there are other forces as well, some of which may arise from magnetic effects. In the present state of knowledge, there is no way to determine such forces from theoretical knowledge. They can be found only from the study of astronomical observations made in ancient and medieval times. This study has given us a great deal of knowledge about the forces, but it cannot give us complete knowledge. The incompleteness of our knowledge leads to uncertainties in the calculated positions of the sun and moon.

In calculating the circumstances of lunar eclipses, the position of the moon relative to the sun is most important, not the individual position of either. We can write the error in the relative position as ET^2, in which E is evaluated from a study of the data and T denotes the time in centuries before the present.

In an earlier study (Ref. 11) I summarized what was believed about the coefficient E at that time. The canons of eclipses presented in this report are based upon the information about forces given in that summary. Since then, I have discovered that some of the observations that were universally accepted as valid in 1973 cannot be used to study E. Some of the records used turn out not to be valid, while others, though valid, cannot be dated. Thus quite a few "observations" used in earlier work must now be removed from consideration, but this loss is balanced by the introduction of additional observations that had not been used in astronomical research by 1973.

In work that is now in preparation, I have studied the effect of removing the invalid or undatable observations and adding some of the new observations. These changes make only a trivial difference in the calculated circumstances of eclipses, and the canons based upon the 1973 results are still as good as we can do. The changes do increase the estimates of the error coefficient E somewhat, but not by a serious amount.

The year -567 is the earliest for which we have an appreciable body of observations. The only earlier observations that are valid and that can be dated are 17 Chinese observations of solar eclipses from -719 February 22 to -573 October 22.* However, many useful observations have been preserved from almost every century since -600. On the basis of these observations, we assign E = 1 second of arc per century per century for times between -600 and the present.

Ref. 11. R. R. Newton, "The Historical Acceleration of the Earth," Geophysical Surveys, Vol. 1, 1973, pp. 123-145.

*Opportunity has allowed the use of only two of these eclipses in the analysis that has been performed. I am analyzing the other eclipses and preparing the results for publication.

More precisely, this is the estimated standard deviation. By the definition of standard deviation, the probability is about 1 in 3 that the error is greater than this value. In most scientific work, a result is usually considered not to be well established unless it is at least on a "two standard deviation" basis. This means a probability of less than 1 in 20 that the error exceeds the stated value. On this basis, then, we must take $E = 2$ seconds of arc per century per century for times since -600.

If it had turned out that the frictional forces were constant since -600, it would be reasonable to assume that they were constant from -600 back to Shang times. However, the data show that the forces have varied widely between -600 and the present, and we must assume that they were also variable between -600 and Shang times. For years before -600, we are extrapolating beyond the available data, and extrapolation always increases an uncertainty. There is obviously no rigorous way to assign E for times before -600. However, if we make the plausible assumption that the forces had the same range of variability before -600 as they have shown since then, we should double the value of E in going back to Shang times.

In sum, we should take the error in the position of the moon, relative to the sun, to be $4T^2$ seconds of arc for the times covered by the canons presented here. Any smaller error estimate is unduly optimistic, in my opinion.

For the middle of the Shang period, the estimated error is about 3600 seconds of arc, or 1°. It takes the moon about 2 hours to move this far relative to the sun, and thus it takes the moon about 2 hours to move this far relative to the earth's shadow. In other words, the uncertainty in BT, GT, and ET is 2 hours.

The uncertainty in MS and MR, on the other hand, is negligible. This uncertainty, like that in BT, GT, and ET, depends upon the uncertainty in the position of the moon relative to the sun, which is about 1°. However, the earth rotates through 1° in 4 minutes, and it is the earth's rotation, in combination with the lunar position, that determines the moonset and moonrise times MS and MR. Hence the uncertainty in MS and MR is only 4 minutes, which is negligible for present purposes.

The change in the magnitude of an eclipse that corresponds to changing its time by 2 hours is about 0.007. In other words, this is the uncertainty in the GM column.

Dubs (Ref. 9) says that the times in his canon are accurate to about 15 minutes, and that the magnitudes are accurate to about

0.03. The statement about the magnitudes seems pessimistic, but the statement about the times is quite optimistic. I believe that this statement refers only to the first kind of error mentioned above, that due to the mathematical approximations made in calculating the canon. Dubs does not seem to have known about the basic uncertainties in the forces acting upon the sun and the moon that cause most of the uncertainty in the canons.

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A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	PT	GT	ET	M2	GM	M3
-42044	1173422	-1500	AUG	27	52	5.26	18.88	-0.69	0.11	0.90	0.13	0.18	0.14
-42033	1173747	-1499	JUL	18	17	4.80	19.14	5.70	6.21	6.72	0.06	0.08	0.06
-42027	1173924	-1498	JAN	11	14	7.40	16.97	12.43	14.25	16.08	0.73	1.14	0.74
-42021	1174101	-1498	JUL	7	11	4.69	19.16	20.90	22.64	24.37	0.84	1.38	0.85
-42015	1174278	-1498	DEC	31	8	7.37	16.83	15.00	16.77	18.55	0.77	1.21	0.77
-42009	1174456	-1497	JUN	27	6	4.61	19.13	9.08	10.71	12.34	0.63	0.94	0.63
-42003	1174633	-1497	DEC	21	3	7.27	16.73	2.25	2.47	2.68	0.01	0.01	0.01
-41986	1175135	-1495	MAY	6	25	5.38	18.48	1.05	2.34	3.62	0.33	0.46	0.33
-41980	1175312	-1495	OCT	30	22	6.32	17.41	18.72	20.39	22.07	0.73	1.12	0.73
-41974	1175489	-1494	APR	25	19	5.58	18.36	7.45	9.30	11.15	0.93	1.77	0.93
-41968	1175667	-1494	OCT	20	17	6.15	17.60	2.38	4.20	6.02	0.80	1.27	0.79
-41962	1175843	-1493	APR	14	13	5.79	18.25	21.92	23.06	24.20	0.31	0.43	0.31
-41939	1176523	-1491	FEB	22	33	7.09	17.58	19.47	21.23	22.99	0.78	1.24	0.79
-41933	1176699	-1491	AUG	17	29	5.13	19.00	21.07	22.69	24.32	0.68	1.03	0.69
-41927	1176878	-1490	FEB	12	28	7.22	17.43	1.23	3.00	4.76	0.70	1.07	0.70
-41921	1177054	-1490	AUG	7	24	4.99	19.07	12.33	14.03	15.74	0.85	1.40	0.85
-41909	1177409	-1489	JUL	28	19	4.88	19.10	6.12	6.61	7.09	0.05	0.07	0.05
-41898	1177734	-1488	JUN	17	44	4.63	19.07	7.57	8.43	9.29	0.15	0.20	0.15
-41892	1177911	-1488	DEC	11	41	7.10	16.79	-0.63	1.04	2.71	0.77	1.20	0.77
-41886	1178088	-1487	JUN	6	38	4.76	18.90	9.73	11.68	13.62	0.88	1.56	0.89
-41880	1178265	-1487	NOV	30	35	6.88	16.91	14.75	16.43	18.10	0.82	1.32	0.82
-41874	1178442	-1486	MAY	26	32	4.96	18.73	10.88	12.42	13.95	0.49	0.70	0.49
-41868	1178620	-1486	NOV	20	30	6.66	17.08	6.72	7.08	7.44	0.03	0.04	0.03
-41851	1179121	-1484	APR	4	51	6.06	18.14	21.68	23.22	24.77	0.65	0.96	0.64
-41845	1179298	-1484	SEP	28	48	5.82	18.07	21.95	23.61	25.28	0.58	0.85	0.58
-41839	1179476	-1483	MAR	25	46	6.38	18.00	14.51	16.25	17.99	0.88	1.48	0.88
-41833	1179653	-1483	SEP	18	43	5.63	18.38	-1.43	0.45	2.34	0.87	1.49	0.87
-41827	1179831	-1482	MAR	15	41	6.69	17.85	6.16	6.58	7.01	0.04	0.05	0.04
-41821	1180007	-1482	SEP	7	37	5.44	18.66	7.29	8.20	9.10	0.18	0.24	0.18
-41804	1180509	-1480	JAN	22	59	7.40	17.11	20.14	21.95	23.75	0.71	1.10	0.72
-41798	1180687	-1480	JUL	18	57	4.77	19.18	4.52	6.23	7.94	0.79	1.26	0.80
-41792	1180864	-1479	JAN	11	54	7.44	16.93	-0.84	0.95	2.73	0.78	1.24	0.79
-41786	1181041	-1479	JUL	7	51	4.64	19.20	16.09	17.80	19.50	0.70	1.06	0.70
-41780	1181218	-1479	DEC	31	48	7.41	16.78	10.77	11.11	11.45	0.02	0.03	0.03
-41763	1181720	-1477	MAY	17	10	5.15	18.61	7.82	8.90	9.98	0.23	0.31	0.23
-41757	1181898	-1477	NOV	11	8	6.52	17.19	3.43	5.11	6.79	0.73	1.12	0.73
-41751	1182074	-1476	MAY	5	4	5.33	18.49	14.54	16.39	18.24	0.93	1.82	0.93
-41745	1182252	-1476	OCT	30	2	6.33	17.36	10.65	12.47	14.30	0.80	1.27	0.79
-41739	1182429	-1475	APR	25	59	5.52	18.38	5.28	6.55	7.82	0.40	0.56	0.40
-41716	1183109	-1473	MAR	6	19	6.87	17.74	3.12	4.85	6.58	0.74	1.15	0.74

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-41710	1183285	-1473	AUG	29	15	5.31	18.82	5.18	6.76	8.35	0.65	0.97	0.65
-41704	1183463	-1472	FEB	23	13	7.04	17.59	8.51	10.32	12.13	0.74	1.15	0.74
-41698	1183639	-1472	AUG	17	9	5.16	18.94	20.42	22.14	23.87	0.88	1.47	0.88
-41686	1183994	-1471	AUG	7	4	5.02	19.02	13.78	14.49	15.19	0.11	0.15	0.11
-41675	1184319	-1470	JUN	28	29	4.59	19.18	14.85	15.30	15.75	0.04	0.05	0.04
-41669	1184496	-1470	DEC	22	26	7.27	16.79	8.18	9.85	11.51	0.77	1.20	0.77
-41663	1184673	-1469	JUN	17	23	4.67	19.03	16.19	18.10	20.02	0.84	1.40	0.84
-41657	1184851	-1469	DEC	12	21	7.07	16.84	-0.31	1.37	3.05	0.82	1.32	0.82
-41651	1185027	-1468	JUN	5	17	4.81	18.87	17.27	18.92	20.57	0.59	0.86	0.59
-41645	1185205	-1468	NOV	30	15	6.66	16.95	15.57	15.89	16.21	0.02	0.03	0.02
-41628	1185707	-1466	APR	16	37	5.77	18.27	5.36	6.83	8.30	0.58	0.84	0.58
-41622	1185884	-1466	OCT	10	34	6.00	17.81	5.79	7.44	9.09	0.57	0.82	0.56
-41616	1186061	-1465	APR	5	31	6.09	18.13	22.16	23.92	25.68	0.91	1.60	0.91
-41610	1186238	-1465	SEP	29	28	5.80	18.12	6.55	8.43	10.32	0.88	1.53	0.88
-41604	1186416	-1464	MAR	25	26	6.42	17.99	13.31	14.04	14.78	0.11	0.15	0.11
-41598	1186592	-1464	SEP	17	22	5.61	18.42	15.48	16.46	17.44	0.21	0.29	0.21
-41581	1187095	-1462	FEB	2	45	7.33	17.28	3.71	5.48	7.26	0.69	1.04	0.69
-41575	1187272	-1462	JUL	29	42	4.89	19.14	12.26	13.93	15.60	0.75	1.16	0.75
-41569	1187449	-1461	JAN	22	39	7.44	17.07	7.22	9.01	10.80	0.80	1.28	0.80
-41563	1187627	-1461	JUL	19	37	4.73	19.22	-0.82	0.94	2.70	0.76	1.18	0.76
-41557	1187803	-1460	JAN	11	33	7.48	16.89	19.20	19.67	20.13	0.05	0.06	0.05
-41540	1188305	-1459	MAY	27	55	4.97	18.75	14.70	15.49	16.28	0.12	0.16	0.12
-41534	1188483	-1459	NOV	21	53	6.72	17.02	12.16	13.84	15.52	0.73	1.12	0.73
-41528	1188659	-1458	MAY	16	49	5.10	18.63	21.63	23.47	25.30	0.92	1.67	0.92
-41522	1188837	-1458	NOV	10	47	6.53	17.14	18.96	20.79	22.62	0.80	1.27	0.79
-41516	1189014	-1457	MAY	6	44	5.27	18.51	12.62	14.00	15.38	0.49	0.70	0.49
-41493	1189694	-1455	MAR	16	4	6.62	17.89	10.64	12.33	14.01	0.69	1.04	0.69
-41487	1189870	-1455	SEP	8	60	5.48	18.61	13.43	14.98	16.53	0.62	0.91	0.62
-41481	1190048	-1454	MAR	5	58	6.82	17.75	15.64	17.49	19.35	0.78	1.25	0.79
-41475	1190225	-1454	AUG	29	55	5.33	18.76	4.66	6.39	8.13	0.90	1.54	0.89
-41463	1190579	-1453	AUG	18	49	5.18	18.89	21.63	22.48	23.33	0.17	0.23	0.17
-41446	1191081	-1451	JAN	1	11	7.39	16.84	16.89	18.55	20.20	0.77	1.19	0.76
-41440	1191259	-1451	JUN	28	9	4.63	19.14	-1.26	0.61	2.49	0.79	1.25	0.79
-41434	1191436	-1451	DEC	22	6	7.23	16.83	8.56	10.24	11.93	0.82	1.32	0.82
-41428	1191613	-1450	JUN	17	3	4.71	18.99	-0.26	1.48	3.27	0.68	1.02	0.68
-41422	1191791	-1450	DEC	12	1	7.04	16.88	0.36	0.65	0.94	0.02	0.02	0.02
-41405	1192292	-1448	APR	26	22	5.49	18.41	12.96	14.34	15.73	0.50	0.71	0.50
-41399	1192469	-1448	OCT	20	19	6.18	17.55	13.77	15.40	17.04	0.56	0.80	0.55
-41393	1192647	-1447	APR	16	17	5.80	18.26	5.71	7.49	9.27	0.93	1.72	0.93
-41387	1192823	-1447	OCT	9	13	5.98	17.86	14.67	16.55	18.44	0.89	1.55	0.88

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	FT	M2	GM	M3
-41381	1193001	-1446	APR	5	11	6.13	18.12	20.43	21.38	22.34	0.19	0.26	0.19
-41375	1193178	-1446	SEP	29	8	5.79	18.16	-0.17	0.86	1.90	0.24	0.32	0.24
-41358	1193680	-1444	FEB	13	30	7.20	17.45	11.17	12.90	14.63	0.65	0.98	0.65
-41352	1193857	-1444	AUG	8	27	5.04	19.04	20.10	21.73	23.37	0.70	1.06	0.70
-41346	1194034	-1443	FEB	1	24	7.38	17.24	15.15	16.96	18.76	0.82	1.34	0.82
-41340	1194212	-1443	JUL	29	22	4.85	19.18	6.39	8.20	10.00	0.80	1.28	0.80
-41334	1194389	-1442	JAN	22	19	7.49	17.04	3.54	4.13	4.71	0.08	0.10	0.08
-41317	1194890	-1441	JUN	7	40	4.83	18.88	21.90	22.13	22.37	0.01	0.01	0.01
-41311	1195068	-1441	DEC	2	38	6.92	16.90	20.85	22.53	24.22	0.73	1.11	0.73
-41305	1195245	-1440	MAY	27	35	4.92	18.77	4.76	6.58	8.39	0.89	1.53	0.89
-41299	1195423	-1440	NOV	21	33	6.73	16.97	3.27	5.10	6.93	0.80	1.27	0.79
-41293	1195599	-1439	MAY	16	29	5.04	18.65	19.96	21.44	22.92	0.58	0.84	0.58
-41270	1196279	-1437	MAR	27	49	6.35	18.03	17.98	19.61	21.24	0.62	0.92	0.62
-41264	1196455	-1437	SEP	19	45	5.66	18.37	21.84	23.36	24.89	0.60	0.88	0.60
-41258	1196634	-1436	MAR	16	44	6.57	17.90	-1.42	0.47	2.36	0.83	1.37	0.83
-41252	1196810	-1436	SEP	8	40	5.50	18.55	13.04	14.78	16.52	0.90	1.59	0.91
-41246	1196988	-1435	MAR	5	38	6.78	17.75	0.51	0.67	0.84	0.00	0.01	0.00
-41240	1197165	-1435	AUG	29	35	5.35	18.71	5.66	6.61	7.56	0.21	0.28	0.21
-41223	1197667	-1433	JAN	13	57	7.45	16.95	1.53	3.18	4.83	0.76	1.17	0.75
-41217	1197844	-1433	JUL	9	54	4.66	19.21	5.36	7.18	8.99	0.72	1.11	0.72
-41211	1198021	-1432	JAN	2	51	7.35	16.88	17.35	19.04	20.73	0.83	1.34	0.83
-41205	1198198	-1432	JUN	27	48	4.67	19.10	6.32	8.13	9.94	0.75	1.16	0.75
-41199	1198376	-1432	DEC	22	46	7.20	16.87	9.05	9.34	9.63	0.02	0.02	0.02
-41182	1198877	-1430	MAY	7	7	5.23	18.54	20.58	21.86	23.13	0.41	0.58	0.42
-41176	1199054	-1430	OCT	31	4	6.36	17.31	21.81	23.43	25.06	0.55	0.79	0.55
-41170	1199232	-1429	APR	27	2	5.52	18.39	13.18	14.97	16.76	0.94	1.85	0.94
-41164	1199409	-1429	OCT	21	59	6.15	17.60	-1.08	0.80	2.68	0.89	1.57	0.89
-41158	1199587	-1428	APR	16	57	5.84	18.25	3.45	4.59	5.72	0.28	0.39	0.28
-41152	1199763	-1428	OCT	9	53	5.96	17.90	8.34	9.40	10.46	0.25	0.35	0.25
-41135	1200265	-1426	FEB	23	15	7.01	17.62	18.48	20.17	21.85	0.61	0.90	0.61
-41129	1200443	-1426	AUG	20	13	5.20	18.90	4.05	5.64	7.24	0.66	0.98	0.66
-41123	1200620	-1425	FEB	13	10	7.24	17.42	-1.04	0.78	2.60	0.85	1.41	0.85
-41117	1200797	-1425	AUG	9	7	5.01	19.09	13.71	15.55	17.38	0.84	1.37	0.84
-41111	1200974	-1424	FEB	2	4	7.42	17.22	11.74	12.45	13.16	0.11	0.15	0.12
-41088	1201654	-1423	DEC	13	24	7.10	16.84	5.50	7.18	8.87	0.72	1.11	0.72
-41082	1201830	-1422	JUN	7	20	4.78	18.90	11.96	13.74	15.51	0.85	1.39	0.85
-41076	1202008	-1422	DEC	2	18	6.94	16.85	11.57	13.41	15.24	0.80	1.27	0.79
-41070	1202185	-1421	MAY	28	15	4.86	18.79	3.32	4.87	6.43	0.66	0.98	0.66
-41047	1202865	-1419	APR	7	35	6.07	18.16	1.23	2.78	4.32	0.55	0.79	0.55
-41041	1203041	-1419	SEP	30	31	5.83	18.11	6.37	7.88	9.39	0.58	0.85	0.58

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	FT	M2	GM	M3
-41035	1203219	-1418	MAR	27	29	6.30	18.03	5.40	7.33	9.25	0.87	1.49	0.86
-41029	1203395	-1418	SEP	19	25	5.67	18.31	21.54	23.29	25.04	0.91	1.63	0.92
-41023	1203573	-1417	MAR	16	23	6.53	17.90	6.88	7.59	8.30	0.09	0.12	0.09
-41017	1203750	-1417	SEP	9	20	5.52	18.49	13.84	14.86	15.89	0.24	0.33	0.24
-41000	1204252	-1415	JAN	23	42	7.45	17.10	10.05	11.68	13.31	0.74	1.14	0.74
-40994	1204429	-1415	JUL	19	39	4.74	19.23	12.13	13.87	15.62	0.65	0.97	0.65
-40988	1204607	-1414	JAN	13	37	7.41	16.99	2.02	3.71	5.41	0.84	1.36	0.84
-40982	1204783	-1414	JUL	8	33	4.69	19.16	13.05	14.90	16.76	0.81	1.30	0.81
-40976	1204961	-1413	JAN	2	31	7.31	16.92	17.59	17.93	18.27	0.02	0.03	0.02
-40959	1205463	-1412	MAY	18	53	5.00	18.69	4.18	5.32	6.46	0.32	0.45	0.32
-40953	1205640	-1412	NOV	11	50	6.56	17.10	5.91	7.53	9.15	0.55	0.79	0.54
-40947	1205817	-1411	MAY	7	47	5.27	18.53	20.60	22.39	24.18	0.94	1.79	0.94
-40941	1205994	-1411	OCT	31	44	6.34	17.36	7.28	9.16	11.03	0.89	1.57	0.89
-40935	1206172	-1410	APR	27	42	5.56	18.38	10.40	11.69	12.98	0.37	0.51	0.37
-40929	1206348	-1410	OCT	20	38	6.14	17.64	16.97	18.05	19.13	0.26	0.36	0.26
-40912	1206851	-1408	MAR	6	1	6.78	17.78	1.68	3.29	4.90	0.55	0.80	0.55
-40906	1207028	-1408	AUG	30	58	5.37	18.70	12.12	13.68	15.24	0.62	0.91	0.61
-40900	1207205	-1407	FEB	23	55	7.06	17.60	6.66	8.49	10.32	0.87	1.49	0.87
-40894	1207382	-1407	AUG	19	52	5.18	18.94	21.15	23.01	24.87	0.86	1.45	0.86
-40888	1207559	-1406	FEB	12	49	7.29	17.40	19.82	20.66	21.50	0.16	0.22	0.16
-40882	1207737	-1406	AUG	9	47	4.97	19.13	0.93	1.40	1.87	0.04	0.05	0.04
-40865	1208239	-1405	DEC	24	9	7.26	16.84	14.05	15.74	17.43	0.72	1.10	0.72
-40859	1208415	-1404	JUN	17	5	4.70	19.02	19.25	20.98	22.71	0.79	1.26	0.80
-40853	1208593	-1404	DEC	12	3	7.13	16.79	19.78	21.62	23.47	0.80	1.28	0.80
-40847	1208770	-1403	JUN	7	60	4.72	18.93	10.73	12.35	13.96	0.73	1.12	0.73
-40841	1208947	-1403	DEC	1	57	6.95	16.80	21.22	21.33	21.45	0.00	0.00	0.00
-40824	1209450	-1401	APR	18	20	5.79	18.28	8.35	9.79	11.22	0.46	0.65	0.46
-40818	1209626	-1401	OCT	11	16	6.00	17.85	15.03	16.53	18.02	0.57	0.83	0.57
-40812	1209804	-1400	APR	6	14	6.02	18.16	12.04	14.00	15.95	0.90	1.63	0.90
-40806	1209981	-1400	SEP	30	11	5.84	18.05	6.18	7.93	9.69	0.92	1.66	0.92
-40800	1210158	-1399	MAR	26	8	6.26	18.03	13.39	14.39	15.39	0.19	0.25	0.19
-40794	1210335	-1399	SEP	19	5	5.68	18.25	22.15	23.22	24.30	0.27	0.37	0.27
-40777	1210837	-1397	FEB	3	27	7.37	17.27	18.47	20.08	21.69	0.72	1.09	0.72
-40771	1211014	-1397	JUL	30	24	4.87	19.19	19.00	20.67	22.34	0.58	0.85	0.58
-40765	1211192	-1396	JAN	24	22	7.39	17.13	10.57	12.28	13.99	0.85	1.40	0.85
-40759	1211368	-1396	JUL	18	18	4.77	19.18	19.94	21.82	23.71	0.86	1.43	0.85
-40753	1211547	-1395	JAN	13	17	7.36	17.02	1.96	2.39	2.81	0.04	0.05	0.04
-40747	1211723	-1395	JUL	8	13	4.73	19.12	4.72	5.34	5.96	0.08	0.11	0.08
-40736	1212048	-1394	MAY	29	38	4.81	18.84	11.83	12.81	13.78	0.23	0.31	0.23
-40730	1212225	-1394	NOV	22	35	6.77	16.94	14.03	15.65	17.26	0.54	0.79	0.54

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FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-40724	1212403	-1393	MAY	19	33	5.04	18.67	3.98	5.76	7.54	0.92	1.65	0.92
-40718	1212579	-1393	NOV	11	29	6.54	17.15	15.70	17.57	19.44	0.89	1.58	0.89
-40712	1212757	-1392	MAY	7	27	5.31	18.51	17.27	18.69	20.12	0.46	0.65	0.46
-40706	1212934	-1392	OCT	31	24	6.32	17.40	1.69	2.78	3.87	0.27	0.37	0.27
-40689	1213436	-1390	MAR	17	46	6.52	17.92	8.76	10.29	11.82	0.49	0.69	0.48
-40683	1213613	-1390	SEP	10	43	5.55	18.48	20.32	21.85	23.37	0.59	0.85	0.58
-40677	1213790	-1389	MAR	6	40	6.83	17.76	14.21	16.06	17.91	0.90	1.58	0.89
-40671	1213968	-1389	AUG	31	38	5.35	18.75	4.73	6.61	8.49	0.88	1.52	0.88
-40665	1214145	-1388	FEB	24	35	7.10	17.58	3.77	4.74	5.70	0.21	0.29	0.22
-40659	1214322	-1388	AUG	19	32	5.15	18.98	7.75	8.52	9.28	0.11	0.14	0.11
-40642	1214825	-1386	JAN	4	55	7.36	16.91	-1.47	0.21	1.90	0.71	1.08	0.71
-40636	1215001	-1386	JUN	29	51	4.68	19.11	2.61	4.28	5.96	0.74	1.13	0.74
-40630	1215179	-1386	DEC	24	49	7.29	16.79	3.94	5.79	7.64	0.80	1.29	0.80
-40624	1215355	-1385	JUN	18	45	4.65	19.05	18.19	19.86	21.52	0.80	1.25	0.80
-40618	1215533	-1385	DEC	13	43	7.15	16.74	5.14	5.39	5.63	0.01	0.01	0.01
-40601	1216035	-1383	APR	28	5	5.53	18.41	15.41	16.72	18.02	0.36	0.51	0.36
-40595	1216212	-1383	OCT	22	2	6.18	17.59	-0.23	1.25	2.74	0.57	0.82	0.57
-40589	1216389	-1382	APR	17	59	5.75	18.29	18.62	20.59	22.55	0.91	1.78	0.91
-40583	1216566	-1382	OCT	11	56	6.01	17.78	14.92	16.68	18.43	0.92	1.68	0.93
-40577	1216743	-1381	APR	6	53	5.99	18.16	19.85	21.07	22.29	0.29	0.39	0.29
-40571	1216921	-1381	OCT	1	51	5.85	17.99	6.59	7.70	8.81	0.28	0.39	0.28
-40554	1217423	-1379	FEB	14	13	7.23	17.45	2.73	4.32	5.90	0.69	1.03	0.69
-40548	1217600	-1379	AUG	10	10	5.02	19.10	2.05	3.64	5.23	0.52	0.74	0.51
-40542	1217777	-1378	FEB	3	7	7.31	17.30	18.98	20.70	22.43	0.87	1.45	0.86
-40536	1217954	-1378	JUL	30	4	4.89	19.14	2.97	4.87	6.78	0.89	1.55	0.88
-40530	1218132	-1377	JAN	24	2	7.34	17.16	10.17	10.71	11.25	0.06	0.08	0.06
-40524	1218308	-1377	JUL	19	58	4.80	19.13	11.85	12.74	13.62	0.17	0.23	0.17
-40513	1218633	-1376	JUN	8	23	4.68	18.98	19.53	20.29	21.05	0.13	0.18	0.13
-40507	1218810	-1376	DEC	2	20	6.97	16.82	22.17	23.78	25.39	0.54	0.78	0.54
-40501	1218988	-1375	MAY	29	18	4.85	18.82	11.34	13.11	14.87	0.88	1.51	0.89
-40495	1219165	-1375	NOV	22	15	6.74	16.98	0.15	2.02	3.89	0.89	1.58	0.89
-40489	1219343	-1374	MAY	19	13	5.08	18.65	0.11	1.64	3.18	0.55	0.79	0.55
-40483	1219519	-1374	NOV	11	9	6.52	17.19	10.49	11.58	12.67	0.27	0.37	0.27
-40466	1220021	-1372	MAR	27	31	6.24	18.06	15.77	17.18	18.59	0.41	0.58	0.41
-40460	1220199	-1372	SEP	21	29	5.72	18.23	4.62	6.12	7.63	0.56	0.80	0.55
-40454	1220375	-1371	MAR	16	25	6.57	17.91	21.68	23.54	25.39	0.92	1.68	0.91
-40448	1220553	-1371	SEP	10	23	5.53	18.52	12.44	14.33	16.23	0.89	1.58	0.89
-40442	1220730	-1370	MAR	6	20	6.87	17.74	11.62	12.70	13.78	0.28	0.38	0.28
-40436	1220907	-1370	AUG	30	17	5.33	18.79	14.83	15.77	16.71	0.16	0.22	0.16
-40419	1221410	-1368	JAN	15	40	7.40	17.02	6.84	8.52	10.19	0.69	1.05	0.69

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-40413	1221586	-1368	JUL	9	36	4.72	19.16	10.10	11.72	13.34	0.68	1.01	0.68
-40407	1221764	-1367	JAN	3	34	7.40	16.86	11.95	13.81	15.67	0.81	1.31	0.81
-40401	1221941	-1367	JUN	29	31	4.63	19.15	1.73	3.44	5.14	0.85	1.38	0.85
-40395	1222118	-1367	DEC	23	28	7.31	16.75	12.99	13.36	13.73	0.02	0.03	0.02
-40389	1222295	-1366	JUN	18	25	4.60	19.09	20.21	20.47	20.73	0.01	0.02	0.02
-40378	1222620	-1365	MAY	9	50	5.29	18.54	22.41	23.52	24.64	0.25	0.35	0.26
-40372	1222797	-1365	NOV	2	47	6.37	17.36	8.60	10.08	11.56	0.57	0.82	0.56
-40366	1222975	-1364	APR	28	45	5.49	18.42	1.09	3.06	5.02	0.91	1.72	0.91
-40360	1223152	-1364	OCT	22	42	6.19	17.53	-0.24	1.51	3.26	0.92	1.69	0.93
-40354	1223329	-1363	APR	17	39	5.71	18.29	2.29	3.68	5.07	0.39	0.54	0.39
-40348	1223506	-1363	OCT	11	36	6.03	17.72	15.16	16.28	17.41	0.29	0.40	0.29
-40331	1224008	-1361	FEB	25	58	7.04	17.62	10.91	12.46	14.00	0.65	0.96	0.65
-40325	1224185	-1361	AUG	21	55	5.19	18.95	9.25	10.75	12.25	0.46	0.64	0.45
-40319	1224363	-1360	FEB	15	53	7.17	17.47	3.23	4.97	6.71	0.88	1.51	0.89
-40313	1224539	-1360	AUG	9	49	5.04	19.05	10.19	12.10	14.02	0.91	1.65	0.90
-40307	1224717	-1359	FEB	3	47	7.26	17.33	18.22	18.88	19.54	0.09	0.12	0.09
-40301	1224893	-1359	JUL	29	43	4.91	19.09	19.23	20.29	21.36	0.25	0.34	0.25
-40290	1225219	-1358	JUN	20	9	4.60	19.12	3.42	3.84	4.25	0.04	0.05	0.04
-40284	1225396	-1358	DEC	14	6	7.16	16.77	6.25	7.85	9.46	0.54	0.78	0.53
-40278	1225573	-1357	JUN	9	3	4.72	18.96	18.71	20.45	22.18	0.84	1.37	0.85
-40272	1225750	-1357	DEC	3	60	6.94	16.86	8.61	10.48	12.35	0.89	1.58	0.89
-40266	1225928	-1356	MAY	29	58	4.90	18.79	6.92	8.56	10.19	0.63	0.93	0.63
-40260	1226104	-1356	NOV	21	54	6.71	17.02	19.31	20.40	21.49	0.27	0.38	0.27
-40243	1226606	-1354	APR	7	16	5.95	18.19	22.68	23.96	25.23	0.32	0.45	0.33
-40237	1226784	-1354	OCT	2	14	5.89	17.97	13.02	14.51	16.00	0.54	0.77	0.53
-40231	1226961	-1353	MAR	28	11	6.29	18.04	5.04	6.89	8.74	0.93	1.80	0.93
-40225	1227138	-1353	SEP	21	8	5.70	18.27	20.28	22.19	24.09	0.90	1.62	0.89
-40219	1227315	-1352	MAR	16	5	6.60	17.89	19.33	20.53	21.72	0.35	0.48	0.35
-40213	1227492	-1352	SEP	9	2	5.50	18.57	22.14	23.19	24.25	0.21	0.28	0.21
-40196	1227995	-1350	JAN	25	25	7.37	17.18	15.05	16.71	18.37	0.67	1.01	0.67
-40190	1228171	-1350	JUL	20	21	4.81	19.16	17.71	19.26	20.82	0.61	0.90	0.61
-40184	1228349	-1349	JAN	14	19	7.44	16.98	19.85	21.72	23.60	0.82	1.34	0.82
-40178	1228526	-1349	JUL	10	16	4.68	19.20	9.36	11.09	12.82	0.89	1.50	0.88
-40172	1228703	-1348	JAN	3	13	7.43	16.82	20.75	21.25	21.75	0.04	0.06	0.04
-40166	1228881	-1348	JUN	29	11	4.59	19.19	3.29	3.97	4.64	0.10	0.14	0.10
-40155	1229206	-1347	MAY	20	36	5.08	18.67	5.46	6.31	7.16	0.14	0.19	0.14
-40149	1229382	-1347	NOV	12	32	6.56	17.15	17.47	18.95	20.43	0.57	0.82	0.57
-40143	1229560	-1346	MAY	9	30	5.24	18.55	7.52	9.47	11.42	0.88	1.56	0.89
-40137	1229737	-1346	NOV	2	27	6.38	17.29	8.65	10.41	12.16	0.92	1.69	0.93
-40131	1229914	-1345	APR	28	24	5.45	18.42	8.69	10.22	11.75	0.49	0.70	0.49

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	FT	M2	GM	M3
-40125	1230092	-1345	OCT	23	22	6.21	17.47	-0.20	0.94	2.08	0.30	0.41	0.30
-40108	1230593	-1343	MAR	7	43	6.81	17.78	18.95	20.45	21.95	0.61	0.88	0.60
-40102	1230770	-1343	AUG	31	40	5.37	18.76	16.60	18.02	19.44	0.40	0.56	0.40
-40096	1230948	-1342	FEB	25	38	6.98	17.64	11.35	13.10	14.86	0.90	1.58	0.91
-40090	1231124	-1342	AUG	20	34	5.20	18.90	17.58	19.50	21.42	0.91	1.74	0.92
-40084	1231303	-1341	FEB	15	33	7.12	17.50	2.08	2.88	3.67	0.13	0.18	0.13
-40078	1231479	-1341	AUG	10	29	5.06	19.00	2.81	4.00	5.18	0.32	0.44	0.32
-40061	1231981	-1340	DEC	24	51	7.32	16.78	14.28	15.88	17.47	0.53	0.76	0.53
-40055	1232159	-1339	JUN	20	49	4.64	19.08	2.11	3.81	5.51	0.78	1.23	0.79
-40049	1232335	-1339	DEC	13	45	7.12	16.81	17.07	18.94	20.80	0.89	1.59	0.89
-40043	1232513	-1338	JUN	9	43	4.76	18.92	13.72	15.43	17.15	0.70	1.07	0.71
-40037	1232690	-1338	DEC	3	40	6.91	16.91	4.14	5.23	6.32	0.28	0.38	0.28
-40020	1233192	-1336	APR	18	2	5.67	18.32	5.59	6.68	7.76	0.23	0.32	0.23
-40014	1233369	-1336	OCT	12	59	6.06	17.70	21.51	22.99	24.47	0.52	0.75	0.52
-40008	1233546	-1335	APR	7	56	6.00	18.18	12.35	14.20	16.04	0.93	1.81	0.93
-40002	1233724	-1335	OCT	2	54	5.87	18.01	4.22	6.13	8.05	0.90	1.65	0.90
-39996	1233901	-1334	MAR	28	51	6.32	18.03	2.98	4.27	5.57	0.42	0.59	0.42
-39990	1234078	-1334	SEP	21	48	5.68	18.32	5.62	6.76	7.90	0.24	0.33	0.24
-39973	1234581	-1332	FEB	6	11	7.28	17.35	-0.93	0.70	2.34	0.64	0.95	0.64
-39967	1234757	-1332	JUL	31	7	4.94	19.11	1.48	2.97	4.45	0.56	0.81	0.56
-39961	1234935	-1331	JAN	25	5	7.42	17.14	3.56	5.45	7.34	0.84	1.39	0.84
-39955	1235111	-1331	JUL	20	1	4.77	19.20	17.10	18.85	20.60	0.91	1.61	0.92
-39949	1235289	-1330	JAN	14	59	7.48	16.94	4.40	5.03	5.66	0.07	0.10	0.07
-39943	1235466	-1330	JUL	10	56	4.63	19.24	10.61	11.51	12.41	0.18	0.25	0.19
-39932	1235791	-1329	MAY	31	21	4.91	18.80	12.66	13.03	13.40	0.03	0.04	0.03
-39926	1235968	-1329	NOV	24	18	6.76	16.99	2.37	3.85	5.33	0.57	0.83	0.57
-39920	1236145	-1328	MAY	19	15	5.03	18.68	13.92	15.84	17.75	0.84	1.40	0.84
-39914	1236322	-1328	NOV	12	12	6.58	17.09	17.60	19.36	21.11	0.92	1.69	0.93
-39908	1236499	-1327	MAY	8	9	5.20	18.56	15.10	16.75	18.40	0.59	0.86	0.59
-39902	1236677	-1327	NOV	2	7	6.40	17.24	8.52	9.65	10.79	0.30	0.41	0.30
-39885	1237179	-1325	MAR	19	29	6.55	17.93	2.88	4.33	5.77	0.54	0.79	0.55
-39879	1237356	-1325	SEP	12	26	5.54	18.53	0.10	1.45	2.80	0.36	0.50	0.36
-39873	1237533	-1324	MAR	7	23	6.75	17.80	19.33	21.10	22.87	0.92	1.67	0.92
-39867	1237710	-1324	AUG	31	20	5.37	18.71	1.18	3.09	5.00	0.92	1.82	0.92
-39861	1237888	-1323	FEB	25	18	6.92	17.66	9.78	10.71	11.64	0.18	0.25	0.18
-39855	1238064	-1323	AUG	20	14	5.22	18.85	10.60	11.87	13.13	0.37	0.52	0.37
-39838	1238566	-1321	JAN	4	36	7.42	16.86	22.23	23.81	25.38	0.52	0.74	0.51
-39832	1238744	-1321	JUL	1	34	4.63	19.18	9.57	11.22	12.87	0.72	1.10	0.72
-39826	1238921	-1321	DEC	25	31	7.28	16.82	1.45	3.31	5.18	0.90	1.60	0.89
-39820	1239098	-1320	JUN	19	28	4.69	19.04	20.57	22.34	24.12	0.78	1.21	0.77

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FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	RT	GT	FT	M2	GM	M3
-39814	1239275	-1320	DEC	13	25	7.09	16.85	12.93	14.03	15.13	0.28	0.39	0.28
-39797	1239777	-1318	APR	29	47	5.39	16.46	12.52	13.35	14.17	0.13	0.17	0.13
-39791	1239955	-1318	OCT	24	45	6.24	17.45	6.10	7.56	9.02	0.51	0.73	0.51
-39785	1240131	-1317	APR	18	41	5.71	18.31	19.57	21.40	23.24	0.92	1.68	0.92
-39779	1240309	-1317	OCT	13	39	6.04	17.75	12.28	14.20	16.13	0.90	1.67	0.90
-39773	1240486	-1316	APR	7	36	6.04	18.16	10.52	11.91	13.30	0.50	0.71	0.50
-39767	1240663	-1316	OCT	1	33	5.85	18.06	13.28	14.47	15.66	0.27	0.37	0.27
-39750	1241166	-1314	FEB	16	56	7.12	17.52	6.95	8.56	10.16	0.60	0.88	0.60
-39744	1241342	-1314	AUG	11	52	5.09	18.99	9.37	10.79	12.21	0.50	0.72	0.50
-39738	1241520	-1313	FEB	5	50	7.32	17.32	11.14	13.05	14.96	0.86	1.45	0.85
-39732	1241697	-1313	AUG	1	47	4.91	19.15	0.97	2.73	4.49	0.93	1.70	0.93
-39726	1241874	-1312	JAN	25	44	7.46	17.10	11.90	12.67	13.45	0.11	0.15	0.11
-39720	1242051	-1312	JUL	20	41	4.74	19.24	18.11	19.17	20.22	0.26	0.36	0.26
-39703	1242553	-1311	DEC	4	3	6.96	16.88	11.26	12.74	14.21	0.57	0.83	0.57
-39697	1242730	-1310	MAY	30	60	4.87	18.82	20.33	22.20	24.07	0.78	1.24	0.78
-39691	1242908	-1310	NOV	24	58	6.79	16.93	2.56	4.31	6.07	0.92	1.69	0.93
-39685	1243084	-1309	MAY	19	54	4.99	18.69	21.50	23.25	24.99	0.68	1.02	0.68
-39679	1243262	-1309	NOV	13	52	6.60	17.03	17.27	18.40	19.54	0.29	0.40	0.29
-39662	1243764	-1307	MAR	29	14	6.28	18.06	10.73	12.09	13.45	0.48	0.68	0.48
-39656	1243941	-1307	SEP	22	11	5.71	18.28	7.77	9.06	10.35	0.32	0.44	0.32
-39650	1244119	-1306	MAR	19	9	6.49	17.94	3.16	4.94	6.72	0.94	1.77	0.93
-39644	1244295	-1306	SEP	11	5	5.55	18.49	8.94	10.85	12.75	0.92	1.80	0.92
-39638	1244473	-1305	MAR	8	3	6.69	17.81	17.30	18.36	19.43	0.24	0.33	0.24
-39632	1244649	-1305	AUG	31	59	5.39	18.66	18.57	19.90	21.23	0.42	0.59	0.42
-39615	1245152	-1303	JAN	15	22	7.47	16.99	6.10	7.65	9.20	0.50	0.71	0.49
-39609	1245329	-1303	JUL	11	19	4.68	19.23	17.09	18.68	20.28	0.65	0.97	0.65
-39603	1245506	-1302	JAN	4	16	7.38	16.89	9.79	11.65	13.51	0.90	1.62	0.90
-39597	1245684	-1302	JUL	1	14	4.67	19.13	3.44	5.27	7.10	0.83	1.34	0.83
-39591	1245860	-1302	DEC	24	10	7.24	16.86	21.68	22.79	23.90	0.29	0.40	0.29
-39574	1246362	-1300	MAY	9	32	5.15	18.60	19.66	20.02	20.38	0.03	0.03	0.03
-39568	1246540	-1300	NOV	3	30	6.43	17.22	14.70	16.16	17.62	0.51	0.73	0.51
-39562	1246717	-1299	APR	29	27	5.44	18.44	2.80	4.61	6.42	0.89	1.55	0.90
-39556	1246894	-1299	OCT	23	24	6.22	17.49	20.42	22.35	24.27	0.90	1.68	0.90
-39550	1247071	-1298	APR	18	21	5.75	18.29	18.00	19.48	20.95	0.57	0.84	0.58
-39544	1247248	-1298	OCT	12	18	6.02	17.79	21.07	22.30	23.53	0.29	0.40	0.29
-39527	1247751	-1296	FEB	27	41	6.92	17.68	14.66	16.21	17.76	0.55	0.80	0.55
-39521	1247927	-1296	AUG	21	37	5.25	18.83	17.44	18.80	20.16	0.46	0.65	0.46
-39515	1248105	-1295	FEB	15	35	7.17	17.49	18.52	20.45	22.38	0.88	1.52	0.87
-39509	1248282	-1295	AUG	11	32	5.06	19.03	8.97	10.74	12.50	0.94	1.79	0.94
-39503	1248459	-1294	FEB	4	29	7.37	17.28	19.26	20.18	21.10	0.15	0.21	0.15

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FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	FT	M2	GM	M3
-39497	1248637	-1294	AUG	1	27	4.88	19.19	1.73	2.90	4.07	0.32	0.45	0.32
-39480	1249138	-1293	DEC	15	48	7.13	16.84	20.13	21.61	23.09	0.57	0.83	0.57
-39474	1249316	-1292	JUN	10	46	4.75	18.95	2.78	4.58	6.38	0.70	1.07	0.70
-39468	1249493	-1292	DEC	4	43	6.99	16.83	11.50	13.26	15.01	0.92	1.69	0.93
-39462	1249670	-1291	MAY	30	40	4.83	18.84	3.98	5.79	7.61	0.76	1.18	0.76
-39456	1249848	-1291	NOV	24	38	6.81	16.87	2.04	3.17	4.30	0.29	0.40	0.29
-39439	1250349	-1289	APR	9	59	6.00	18.19	18.51	19.77	21.04	0.40	0.57	0.41
-39433	1250526	-1289	OCT	3	56	5.88	18.02	15.57	16.81	18.04	0.29	0.40	0.29
-39427	1250704	-1288	MAR	29	54	6.22	18.08	10.87	12.66	14.45	0.94	1.88	0.94
-39421	1250880	-1288	SEP	21	50	5.72	18.24	16.88	18.78	20.68	0.91	1.75	0.91
-39415	1251059	-1287	MAR	19	49	6.44	17.95	0.68	1.88	3.07	0.31	0.43	0.31
-39409	1251235	-1287	SEP	11	45	5.56	18.43	2.71	4.09	5.46	0.46	0.65	0.46
-39392	1251737	-1285	JAN	26	7	7.44	17.15	13.83	15.34	16.85	0.47	0.67	0.47
-39386	1251915	-1285	JUL	23	5	4.78	19.23	0.70	2.23	3.76	0.59	0.86	0.59
-39380	1252091	-1284	JAN	15	1	7.42	17.01	18.01	19.87	21.73	0.91	1.65	0.90
-39374	1252269	-1284	JUL	11	59	4.72	19.18	10.40	12.27	14.14	0.87	1.47	0.87
-39368	1252446	-1283	JAN	4	56	7.33	16.93	6.32	7.45	8.58	0.30	0.42	0.30
-39362	1252623	-1283	JUN	30	53	4.71	19.09	15.05	15.32	15.59	0.01	0.02	0.01
-39345	1253126	-1282	NOV	15	16	6.64	17.02	-0.65	0.82	2.28	0.51	0.72	0.51
-39339	1253302	-1281	MAY	10	12	5.19	18.58	9.99	11.77	13.55	0.85	1.41	0.86
-39333	1253480	-1281	NOV	4	10	6.41	17.26	4.63	6.56	8.49	0.90	1.68	0.90
-39327	1253657	-1280	APR	29	7	5.48	18.42	1.44	2.99	4.54	0.65	0.97	0.65
-39321	1253834	-1280	OCT	23	4	6.20	17.54	5.00	6.26	7.51	0.30	0.41	0.30
-39304	1254336	-1278	MAR	9	26	6.67	17.84	22.24	23.72	25.20	0.50	0.71	0.49
-39298	1254513	-1278	SEP	2	23	5.42	18.63	1.64	2.95	4.25	0.42	0.59	0.42
-39292	1254691	-1277	FEB	27	21	6.96	17.66	1.74	3.69	5.64	0.89	1.61	0.89
-39286	1254867	-1277	AUG	22	17	5.24	18.87	17.10	18.87	20.64	0.94	1.87	0.94
-39280	1255045	-1276	FEB	16	15	7.21	17.46	2.48	3.54	4.60	0.21	0.29	0.21
-39274	1255222	-1276	AUG	11	12	5.04	19.07	9.49	10.75	12.01	0.38	0.53	0.38
-39257	1255724	-1275	DEC	26	34	7.28	16.86	4.94	6.41	7.88	0.57	0.82	0.57
-39251	1255901	-1274	JUN	21	31	4.70	19.06	9.29	11.00	12.71	0.62	0.91	0.62
-39245	1256078	-1274	DEC	15	28	7.17	16.79	20.40	22.16	23.92	0.92	1.70	0.93
-39239	1256255	-1273	JUN	10	25	4.71	18.97	10.52	12.38	14.25	0.83	1.34	0.82
-39233	1256433	-1273	DEC	5	23	7.02	16.77	10.77	11.89	13.02	0.28	0.39	0.28
-39216	1256935	-1271	APR	20	45	5.73	18.32	2.24	3.37	4.51	0.32	0.44	0.32
-39210	1257112	-1271	OCT	14	42	6.06	17.76	-0.51	0.69	1.88	0.27	0.38	0.27
-39204	1257289	-1270	APR	9	39	5.94	18.20	18.47	20.26	22.05	0.94	1.77	0.94
-39198	1257466	-1270	OCT	3	36	5.89	17.98	0.98	2.88	4.77	0.91	1.72	0.91
-39192	1257644	-1269	MAR	30	34	6.16	18.09	7.89	9.21	10.53	0.39	0.54	0.39
-39186	1257820	-1269	SEP	22	30	5.72	18.18	11.03	12.44	13.85	0.49	0.69	0.49

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	FT	M2	GM	M3
-39169	1258322	-1267	FEB	5	52	7.34	17.32	21.47	22.92	24.37	0.44	0.61	0.43
-39163	1258500	-1267	AUG	2	50	4.92	19.17	8.40	9.87	11.33	0.52	0.75	0.52
-39157	1258677	-1266	JAN	26	47	7.39	17.17	2.15	4.01	5.86	0.92	1.69	0.91
-39151	1258854	-1266	JUL	22	44	4.81	19.18	17.44	19.33	21.22	0.90	1.59	0.89
-39145	1259031	-1265	JAN	15	41	7.37	17.05	14.88	16.04	17.20	0.32	0.45	0.32
-39139	1259208	-1265	JUL	11	38	4.75	19.14	21.14	21.93	22.72	0.11	0.15	0.11
-39122	1259711	-1264	NOV	25	1	6.84	16.87	7.99	9.45	10.92	0.50	0.72	0.50
-39116	1259887	-1263	MAY	20	57	4.97	18.72	17.23	18.97	20.70	0.80	1.28	0.80
-39110	1260065	-1263	NOV	14	55	6.61	17.07	12.86	14.79	16.72	0.90	1.69	0.90
-39104	1260242	-1262	MAY	10	52	5.23	18.56	8.86	10.47	12.08	0.73	1.10	0.73
-39098	1260419	-1262	NOV	3	49	6.39	17.31	13.02	14.29	15.55	0.31	0.42	0.31
-39081	1260922	-1260	MAR	20	12	6.41	17.98	5.65	7.04	8.42	0.42	0.59	0.42
-39075	1261098	-1260	SEP	12	8	5.59	18.39	10.00	11.26	12.52	0.39	0.54	0.39
-39069	1261276	-1259	MAR	9	6	6.72	17.82	8.78	10.74	12.70	0.91	1.72	0.91
-39063	1261453	-1259	SFP	2	3	5.41	18.67	1.38	3.15	4.91	0.94	1.84	0.94
-39057	1261630	-1258	FEB	26	60	7.01	17.64	9.56	10.75	11.95	0.28	0.38	0.28
-39051	1261807	-1258	AUG	22	57	5.22	18.91	17.39	18.71	20.03	0.43	0.60	0.43
-39034	1262309	-1256	JAN	6	19	7.36	16.94	13.68	15.14	16.60	0.56	0.81	0.56
-39028	1262486	-1256	JUL	1	16	4.70	19.13	15.89	17.50	19.10	0.53	0.76	0.53
-39022	1262664	-1256	DEC	26	14	7.31	16.81	5.25	7.01	8.78	0.93	1.71	0.92
-39016	1262840	-1255	JUN	20	10	4.65	19.08	17.15	19.05	20.95	0.88	1.49	0.87
-39010	1263018	-1255	DEC	15	8	7.20	16.74	19.46	20.58	21.71	0.28	0.39	0.28
-39004	1263195	-1254	JUN	10	5	4.66	18.99	2.28	2.99	3.70	0.11	0.14	0.11
-38993	1263520	-1253	MAY	1	30	5.47	18.45	9.94	10.92	11.89	0.23	0.32	0.23
-38987	1263697	-1253	OCT	25	27	6.23	17.51	7.51	8.68	9.85	0.26	0.36	0.26
-38981	1263875	-1252	APR	20	25	5.67	18.33	1.99	3.77	5.55	0.92	1.65	0.92
-38975	1264051	-1252	OCT	13	21	6.06	17.72	9.21	11.09	12.98	0.91	1.69	0.91
-38969	1264229	-1251	APR	9	19	5.88	18.22	15.00	16.43	17.86	0.47	0.66	0.47
-38963	1264405	-1251	OCT	2	15	5.89	17.92	19.50	20.93	22.36	0.51	0.73	0.51
-38946	1264908	-1249	FEB	17	38	7.18	17.50	4.96	6.35	7.73	0.39	0.54	0.39
-38940	1265085	-1249	AUG	13	35	5.08	19.05	16.24	17.63	19.02	0.46	0.65	0.46
-38934	1265262	-1248	FEB	6	32	7.29	17.34	10.14	11.99	13.85	0.93	1.75	0.92
-38928	1265440	-1248	AUG	2	30	4.94	19.12	0.61	2.52	4.43	0.91	1.69	0.91
-38922	1265617	-1247	JAN	26	27	7.33	17.20	-0.69	0.52	1.72	0.35	0.49	0.35
-38916	1265794	-1247	JUL	22	24	4.84	19.13	3.58	4.63	5.69	0.21	0.28	0.21
-38899	1266296	-1246	DEC	6	46	7.05	16.78	16.62	18.08	19.55	0.50	0.72	0.50
-38893	1266473	-1245	JUN	1	43	4.80	18.87	0.48	2.16	3.84	0.74	1.14	0.74
-38887	1266650	-1245	NOV	25	40	6.81	16.92	21.11	23.04	24.98	0.90	1.69	0.90
-38881	1266827	-1244	MAY	20	37	5.01	18.70	16.28	17.94	19.60	0.79	1.24	0.79
-38875	1267004	-1244	NOV	13	34	6.58	17.11	21.09	22.37	23.64	0.31	0.43	0.31

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	PT	GT	ET	M2	GM	M3
-38858	1267507	-1242	MAR	31	57	6.12	18.12	12.94	14.21	15.48	0.34	0.47	0.34
-38852	1267683	-1242	SEP	23	53	5.76	18.14	18.49	19.71	20.93	0.37	0.51	0.37
-38846	1267861	-1241	MAR	20	51	6.45	17.96	15.69	17.65	19.62	0.91	1.82	0.91
-38840	1268038	-1241	SEP	13	48	5.58	18.43	9.79	11.55	13.32	0.94	1.79	0.94
-38834	1268215	-1240	MAR	8	45	6.77	17.80	16.50	17.83	19.16	0.35	0.48	0.35
-38828	1268393	-1240	SEP	2	43	5.39	18.70	1.43	2.81	4.18	0.47	0.66	0.46
-38811	1268894	-1238	JAN	16	4	7.38	17.07	22.32	23.77	25.21	0.54	0.79	0.54
-38805	1269072	-1238	JUL	13	2	4.76	19.16	-1.39	0.09	1.57	0.44	0.62	0.44
-38799	1269249	-1237	JAN	6	59	7.40	16.90	13.98	15.75	17.52	0.93	1.72	0.92
-38793	1269426	-1237	JUL	2	56	4.65	19.16	-0.10	1.81	3.73	0.91	1.64	0.90
-38787	1269604	-1237	DEC	27	54	7.35	16.77	4.04	5.18	6.31	0.28	0.39	0.26
-38781	1269780	-1236	JUN	20	50	4.60	19.11	9.20	10.19	11.17	0.21	0.29	0.21
-38770	1270105	-1235	MAY	11	15	5.24	18.58	17.65	18.41	19.17	0.13	0.18	0.13
-38764	1270282	-1235	NOV	4	12	6.42	17.29	15.62	16.77	17.93	0.25	0.35	0.26
-38758	1270460	-1234	MAY	1	10	5.41	18.46	9.41	11.17	12.94	0.88	1.51	0.89
-38752	1270636	-1234	OCT	24	6	6.24	17.47	17.58	19.45	21.33	0.91	1.68	0.91
-38746	1270814	-1233	APR	20	4	5.61	18.34	21.97	23.51	25.04	0.55	0.79	0.55
-38740	1270991	-1233	OCT	14	1	6.07	17.66	4.11	5.55	6.99	0.52	0.75	0.52
-38723	1271493	-1231	FEB	27	23	6.98	17.67	12.38	13.67	14.96	0.33	0.46	0.33
-38717	1271671	-1231	AUG	24	21	5.25	18.89	0.17	1.48	2.80	0.41	0.57	0.41
-38711	1271847	-1230	FEB	16	17	7.13	17.52	18.04	19.90	21.75	0.93	1.82	0.93
-38705	1272025	-1230	AUG	13	15	5.10	19.00	7.88	9.80	11.72	0.92	1.79	0.92
-38699	1272202	-1229	FEB	6	12	7.23	17.37	7.62	8.87	10.12	0.39	0.55	0.39
-38693	1272379	-1229	AUG	2	9	4.96	19.07	10.24	11.47	12.70	0.29	0.40	0.29
-38676	1272882	-1228	DEC	17	32	7.23	16.76	1.16	2.62	4.08	0.50	0.71	0.50
-38670	1273058	-1227	JUN	11	28	4.69	19.01	7.82	9.43	11.04	0.67	1.00	0.67
-38664	1273236	-1227	DEC	6	26	7.01	16.83	5.31	7.25	9.19	0.90	1.69	0.90
-38658	1273413	-1226	JUN	1	23	4.84	18.84	-0.30	1.40	3.11	0.85	1.38	0.85
-38652	1273590	-1226	NOV	25	20	6.78	16.96	5.20	6.48	7.75	0.31	0.44	0.31
-38646	1273767	-1225	MAY	21	17	5.05	18.68	18.39	18.54	18.70	0.01	0.01	0.01
-38635	1274092	-1224	APR	10	42	5.84	18.25	20.13	21.23	22.33	0.25	0.34	0.25
-38629	1274269	-1224	OCT	4	39	5.93	17.88	3.11	4.31	5.50	0.35	0.49	0.35
-38623	1274447	-1223	MAR	31	37	6.17	18.10	-1.56	0.41	2.38	0.90	1.69	0.90
-38617	1274623	-1223	SEP	23	33	5.75	18.17	18.33	20.09	21.85	0.93	1.75	0.93
-38611	1274801	-1222	MAR	20	31	6.50	17.94	-0.67	0.78	2.23	0.43	0.60	0.43
-38605	1274978	-1222	SEP	13	28	5.57	18.47	9.61	11.02	12.43	0.49	0.70	0.49
-38588	1275480	-1220	JAN	28	50	7.34	17.23	6.88	8.30	9.72	0.52	0.75	0.52
-38582	1275657	-1220	JUL	23	47	4.86	19.14	5.46	6.80	8.15	0.35	0.49	0.35
-38576	1275835	-1219	JAN	17	45	7.43	17.04	-1.38	0.40	2.17	0.93	1.75	0.93
-38570	1276011	-1219	JUL	12	41	4.71	19.20	6.78	8.71	10.63	0.92	1.77	0.92

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-38564	1276189	-1218	JAN	6	39	7.44	16.86	12.53	13.68	14.83	0.29	0.40	0.29
-38558	1276365	-1218	JUL	1	35	4.61	19.20	16.29	17.46	18.62	0.31	0.42	0.31
-38547	1276691	-1217	MAY	23	1	5.04	18.71	1.51	1.91	2.31	0.04	0.05	0.04
-38541	1276868	-1217	NOV	16	58	6.62	17.10	-0.25	0.90	2.04	0.25	0.34	0.25
-38535	1277045	-1216	MAY	11	55	5.18	18.60	16.80	18.54	20.28	0.84	1.37	0.85
-38529	1277222	-1216	NOV	4	52	6.43	17.24	2.03	3.90	5.77	0.91	1.68	0.91
-38523	1277400	-1215	MAY	1	50	5.35	18.48	4.87	6.50	8.13	0.63	0.93	0.63
-38517	1277576	-1215	OCT	24	46	6.25	17.41	12.82	14.27	15.72	0.53	0.76	0.53
-38500	1278078	-1213	MAR	10	8	6.74	17.83	19.66	20.82	21.98	0.27	0.37	0.27
-38494	1278256	-1213	SEP	4	6	5.43	18.68	8.23	9.49	10.74	0.36	0.50	0.36
-38488	1278433	-1212	FEB	28	3	6.93	17.68	1.81	3.65	5.50	0.93	1.81	0.93
-38482	1278610	-1212	AUG	23	60	5.27	18.83	15.28	17.21	19.13	0.92	1.79	0.92
-38476	1278787	-1211	FEB	16	57	7.08	17.54	15.78	17.09	18.40	0.44	0.61	0.43
-38470	1278964	-1211	AUG	12	54	5.12	18.96	17.09	18.45	19.81	0.36	0.50	0.36
-38453	1279467	-1210	DEC	28	17	7.37	16.80	9.65	11.10	12.56	0.49	0.69	0.49
-38447	1279643	-1209	JUN	22	13	4.63	19.12	15.22	16.76	18.29	0.60	0.87	0.60
-38441	1279821	-1209	DEC	17	11	7.19	16.60	13.47	15.41	17.36	0.90	1.70	0.90
-38435	1279998	-1208	JUN	11	8	4.73	18.97	7.17	8.91	10.65	0.89	1.51	0.89
-38429	1280175	-1208	DEC	5	5	6.97	16.87	13.30	14.59	15.87	0.32	0.44	0.32
-38423	1280353	-1207	JUN	1	3	4.88	18.82	1.26	1.93	2.60	0.10	0.14	0.10
-38412	1280678	-1206	APR	22	28	5.55	18.38	3.29	4.15	5.00	0.14	0.20	0.15
-38406	1280854	-1206	OCT	15	24	6.11	17.61	11.83	13.01	14.19	0.34	0.47	0.34
-38400	1281032	-1205	APR	11	22	5.88	18.23	5.09	7.03	8.98	0.88	1.55	0.89
-38394	1281209	-1205	OCT	5	19	5.92	17.91	2.98	4.74	6.50	0.93	1.72	0.93
-38388	1281386	-1204	MAR	30	16	6.22	18.08	6.07	7.63	9.18	0.51	0.73	0.51
-38382	1281563	-1204	SEP	23	13	5.74	18.21	17.91	19.35	20.79	0.51	0.73	0.51
-38365	1282065	-1202	FEB	7	35	7.22	17.40	15.30	16.68	18.06	0.49	0.71	0.50
-38359	1282242	-1202	AUG	3	32	5.00	19.06	12.46	13.66	14.85	0.27	0.37	0.27
-38353	1282420	-1201	JAN	28	30	7.38	17.20	7.12	8.90	10.67	0.94	1.79	0.93
-38347	1282596	-1201	JUL	23	26	4.82	19.18	13.84	15.75	17.67	0.92	1.79	0.92
-38341	1282774	-1200	JAN	17	24	7.47	17.00	20.85	22.03	23.22	0.31	0.43	0.31
-38335	1282951	-1200	JUL	12	21	4.67	19.24	-0.43	0.86	2.16	0.39	0.55	0.39
-38318	1283453	-1199	NOV	26	43	6.82	16.95	7.93	9.08	10.22	0.25	0.34	0.25
-38312	1283631	-1198	MAY	23	41	4.98	18.73	0.14	1.84	3.54	0.78	1.23	0.78
-38306	1283807	-1198	NOV	15	37	6.63	17.05	10.56	12.42	14.29	0.91	1.68	0.91
-38300	1283985	-1197	MAY	12	35	5.12	18.61	11.67	13.39	15.10	0.70	1.07	0.71
-38294	1284161	-1197	NOV	4	31	6.44	17.18	21.63	23.08	24.53	0.53	0.77	0.53
-38277	1284664	-1195	MAR	21	54	6.48	17.97	2.90	3.89	4.89	0.19	0.26	0.19
-38271	1284841	-1195	SEP	14	51	5.60	18.44	16.40	17.59	18.78	0.32	0.44	0.32
-38265	1285018	-1194	MAR	10	48	6.69	17.84	9.47	11.31	13.15	0.92	1.73	0.93

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-38259	1285196	-1194	SEP	4	46	5.44	18.63	-1.19	0.73	2.66	0.91	1.72	0.91
-38253	1285373	-1193	FEB	28	43	6.87	17.70	-0.18	1.19	2.57	0.49	0.69	0.48
-38247	1285550	-1193	AUG	24	40	5.28	18.79	0.14	1.59	3.04	0.42	0.59	0.42
-38230	1286052	-1191	JAN	7	2	7.45	16.90	18.01	19.45	20.89	0.47	0.67	0.47
-38224	1286229	-1191	JUL	3	59	4.63	19.21	-1.28	0.18	1.63	0.52	0.75	0.52
-38218	1286406	-1191	DEC	27	56	7.32	16.83	21.53	23.48	25.42	0.90	1.71	0.90
-38212	1286583	-1190	JUN	22	53	4.67	19.09	14.69	16.45	18.20	0.92	1.64	0.92
-38206	1286760	-1190	DEC	16	50	7.15	16.83	21.34	22.64	23.94	0.33	0.46	0.33
-38200	1286938	-1189	JUN	12	48	4.77	18.94	8.40	9.32	10.24	0.19	0.27	0.20
-38189	1287263	-1188	MAY	2	13	5.29	18.52	10.53	10.96	11.38	0.04	0.05	0.04
-38183	1287439	-1188	OCT	25	9	6.29	17.37	20.64	21.81	22.98	0.34	0.47	0.34
-38177	1287617	-1187	APR	21	7	5.60	18.36	11.65	13.56	15.48	0.84	1.40	0.84
-38171	1287794	-1187	OCT	15	4	6.10	17.65	11.75	13.50	15.26	0.92	1.71	0.93
-38165	1287971	-1186	APR	10	1	5.93	18.21	12.71	14.36	16.02	0.60	0.87	0.60
-38159	1288149	-1186	OCT	5	59	5.91	17.95	2.34	3.80	5.25	0.53	0.75	0.53
-38142	1288651	-1184	FEB	19	21	7.05	17.57	-0.39	0.94	2.27	0.46	0.65	0.46
-38136	1288827	-1184	AUG	13	17	5.15	18.93	19.64	20.67	21.70	0.20	0.27	0.20
-38130	1289005	-1183	FEB	7	15	7.26	17.38	15.50	17.28	19.07	0.94	1.84	0.94
-38124	1289181	-1183	AUG	2	11	4.96	19.11	21.04	22.94	24.84	0.91	1.68	0.91
-38118	1289360	-1182	JAN	28	10	7.42	17.17	5.04	6.27	7.49	0.33	0.46	0.33
-38112	1289536	-1182	JUL	23	6	4.78	19.22	7.00	8.39	9.78	0.47	0.66	0.47
-38095	1290038	-1181	DEC	7	28	7.01	16.87	16.09	17.23	18.36	0.25	0.34	0.25
-38089	1290216	-1180	JUN	2	26	4.83	18.87	7.50	9.14	10.79	0.71	1.08	0.71
-38083	1290392	-1180	NOV	25	22	6.83	16.90	19.09	20.95	22.81	0.91	1.68	0.91
-38077	1290570	-1179	MAY	22	20	4.93	18.75	18.46	20.24	22.02	0.78	1.21	0.77
-38071	1290747	-1179	NOV	15	17	6.65	16.99	6.47	7.93	9.38	0.54	0.77	0.54
-38054	1291249	-1177	APR	1	39	6.21	18.10	10.09	10.83	11.58	0.11	0.14	0.11
-38048	1291427	-1177	SEP	26	37	5.77	18.19	0.69	1.83	2.97	0.29	0.39	0.29
-38042	1291603	-1176	MAR	20	33	6.43	17.98	17.01	18.83	20.66	0.91	1.63	0.91
-38036	1291781	-1176	SEP	14	31	5.61	18.39	6.49	8.41	10.33	0.90	1.66	0.90
-38030	1291958	-1175	MAR	10	28	6.63	17.85	7.72	9.16	10.61	0.54	0.78	0.54
-38024	1292135	-1175	SEP	3	25	5.45	18.59	7.35	8.87	10.39	0.47	0.67	0.47
-38007	1292638	-1173	JAN	19	48	7.46	17.04	2.26	3.67	5.08	0.45	0.63	0.45
-38001	1292814	-1173	JUL	14	44	4.70	19.25	6.34	7.70	9.06	0.45	0.64	0.45
-37995	1292992	-1172	JAN	8	42	7.40	16.93	5.49	7.44	9.39	0.91	1.74	0.90
-37989	1293169	-1172	JUL	3	39	4.67	19.17	-1.71	0.06	1.83	0.94	1.77	0.94
-37983	1293346	-1172	DEC	27	36	7.28	16.86	5.32	6.64	7.96	0.34	0.47	0.34
-37977	1293523	-1171	JUN	22	33	4.71	19.05	15.64	16.74	17.84	0.28	0.39	0.28
-37960	1294025	-1170	NOV	6	55	6.49	17.14	5.51	6.68	7.84	0.34	0.47	0.34
-37954	1294202	-1169	MAY	2	52	5.34	18.50	18.15	20.02	21.89	0.79	1.25	0.78

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FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-37948	1294379	-1169	OCT	26	49	6.28	17.40	20.58	22.34	24.10	0.92	1.69	0.93
-37942	1294556	-1168	APR	20	46	5.65	18.34	19.31	21.05	22.78	0.68	1.02	0.68
-37936	1294734	-1168	OCT	15	44	6.08	17.69	10.87	12.34	13.81	0.53	0.76	0.53
-37919	1295236	-1166	MAR	1	6	6.84	17.74	7.79	9.06	10.34	0.41	0.58	0.41
-37913	1295413	-1166	AUG	25	3	5.32	18.75	3.00	3.86	4.71	0.13	0.18	0.13
-37907	1295591	-1165	FEB	19	1	7.09	17.55	-0.30	1.49	3.27	0.94	1.86	0.94
-37901	1295767	-1165	AUG	14	57	5.12	18.98	4.43	6.32	8.20	0.90	1.58	0.89
-37895	1295945	-1164	FEB	8	55	7.31	17.35	13.04	14.32	15.60	0.36	0.51	0.36
-37889	1296121	-1164	AUG	2	51	4.93	19.15	14.58	16.05	17.52	0.54	0.77	0.53
-37872	1296624	-1163	DEC	18	14	7.17	16.85	0.24	1.37	2.50	0.24	0.33	0.25
-37866	1296801	-1162	JUN	13	11	4.74	18.99	14.83	16.41	17.99	0.63	0.94	0.63
-37860	1296978	-1162	DEC	7	8	7.03	16.82	3.64	5.50	7.35	0.91	1.68	0.91
-37854	1297156	-1161	JUN	3	6	4.78	18.89	1.20	3.04	4.87	0.83	1.36	0.83
-37848	1297332	-1161	NOV	26	2	6.85	16.85	15.36	16.80	18.25	0.54	0.78	0.54
-37831	1297834	-1159	APR	11	24	5.93	18.23	17.45	17.72	17.99	0.01	0.02	0.01
-37825	1298012	-1159	OCT	6	22	5.94	17.92	9.06	10.15	11.25	0.26	0.36	0.26
-37819	1298189	-1158	APR	1	19	6.15	18.11	0.49	2.29	4.09	0.88	1.52	0.89
-37813	1298366	-1158	SEP	25	16	5.78	18.14	14.29	16.21	18.12	0.89	1.61	0.90
-37807	1298543	-1157	MAR	21	13	6.37	17.99	15.51	17.02	18.52	0.60	0.88	0.60
-37801	1298720	-1157	SEP	14	10	5.61	18.35	14.75	16.32	17.90	0.51	0.73	0.51
-37784	1299223	-1155	JAN	29	33	7.41	17.21	10.35	11.72	13.10	0.42	0.59	0.42
-37778	1299399	-1155	JUL	24	29	4.81	19.23	14.10	15.35	16.60	0.38	0.53	0.38
-37772	1299577	-1154	JAN	18	27	7.41	17.06	13.29	15.24	17.20	0.91	1.78	0.91
-37766	1299754	-1154	JUL	14	24	4.74	19.20	5.98	7.75	9.52	0.94	1.88	0.94
-37760	1299931	-1153	JAN	7	21	7.36	16.95	13.18	14.54	15.89	0.36	0.50	0.36
-37754	1300109	-1153	JUL	4	19	4.71	19.12	-1.03	0.20	1.44	0.36	0.51	0.36
-37737	1300610	-1152	NOV	16	40	6.69	16.96	14.43	15.60	16.78	0.34	0.47	0.34
-37731	1300788	-1151	MAY	13	38	5.10	18.64	0.58	2.39	4.19	0.71	1.09	0.71
-37725	1300965	-1151	NOV	6	35	6.47	17.18	5.49	7.25	9.01	0.92	1.69	0.93
-37719	1301142	-1150	MAY	2	32	5.39	18.47	1.85	3.66	5.47	0.75	1.17	0.75
-37713	1301319	-1150	OCT	26	29	6.27	17.44	19.49	20.96	22.44	0.53	0.77	0.53
-37696	1301821	-1148	MAR	11	51	6.59	17.89	15.89	17.08	18.27	0.35	0.49	0.36
-37690	1301998	-1148	SEP	4	48	5.49	18.54	10.52	11.18	11.84	0.08	0.11	0.08
-37684	1302176	-1147	MAR	1	46	6.87	17.72	7.79	9.57	11.36	0.93	1.78	0.94
-37678	1302352	-1147	AUG	24	42	5.29	18.80	11.97	13.84	15.70	0.87	1.50	0.88
-37672	1302530	-1146	FEB	18	40	7.13	17.53	20.86	22.21	23.55	0.41	0.57	0.41
-37666	1302706	-1146	AUG	13	36	5.10	19.02	22.34	23.86	25.38	0.59	0.86	0.59
-37649	1303209	-1145	DEC	29	59	7.29	16.89	8.31	9.41	10.51	0.23	0.32	0.24
-37643	1303386	-1144	JUN	23	56	4.70	19.09	22.24	23.73	25.22	0.56	0.80	0.55
-37637	1303563	-1144	DEC	17	53	7.20	16.80	12.16	14.01	15.86	0.91	1.68	0.91

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-37631	1303741	-1143	JUN	13	51	4.69	19.02	7.95	9.83	11.71	0.88	1.51	0.87
-37625	1303916	-1143	DEC	7	48	7.05	16.76	0.22	1.67	3.11	0.54	0.78	0.54
-37619	1304095	-1142	JUN	2	45	4.73	18.91	12.54	12.94	13.34	0.03	0.04	0.03
-37602	1304597	-1141	OCT	17	7	6.12	17.67	17.53	18.59	19.65	0.24	0.33	0.25
-37596	1304774	-1140	APR	11	4	5.88	18.24	7.88	9.66	11.43	0.85	1.40	0.85
-37590	1304952	-1140	OCT	6	2	5.95	17.88	-1.80	0.12	2.03	0.89	1.57	0.88
-37584	1305129	-1139	APR	1	59	6.10	18.12	-0.79	0.77	2.33	0.67	0.99	0.67
-37578	1305305	-1139	SEP	24	55	5.78	18.10	22.32	23.93	25.55	0.54	0.78	0.54
-37561	1305808	-1137	FEB	9	18	7.29	17.39	18.30	19.62	20.94	0.38	0.53	0.38
-37555	1305984	-1137	AUG	4	14	4.96	19.15	22.00	23.14	24.29	0.32	0.44	0.32
-37549	1306162	-1136	JAN	29	12	7.36	17.23	20.95	22.91	24.87	0.91	1.81	0.91
-37543	1306339	-1136	JUL	24	9	4.84	19.18	13.78	15.55	17.31	0.94	1.79	0.94
-37537	1306516	-1135	JAN	17	6	7.37	17.09	20.95	22.34	23.74	0.39	0.54	0.39
-37531	1306694	-1135	JUL	14	4	4.77	19.15	6.38	7.72	9.06	0.44	0.62	0.44
-37514	1307196	-1134	NOV	28	26	6.90	16.82	-0.64	0.53	1.71	0.34	0.48	0.34
-37508	1307373	-1133	MAY	24	23	4.90	18.78	7.03	8.75	10.47	0.63	0.92	0.62
-37502	1307550	-1133	NOV	17	20	6.67	17.00	14.41	16.18	17.94	0.92	1.69	0.92
-37496	1307727	-1132	MAY	12	17	5.15	18.61	8.42	10.28	12.14	0.82	1.33	0.82
-37490	1307905	-1132	NOV	6	15	6.46	17.22	4.13	5.61	7.09	0.53	0.77	0.53
-37473	1308407	-1130	MAR	23	37	6.31	18.03	-0.13	0.94	2.02	0.29	0.40	0.29
-37467	1308583	-1130	SEP	15	33	5.65	18.30	18.26	18.70	19.14	0.04	0.05	0.03
-37461	1308761	-1129	MAR	12	31	6.62	17.87	15.70	17.48	19.26	0.92	1.69	0.93
-37455	1308937	-1129	SEP	4	27	5.46	18.58	19.72	21.57	23.41	0.85	1.43	0.85
-37449	1309116	-1128	MAR	1	26	6.91	17.70	4.49	5.91	7.33	0.46	0.65	0.46
-37443	1309292	-1128	AUG	24	22	5.27	18.84	6.27	7.84	9.40	0.63	0.94	0.64
-37426	1309794	-1126	JAN	8	44	7.36	16.98	16.33	17.40	18.47	0.22	0.30	0.22
-37420	1309972	-1126	JUL	5	42	4.72	19.15	5.67	7.07	8.46	0.47	0.67	0.47
-37414	1310148	-1126	DEC	28	38	7.33	16.84	20.63	22.48	24.32	0.91	1.67	0.91
-37408	1310326	-1125	JUN	24	36	4.65	19.12	14.73	16.64	18.54	0.91	1.65	0.91
-37402	1310503	-1125	DEC	18	33	7.23	16.75	9.07	10.51	11.96	0.55	0.79	0.55
-37396	1310680	-1124	JUN	12	30	4.64	19.04	18.46	19.35	20.23	0.14	0.19	0.14
-37379	1311183	-1123	OCT	28	53	6.30	17.42	2.05	3.09	4.12	0.23	0.32	0.23
-37373	1311359	-1122	APR	22	49	5.61	18.37	15.23	16.97	18.70	0.80	1.27	0.80
-37367	1311537	-1122	OCT	17	47	6.12	17.62	6.21	8.12	10.04	0.88	1.54	0.88
-37361	1311714	-1121	APR	12	44	5.82	18.25	6.82	8.44	10.05	0.73	1.12	0.73
-37355	1311891	-1121	OCT	6	41	5.95	17.84	6.03	7.67	9.32	0.57	0.82	0.57
-37338	1312394	-1119	FEB	20	4	7.11	17.57	2.09	3.33	4.57	0.32	0.45	0.33
-37332	1312570	-1119	AUG	15	60	5.12	19.02	6.02	7.06	8.11	0.26	0.35	0.26
-37326	1312748	-1118	FEB	9	58	7.24	17.41	4.43	6.39	8.35	0.91	1.74	0.91
-37320	1312924	-1118	AUG	4	54	4.99	19.10	21.69	23.45	25.21	0.93	1.69	0.93

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FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	PT	GT	ET	M2	GM	M3
-37314	1313102	-1117	JAN	29	52	7.31	17.25	4.53	5.98	7.43	0.42	0.60	0.42
-37308	1313279	-1117	JUL	25	49	4.88	19.13	13.89	15.32	16.74	0.51	0.72	0.51
-37291	1313781	-1116	DEC	8	11	7.10	16.75	8.28	9.45	10.63	0.34	0.48	0.35
-37285	1313958	-1115	JUN	3	8	4.75	18.93	13.49	15.10	16.70	0.53	0.76	0.53
-37279	1314136	-1115	NOV	28	6	6.88	16.87	-0.64	1.12	2.89	0.92	1.69	0.92
-37273	1314312	-1114	MAY	23	2	4.95	18.75	14.97	16.87	18.76	0.68	1.49	0.87
-37267	1314490	-1114	NOV	17	60	6.65	17.04	12.84	14.31	15.79	0.53	0.76	0.53
-37261	1314667	-1113	MAY	13	57	5.19	18.59	0.36	1.04	1.72	0.10	0.13	0.10
-37250	1314992	-1112	APR	2	22	6.03	18.16	7.78	8.72	9.66	0.21	0.29	0.22
-37244	1315169	-1112	SEP	26	19	5.82	18.04	2.30	2.36	2.43	0.00	0.00	0.00
-37238	1315347	-1111	MAR	23	17	6.35	18.02	-0.50	1.27	3.05	0.90	1.59	0.91
-37232	1315523	-1111	SEP	15	13	5.63	18.34	3.61	5.44	7.27	0.84	1.38	0.84
-37226	1315701	-1110	MAR	12	11	6.66	17.86	11.97	13.46	14.95	0.51	0.73	0.51
-37220	1315877	-1110	SEP	4	7	5.44	18.63	14.37	15.97	17.57	0.67	1.00	0.67
-37203	1316380	-1108	JAN	20	30	7.36	17.12	0.25	1.26	2.28	0.20	0.27	0.20
-37197	1316557	-1108	JUL	15	27	4.80	19.16	13.20	14.48	15.77	0.39	0.54	0.39
-37191	1316734	-1107	JAN	8	24	7.40	16.94	5.01	6.85	8.69	0.91	1.65	0.91
-37185	1316911	-1107	JUL	4	21	4.68	19.18	21.57	23.49	25.41	0.92	1.79	0.92
-37179	1317088	-1107	DEC	28	18	7.37	16.79	17.83	19.29	20.75	0.55	0.80	0.55
-37173	1317266	-1106	JUN	24	16	4.61	19.15	0.62	1.78	2.94	0.25	0.35	0.25
-37156	1317768	-1105	NOV	8	38	6.49	17.21	10.61	11.64	12.66	0.22	0.31	0.23
-37150	1317945	-1104	MAY	3	35	5.36	18.50	-1.44	0.24	1.92	0.74	1.14	0.74
-37144	1318122	-1104	OCT	27	32	6.31	17.38	14.31	16.23	18.14	0.87	1.52	0.87
-37138	1318299	-1103	APR	22	29	5.55	18.38	14.35	16.01	17.68	0.79	1.24	0.79
-37132	1318476	-1103	OCT	16	26	6.12	17.58	13.89	15.55	17.21	0.58	0.85	0.58
-37115	1318979	-1101	MAR	3	49	6.89	17.73	9.74	10.87	12.00	0.26	0.36	0.26
-37109	1319155	-1101	AUG	26	45	5.30	18.84	14.20	15.14	16.09	0.21	0.28	0.21
-37103	1319333	-1100	FEB	20	43	7.07	17.58	11.77	13.73	15.69	0.90	1.67	0.90
-37097	1319510	-1100	AUG	15	40	5.15	18.96	5.71	7.46	9.21	0.91	1.60	0.91
-37091	1319687	-1099	FEB	8	37	7.20	17.42	12.02	13.52	15.03	0.47	0.66	0.47
-37085	1319864	-1099	AUG	4	34	5.01	19.04	21.51	23.01	24.50	0.57	0.82	0.57
-37068	1320366	-1098	DEC	19	56	7.27	16.74	17.15	18.32	19.50	0.34	0.48	0.34
-37062	1320543	-1097	JUN	14	53	4.65	19.06	20.03	21.49	22.96	0.43	0.60	0.43
-37056	1320721	-1097	DEC	9	51	7.07	16.79	8.26	10.02	11.79	0.92	1.69	0.92
-37050	1320897	-1096	JUN	2	47	4.79	18.90	21.60	23.52	25.44	0.91	1.64	0.90
-37044	1321075	-1096	NOV	27	45	6.85	16.91	21.52	22.99	24.47	0.52	0.75	0.53
-37038	1321252	-1095	MAY	23	42	4.99	18.73	7.19	8.17	9.14	0.20	0.28	0.20
-37027	1321577	-1094	APR	13	7	5.74	18.29	15.64	16.39	17.13	0.13	0.18	0.13
-37015	1321932	-1093	APR	3	2	6.06	18.15	7.14	8.90	10.66	0.87	1.48	0.88
-37009	1322108	-1093	SEP	26	58	5.80	18.08	11.69	13.50	15.31	0.82	1.34	0.82

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-37003	1322286	-1092	MAR	22	56	6.39	18.00	19.27	20.83	22.40	0.57	0.83	0.57
-36997	1322463	-1092	SEP	15	53	5.62	18.38	-1.37	0.25	1.87	0.70	1.06	0.70
-36980	1322965	-1090	JAN	30	15	7.29	17.29	8.07	9.01	9.95	0.17	0.23	0.17
-36974	1323142	-1090	JUL	26	12	4.91	19.11	20.79	21.96	23.12	0.31	0.42	0.31
-36968	1323319	-1089	JAN	19	9	7.40	17.09	13.32	15.15	16.98	0.90	1.63	0.91
-36962	1323497	-1089	JUL	16	7	4.76	19.20	4.49	6.41	8.33	0.92	1.76	0.92
-36956	1323674	-1088	JAN	9	4	7.44	16.90	2.51	3.98	5.45	0.57	0.82	0.57
-36950	1323851	-1088	JUL	4	1	4.64	19.22	6.95	8.30	9.65	0.35	0.49	0.35
-36933	1324353	-1087	NOV	18	23	6.69	17.04	19.18	20.20	21.22	0.22	0.30	0.22
-36927	1324530	-1086	MAY	14	20	5.13	18.64	5.88	7.49	9.11	0.67	1.01	0.67
-36921	1324708	-1086	NOV	8	18	6.50	17.16	-1.55	0.37	2.29	0.87	1.51	0.87
-36915	1324884	-1085	MAY	3	14	5.30	18.52	21.84	23.54	25.24	0.85	1.38	0.85
-36909	1325061	-1085	OCT	27	11	6.31	17.34	21.86	23.53	25.20	0.59	0.87	0.59
-36903	1325239	-1084	APR	22	9	5.49	18.40	16.43	16.59	16.75	0.01	0.01	0.01
-36892	1325564	-1083	MAR	13	34	6.64	17.89	17.25	18.22	19.20	0.19	0.26	0.19
-36886	1325740	-1083	SEP	5	30	5.47	18.63	22.52	23.37	24.22	0.17	0.23	0.17
-36880	1325918	-1082	MAR	2	28	6.85	17.74	18.91	20.86	22.81	0.88	1.57	0.89
-36874	1326095	-1082	AUG	26	25	5.32	18.78	13.89	15.62	17.35	0.89	1.52	0.89
-36868	1326272	-1081	FEB	19	22	7.02	17.59	19.32	20.89	22.46	0.52	0.75	0.52
-36862	1326450	-1081	AUG	16	20	5.17	18.91	5.27	6.82	8.37	0.61	0.90	0.61
-36845	1326952	-1080	DEC	30	42	7.40	16.80	1.98	3.15	4.32	0.34	0.47	0.34
-36839	1327129	-1079	JUN	25	39	4.62	19.17	2.62	3.91	5.21	0.32	0.45	0.32
-36833	1327306	-1079	DEC	19	36	7.24	16.79	17.14	18.90	20.67	0.92	1.69	0.92
-36827	1327483	-1078	JUN	14	33	4.70	19.02	4.29	6.21	8.13	0.92	1.80	0.92
-36821	1327661	-1078	DEC	9	31	7.04	16.84	6.18	7.65	9.13	0.52	0.75	0.52
-36815	1327837	-1077	JUN	3	27	4.84	18.86	14.15	15.32	16.49	0.31	0.43	0.31
-36804	1328163	-1076	APR	24	53	5.46	18.43	-0.42	0.00	0.42	0.04	0.05	0.04
-36792	1328517	-1075	APR	13	47	5.78	18.28	14.71	16.44	18.18	0.83	1.36	0.84
-36786	1328693	-1075	OCT	6	43	5.97	17.82	19.90	21.70	23.50	0.81	1.31	0.81
-36780	1328872	-1074	APR	3	42	6.10	18.14	2.41	4.05	5.70	0.64	0.95	0.64
-36774	1329048	-1074	SEP	26	38	5.79	18.12	7.05	8.68	10.31	0.71	1.09	0.72
-36757	1329550	-1072	FEB	10	60	7.16	17.46	15.79	16.62	17.44	0.13	0.18	0.13
-36751	1329728	-1072	AUG	6	58	5.06	19.01	4.52	5.55	6.58	0.23	0.32	0.23
-36745	1329904	-1071	JAN	29	54	7.34	17.26	21.50	23.33	25.15	0.90	1.59	0.90
-36739	1330082	-1071	JUL	26	52	4.88	19.16	11.49	13.40	15.31	0.90	1.64	0.91
-36733	1330259	-1070	JAN	19	49	7.44	17.05	11.08	12.57	14.06	0.59	0.85	0.59
-36727	1330436	-1070	JUL	15	46	4.72	19.24	13.42	14.90	16.39	0.45	0.63	0.45
-36710	1330939	-1069	NOV	30	9	6.88	16.91	3.76	4.77	5.78	0.21	0.29	0.22
-36704	1331115	-1068	MAY	24	5	4.95	18.77	13.22	14.75	16.28	0.60	0.87	0.59
-36698	1331293	-1068	NOV	18	3	6.70	16.99	6.63	8.55	10.47	0.87	1.50	0.87

THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
LAUREL, MARYLAND

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-36692	1331470	-1067	MAY	14	60	5.08	18.66	5.29	7.03	8.77	0.89	1.51	0.89
-36686	1331647	-1067	NOV	7	57	6.50	17.12	5.92	7.60	9.28	0.60	0.88	0.60
-36680	1331825	-1066	MAY	4	55	5.24	18.53	-0.65	0.02	0.69	0.10	0.13	0.10
-36669	1332150	-1065	MAR	25	20	6.37	18.03	0.69	1.43	2.16	0.10	0.14	0.11
-36663	1332326	-1065	SEP	17	16	5.64	18.38	6.98	7.74	8.50	0.13	0.18	0.14
-36657	1332504	-1064	MAR	13	14	6.60	17.89	1.94	3.87	5.80	0.86	1.46	0.86
-36651	1332680	-1064	SEP	5	10	5.49	18.57	22.18	23.90	25.62	0.87	1.46	0.87
-36645	1332858	-1063	MAR	2	8	6.61	17.75	2.51	4.15	5.78	0.58	0.84	0.58
-36639	1333035	-1063	AUG	26	5	5.34	18.72	13.13	14.73	16.32	0.65	0.97	0.66
-36622	1333537	-1061	JAN	10	27	7.47	16.92	10.72	11.87	13.01	0.33	0.45	0.33
-36616	1333714	-1061	JUL	6	24	4.65	19.24	9.37	10.45	11.54	0.22	0.30	0.22
-36610	1333892	-1061	DEC	31	22	7.36	16.84	1.92	3.69	5.46	0.92	1.67	0.92
-36604	1334068	-1060	JUN	24	18	4.66	19.13	11.08	13.00	14.91	0.92	1.75	0.92
-36598	1334246	-1060	DEC	19	16	7.20	16.83	14.75	16.24	17.72	0.52	0.75	0.52
-36592	1334422	-1059	JUN	13	12	4.74	18.99	21.22	22.53	23.85	0.41	0.57	0.41
-36569	1335102	-1057	APR	24	32	5.50	18.42	22.16	23.86	25.57	0.78	1.23	0.78
-36563	1335279	-1057	OCT	18	29	6.15	17.56	4.26	6.04	7.83	0.81	1.30	0.81
-36557	1335457	-1056	APR	13	27	5.82	18.27	9.42	11.13	12.85	0.71	1.07	0.71
-36551	1335633	-1056	OCT	6	23	5.96	17.86	15.61	17.25	18.89	0.73	1.12	0.74
-36534	1336136	-1054	FEB	21	46	6.98	17.63	-0.55	0.11	0.76	0.08	0.11	0.08
-36528	1336313	-1054	AUG	17	43	5.22	18.86	12.37	13.24	14.12	0.16	0.22	0.17
-36522	1336490	-1053	FEB	10	40	7.20	17.43	5.57	7.39	9.20	0.89	1.54	0.89
-36516	1336667	-1053	AUG	6	37	5.03	19.06	18.61	20.51	22.41	0.88	1.53	0.88
-36510	1336844	-1052	JAN	30	34	7.38	17.23	19.55	21.06	22.58	0.61	0.90	0.61
-36504	1337021	-1052	JUL	25	31	4.84	19.20	20.02	21.62	23.21	0.53	0.76	0.53
-36487	1337524	-1051	DEC	10	54	7.06	16.85	12.28	13.28	14.29	0.21	0.29	0.21
-36481	1337700	-1050	JUN	4	50	4.82	18.90	20.60	22.03	23.47	0.51	0.73	0.51
-36475	1337878	-1050	NOV	29	48	6.90	16.86	14.80	16.72	18.64	0.87	1.49	0.87
-36469	1338055	-1049	MAY	25	45	4.89	18.80	12.75	14.51	16.27	0.92	1.65	0.93
-36463	1338232	-1049	NOV	18	42	6.71	16.94	14.01	15.69	17.37	0.61	0.89	0.61
-36457	1338410	-1048	MAY	14	40	5.02	18.68	6.49	7.41	8.33	0.19	0.26	0.19
-36446	1338735	-1047	APR	4	5	6.10	18.16	8.24	8.46	8.67	0.01	0.01	0.01
-36440	1338911	-1047	SEP	27	1	5.81	18.12	15.56	16.25	16.94	0.11	0.15	0.11
-36434	1339089	-1046	MAR	24	59	6.33	18.03	8.78	10.68	12.59	0.82	1.34	0.82
-36428	1339266	-1046	SEP	17	56	5.66	18.32	6.61	8.32	10.03	0.86	1.41	0.85
-36422	1339443	-1045	MAR	13	53	6.56	17.90	9.54	11.24	12.94	0.64	0.95	0.64
-36416	1339620	-1045	SEP	6	50	5.50	18.51	21.15	22.78	24.41	0.68	1.03	0.69
-36399	1340122	-1043	JAN	20	12	7.46	17.08	19.39	20.50	21.61	0.31	0.43	0.31
-36393	1340299	-1043	JUL	16	9	4.73	19.26	16.26	17.08	17.89	0.12	0.16	0.12
-36387	1340477	-1042	JAN	10	7	7.42	16.96	10.62	12.39	14.16	0.92	1.66	0.92

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	FT	M2	GM	M3
-36381	1340653	-1042	JUL	5	3	4.68	19.20	17.99	19.88	21.77	0.90	1.61	0.90
-36375	1340832	-1042	DEC	31	2	7.31	16.88	-0.75	0.74	2.23	0.53	0.75	0.53
-36369	1341008	-1041	JUN	25	58	4.70	19.09	4.40	5.83	7.26	0.50	0.71	0.49
-36346	1341688	-1039	MAY	5	18	5.24	18.55	5.55	7.21	8.86	0.72	1.09	0.72
-36340	1341864	-1039	OCT	28	14	6.33	17.32	12.71	14.49	16.27	0.80	1.29	0.80
-36334	1342042	-1038	APR	24	12	5.54	18.40	16.32	18.10	19.88	0.77	1.21	0.77
-36328	1342219	-1038	OCT	18	9	6.13	17.60	0.30	1.94	3.58	0.74	1.14	0.74
-36311	1342721	-1036	MAR	3	31	6.75	17.79	7.12	7.46	7.81	0.02	0.03	0.02
-36305	1342898	-1036	AUG	27	28	5.38	18.67	20.34	21.05	21.76	0.10	0.14	0.11
-36299	1343075	-1035	FEB	20	25	7.02	17.61	13.52	15.32	17.12	0.87	1.48	0.88
-36293	1343253	-1035	AUG	17	23	5.19	18.91	1.85	3.73	5.62	0.85	1.42	0.85
-36287	1343430	-1034	FEB	10	20	7.25	17.41	3.87	5.40	6.94	0.64	0.95	0.65
-36281	1343607	-1034	AUG	6	17	5.00	19.10	2.79	4.47	6.16	0.60	0.88	0.60
-36264	1344109	-1033	DEC	21	39	7.22	16.85	20.75	21.74	22.72	0.20	0.27	0.20
-36258	1344286	-1032	JUN	15	36	4.74	19.02	4.05	5.37	6.69	0.43	0.60	0.43
-36252	1344464	-1032	DEC	10	34	7.09	16.80	-1.05	0.87	2.79	0.86	1.49	0.86
-36246	1344640	-1031	JUN	4	30	4.76	18.93	20.21	21.98	23.75	0.94	1.79	0.94
-36240	1344817	-1031	NOV	26	27	6.91	16.82	22.15	23.84	25.52	0.61	0.90	0.61
-36234	1344995	-1030	MAY	25	25	4.84	18.82	13.65	14.76	15.86	0.29	0.40	0.29
-36217	1345497	-1029	OCT	9	47	5.98	17.86	0.26	0.90	1.53	0.09	0.12	0.09
-36211	1345674	-1028	APR	3	44	6.06	18.16	15.55	17.41	19.26	0.77	1.21	0.77
-36205	1345851	-1028	SEP	27	41	5.82	18.06	15.14	16.85	18.55	0.84	1.37	0.84
-36199	1346028	-1027	MAR	23	38	6.29	18.03	16.48	18.24	20.01	0.70	1.07	0.71
-36193	1346206	-1027	SEP	17	36	5.67	18.26	5.29	6.95	8.60	0.70	1.07	0.71
-36176	1346708	-1025	FEB	1	58	7.39	17.25	3.93	5.00	6.06	0.28	0.39	0.28
-36170	1346884	-1025	JUL	27	54	4.86	19.22	23.46	23.86	24.26	0.03	0.04	0.03
-36164	1347062	-1024	JAN	21	52	7.41	17.11	19.18	20.95	22.72	0.91	1.62	0.91
-36158	1347239	-1024	JUL	16	49	4.76	19.21	1.04	2.90	4.76	0.87	1.48	0.88
-36152	1347417	-1023	JAN	10	47	7.37	16.99	7.62	9.13	10.63	0.54	0.77	0.54
-36146	1347593	-1023	JUL	5	43	4.72	19.15	11.68	13.19	14.71	0.58	0.84	0.58
-36123	1348273	-1021	MAY	16	3	5.02	18.70	12.89	14.47	16.06	0.64	0.95	0.64
-36117	1348449	-1021	NOV	8	59	6.53	17.11	21.26	23.03	24.81	0.80	1.29	0.81
-36111	1348628	-1020	MAY	5	58	5.29	18.54	-0.88	0.95	2.79	0.83	1.35	0.83
-36105	1348804	-1020	OCT	28	54	6.32	17.36	9.07	10.72	12.36	0.75	1.15	0.75
-36082	1349484	-1018	SEP	8	14	5.55	18.44	4.47	4.98	5.49	0.05	0.07	0.05
-36076	1349660	-1017	MAR	3	10	6.79	17.77	21.38	23.15	24.92	0.85	1.41	0.86
-36070	1349838	-1017	AUG	28	6	5.36	18.71	9.21	11.08	12.94	0.82	1.34	0.82
-36064	1350015	-1016	FEB	21	5	7.06	17.59	12.08	13.64	15.21	0.68	1.02	0.68
-36058	1350192	-1016	AUG	16	2	5.16	18.95	9.74	11.48	13.22	0.65	0.98	0.65
-36041	1350695	-1014	JAN	1	25	7.32	16.92	5.13	6.09	7.05	0.19	0.25	0.19

A CANON OF UMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-36035	1350871	-1014	JUN	26	21	4.72	19.10	11.60	12.79	13.98	0.34	0.48	0.34
-36029	1351049	-1014	DEC	21	19	7.24	16.81	7.02	8.94	10.86	0.86	1.47	0.86
-36023	1351226	-1013	JUN	16	16	4.69	19.05	3.73	5.50	7.27	0.95	1.86	0.95
-36017	1351403	-1013	DEC	10	13	7.10	16.76	6.26	7.95	9.64	0.61	0.91	0.62
-36011	1351580	-1012	JUN	4	10	4.71	18.96	20.83	22.09	23.34	0.38	0.53	0.38
-35994	1352082	-1011	OCT	19	32	6.16	17.61	9.05	9.66	10.26	0.08	0.11	0.08
-35988	1352259	-1010	APR	14	29	5.78	18.29	22.16	23.96	25.76	0.70	1.07	0.70
-35982	1352437	-1010	OCT	9	27	6.00	17.80	-0.19	1.51	3.20	0.83	1.34	0.83
-35976	1352614	-1009	APR	4	24	6.02	18.17	-0.69	1.13	2.95	0.77	1.20	0.77
-35970	1352791	-1009	SEP	28	21	5.84	18.00	13.56	15.23	16.91	0.72	1.11	0.73
-35953	1353293	-1007	FEB	11	43	7.25	17.44	12.38	13.39	14.39	0.25	0.34	0.24
-35941	1353648	-1006	FEB	1	36	7.33	17.28	3.63	5.40	7.17	0.90	1.58	0.91
-35935	1353824	-1006	JUL	27	34	4.88	19.17	8.23	10.06	11.90	0.83	1.37	0.83
-35929	1354002	-1005	JAN	21	32	7.36	17.14	15.85	17.38	18.91	0.55	0.80	0.55
-35923	1354178	-1005	JUL	16	28	4.79	19.16	19.11	20.69	22.27	0.65	0.96	0.65
-35900	1354858	-1003	MAY	26	48	4.84	18.85	20.21	21.71	23.21	0.56	0.81	0.56
-35894	1355035	-1003	NOV	19	45	6.73	16.94	5.85	7.62	9.39	0.81	1.29	0.81
-35888	1355213	-1002	MAY	16	43	5.06	18.68	5.86	7.74	9.61	0.87	1.50	0.88
-35882	1355389	-1002	NOV	8	39	6.51	17.15	17.92	19.56	21.20	0.75	1.15	0.75
-35876	1355567	-1001	MAY	5	37	5.33	18.51	10.41	10.74	11.08	0.02	0.03	0.02
-35859	1356069	-1000	SEP	18	59	5.72	18.19	12.80	13.04	13.28	0.01	0.02	0.01

A CANON OF PENUMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-42050	1173245	-1500	MAR	3	55	6.95	17.69	21.85	22.95	24.04	-0.12	-0.04	-0.12
-42039	1173570	-1499	JAN	22	20	7.36	17.15	13.82	14.83	15.84	-0.18	-0.12	-0.18
-41992	1174958	-1496	NOV	10	28	6.50	17.25	5.52	6.57	7.61	-0.12	-0.04	-0.12
-41956	1176021	-1493	OCT	9	11	5.97	17.81	3.96	5.13	6.30	-0.12	-0.05	-0.13
-41951	1176169	-1492	MAR	5	39	6.93	17.73	7.21	8.30	9.39	-0.11	-0.02	-0.11
-41915	1177232	-1489	FEB	1	22	7.29	17.27	2.42	3.05	3.67	-0.28	-0.26	-0.28
-41904	1177556	-1489	DEC	22	46	7.31	16.74	12.68	13.55	14.42	-0.21	-0.16	-0.21
-41816	1180155	-1481	FEB	2	5	7.29	17.31	21.54	22.41	23.29	-0.22	-0.18	-0.22
-41810	1180332	-1481	JUL	29	2	4.92	19.10	12.99	14.07	15.15	-0.10	-0.02	-0.10
-41769	1181543	-1478	NOV	21	13	6.70	17.08	14.48	15.52	16.56	-0.12	-0.05	-0.12
-41733	1182606	-1475	OCT	19	56	6.15	17.56	11.86	13.06	14.27	-0.11	-0.03	-0.11
-41728	1182754	-1474	MAR	16	24	6.68	17.88	15.23	16.14	17.05	-0.18	-0.12	-0.18
-41692	1183817	-1471	FEB	11	7	7.17	17.44	9.54	10.41	11.28	-0.23	-0.19	-0.23
-41661	1184141	-1470	JAN	1	31	7.44	16.80	21.09	21.94	22.80	-0.21	-0.17	-0.21
-41593	1186741	-1463	FEB	13	51	7.15	17.48	5.15	5.79	6.43	-0.28	-0.26	-0.28
-41587	1186917	-1463	AUG	8	47	5.06	19.00	21.14	22.07	23.00	-0.17	-0.11	-0.17
-41551	1187981	-1460	JUL	7	31	4.60	19.23	4.37	4.88	5.38	-0.30	-0.29	-0.30
-41546	1188129	-1460	DEC	2	59	6.89	16.95	-0.57	0.46	1.50	-0.13	-0.05	-0.13
-41510	1189191	-1457	OCT	30	41	6.34	17.31	19.85	21.08	22.31	-0.10	-0.02	-0.10
-41505	1189339	-1456	MAR	26	9	6.40	18.02	23.19	23.83	24.48	-0.26	-0.23	-0.26
-41469	1190402	-1453	FEB	22	52	7.00	17.60	16.55	17.62	18.69	-0.16	-0.10	-0.16
-41458	1190727	-1452	JAN	13	17	7.50	16.92	5.42	6.23	7.04	-0.23	-0.19	-0.23
-41452	1190904	-1452	JUL	8	14	4.63	19.25	21.17	22.24	23.30	-0.15	-0.08	-0.15
-41416	1191967	-1449	JUN	6	57	4.85	18.63	7.44	7.83	8.21	-0.32	-0.31	-0.32
-41364	1193503	-1445	AUG	20	33	5.22	16.86	5.42	6.18	6.95	-0.22	-0.18	-0.22
-41328	1194566	-1442	JUL	18	16	4.68	19.26	10.67	11.59	12.52	-0.21	-0.17	-0.21
-41323	1194714	-1442	DEC	13	44	7.07	16.89	8.33	9.36	10.39	-0.13	-0.05	-0.13
-41235	1197312	-1434	JAN	23	2	7.50	17.07	13.71	14.44	15.1[illegible]	-0.25	-0.21	-0.24
-41229	1197490	-1434	JUL	20	60	4.71	19.27	4.47	5.22	5.98	-0.25	-0.22	-0.25
-41193	1198552	-1431	JUN	16	42	4.75	18.96	14.04	14.91	15.77	-0.21	-0.16	-0.21
-41141	1200088	-1427	AUG	30	18	5.39	18.66	13.85	14.44	15.04	-0.27	-0.25	-0.27
-41105	1201151	-1424	JUL	28	1	4.82	19.22	17.27	18.43	19.60	-0.13	-0.05	-0.13
-41100	1201299	-1424	DEC	23	29	7.22	16.89	17.19	18.20	19.22	-0.14	-0.06	-0.14
-41094	1201476	-1423	JUN	18	26	4.75	18.99	3.87	4.85	5.83	-0.18	-0.13	-0.18
-41012	1203897	-1416	FEB	3	47	7.43	17.25	21.89	22.49	23.09	-0.28	-0.25	-0.28
-41006	1204075	-1416	JUL	30	45	4.85	19.24	12.15	12.31	12.47	-0.34	-0.33	-0.34
-40970	1205137	-1413	JUN	27	27	4.71	19.06	20.92	22.05	23.19	-0.11	-0.02	-0.11
-40918	1206673	-1409	SEP	10	3	5.56	18.44	22.43	22.83	23.22	-0.31	-0.30	-0.31
-40877	1207885	-1405	JAN	4	15	7.32	16.95	1.96	2.94	3.92	-0.15	-0.08	-0.15
-40871	1208061	-1405	JUN	29	11	4.73	19.08	11.04	11.66	12.27	-0.28	-0.26	-0.28

A CANON OF PENUMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-40835	1209125	-1402	MAY	28	55	4.80	18.82	4.95	5.60	6.24	-0.26	-0.23	-0.26
-40789	1210483	-1398	FEB	14	33	7.29	17.43	6.06	6.45	6.83	-0.32	-0.31	-0.31
-40654	1214470	-1387	JAN	14	60	7.36	17.06	10.64	11.57	12.50	-0.17	-0.11	-0.17
-40612	1215710	-1384	JUN	7	40	4.67	18.96	12.09	13.03	13.97	-0.17	-0.11	-0.17
-40431	1221055	-1369	JAN	25	45	7.33	17.21	19.22	20.07	20.91	-0.20	-0.15	-0.20
-40208	1227641	-1351	FEB	5	31	7.24	17.37	3.70	4.43	5.15	-0.24	-0.20	-0.24
-40067	1231804	-1340	JUN	30	54	4.59	19.22	10.43	11.43	12.42	-0.14	-0.07	-0.14
-39985	1234226	-1333	FEB	16	16	7.08	17.54	12.08	12.62	13.15	-0.29	-0.27	-0.29
-39844	1238389	-1322	JUL	11	39	4.64	19.28	18.35	19.10	19.85	-0.23	-0.19	-0.23
-39808	1239453	-1319	JUN	9	23	4.81	18.89	1.77	2.34	2.91	-0.29	-0.28	-0.29
-39709	1242376	-1311	JUN	10	6	4.80	18.93	18.77	19.76	20.76	-0.18	-0.12	-0.18
-39673	1243439	-1308	MAY	8	49	5.16	18.57	5.44	5.82	6.20	-0.32	-0.31	-0.32
-39621	1244975	-1304	JUL	22	25	4.75	19.28	2.45	2.86	3.27	-0.31	-0.30	-0.31
-39585	1246038	-1301	JUN	20	8	4.73	19.01	7.79	8.80	9.81	-0.18	-0.13	-0.18
-39486	1248962	-1293	JUN	22	52	4.74	19.03	1.93	2.48	3.04	-0.29	-0.27	-0.29
-39450	1250024	-1290	MAY	19	34	4.94	18.71	11.96	12.84	13.72	-0.20	-0.16	-0.20
-39351	1252948	-1282	MAY	21	18	4.93	18.75	1.65	2.66	3.68	-0.17	-0.11	-0.17
-39227	1256609	-1272	MAY	29	19	4.77	18.86	18.73	19.89	21.05	-0.09	-0.01	-0.09
-39128	1259533	-1264	MAY	31	3	4.76	18.90	8.73	9.37	10.00	-0.28	-0.25	-0.27
-39092	1260597	-1261	APR	30	47	5.51	18.41	3.09	3.69	4.30	-0.27	-0.25	-0.27
-38869	1267182	-1243	MAY	10	32	5.27	18.54	10.24	11.15	12.06	-0.18	-0.12	-0.18
-38324	1283276	-1199	JUN	2	46	4.89	18.84	8.42	9.38	10.35	-0.15	-0.09	-0.15
-38101	1289861	-1181	JUN	13	31	4.79	18.96	16.22	16.89	17.56	-0.25	-0.22	-0.25
-38065	1290925	-1178	MAY	12	15	5.08	18.63	-0.42	0.15	0.72	-0.29	-0.28	-0.29
-37966	1293848	-1170	MAY	13	58	5.05	18.66	16.65	17.67	18.69	-0.17	-0.11	-0.17
-37930	1294911	-1167	APR	10	41	5.98	18.20	3.18	3.63	4.07	-0.31	-0.30	-0.31
-37842	1297510	-1160	MAY	22	60	4.88	18.77	5.54	6.56	7.59	-0.18	-0.12	-0.18
-37743	1300434	-1152	MAY	24	44	4.95	18.81	-0.25	0.34	0.93	-0.29	-0.27	-0.28
-37707	1301496	-1149	APR	21	26	5.70	18.32	9.91	10.79	11.67	-0.21	-0.16	-0.21
-37608	1304420	-1141	APR	23	10	5.66	18.36	-0.50	0.51	1.51	-0.17	-0.12	-0.17
-37572	1305483	-1138	MAR	21	53	6.31	18.00	17.47	17.71	17.95	-0.33	-0.33	-0.33
-37484	1308081	-1131	MAY	1	11	5.43	18.46	16.79	17.93	19.07	-0.10	-0.02	-0.10
-37431	1309646	-1127	AUG	13	16	5.07	19.06	22.99	23.42	23.85	-0.30	-0.29	-0.30
-37385	1311005	-1123	MAY	3	55	5.41	18.49	6.64	7.29	7.93	-0.27	-0.25	-0.27
-37349	1312069	-1120	APR	1	39	6.03	18.14	0.77	1.45	2.12	-0.25	-0.22	-0.25
-37208	1316232	-1109	AUG	25	2	5.25	18.88	6.90	7.58	8.25	-0.25	-0.22	-0.25
-37126	1318654	-1102	APR	12	24	5.76	18.27	8.14	9.07	9.99	-0.17	-0.11	-0.17
-37021	1321754	-1094	OCT	7	4	5.99	17.77	9.00	10.19	11.39	-0.11	-0.03	-0.11
-36985	1322817	-1091	SEP	4	47	5.43	18.66	15.04	15.86	16.67	-0.21	-0.16	-0.21
-36897	1325416	-1084	OCT	16	6	6.13	17.54	0.84	1.16	1.47	-0.33	-0.32	-0.33

A CANON OF PENUMBRAL LUNAR ECLIPSES

FROM -1500 TO -1000

L	JDN	Y	M	D	C	MS	MR	BT	GT	ET	M2	GM	M3
-36798	1328339	-1076	OCT	17	49	6.17	17.51	16.97	18.12	19.27	-0.13	-0.05	-0.13
-36762	1329403	-1073	SEP	16	33	5.60	18.42	-0.63	0.28	1.19	-0.17	-0.11	-0.17
-36674	1332001	-1066	OCT	27	51	6.31	17.29	9.04	9.47	9.90	-0.31	-0.30	-0.31
-36581	1334748	-1058	MAY	5	38	5.20	18.57	6.53	7.51	8.50	-0.15	-0.08	-0.15
-36575	1334925	-1058	OCT	29	35	6.35	17.27	1.06	2.19	3.32	-0.14	-0.06	-0.14
-36539	1335988	-1055	SEP	26	18	5.77	18.16	7.85	8.82	9.80	-0.15	-0.08	-0.15
-36498	1337199	-1051	JAN	19	29	7.49	17.02	13.06	13.18	13.29	-0.34	-0.34	-0.34
-36451	1338586	-1048	NOV	6	36	6.51	17.07	17.36	17.86	18.35	-0.30	-0.29	-0.30
-36410	1339797	-1044	MAR	1	47	6.76	17.76	16.87	17.15	17.44	-0.33	-0.32	-0.33
-36358	1341333	-1040	MAY	15	23	4.98	18.72	14.32	15.02	15.73	-0.24	-0.21	-0.24
-36352	1341510	-1040	NOV	8	20	6.55	17.06	9.21	10.33	11.45	-0.14	-0.07	-0.14
-36322	1342396	-1037	APR	13	6	5.66	18.25	21.14	21.74	22.34	-0.29	-0.27	-0.29
-36316	1342573	-1037	OCT	7	3	5.95	17.89	16.48	17.49	18.51	-0.13	-0.06	-0.13
-36275	1343784	-1033	JAN	30	14	7.42	17.20	21.29	21.68	22.07	-0.31	-0.30	-0.31
-36228	1345172	-1030	NOV	18	22	6.72	16.90	1.78	2.31	2.85	-0.29	-0.28	-0.29
-36223	1345320	-1029	APR	15	50	5.82	18.29	14.38	15.36	16.35	-0.18	-0.13	-0.18
-36187	1346383	-1026	MAR	13	33	6.51	17.90	0.01	0.73	1.44	-0.25	-0.22	-0.25
-36129	1348095	-1022	NOV	19	5	6.76	16.89	17.41	18.53	19.65	-0.14	-0.07	-0.14
-36099	1348982	-1019	APR	24	52	5.59	18.38	3.26	4.28	5.30	-0.18	-0.12	-0.18
-36093	1349159	-1019	OCT	18	49	6.12	17.64	1.23	2.26	3.30	-0.12	-0.04	-0.12
-36088	1349306	-1018	MAR	14	16	6.49	17.94	13.58	14.69	15.80	-0.13	-0.06	-0.13
-36052	1350370	-1015	FEB	10	60	7.29	17.39	5.49	6.06	6.63	-0.28	-0.26	-0.28
-36046	1350546	-1015	AUG	5	56	4.96	19.14	12.68	13.08	13.48	-0.32	-0.31	-0.32
-36005	1351757	-1012	NOV	28	7	6.93	16.77	10.22	10.79	11.36	-0.29	-0.27	-0.29
-36000	1351905	-1011	APR	25	35	5.56	18.41	21.59	22.14	22.69	-0.29	-0.28	-0.29
-35964	1352968	-1008	MAR	23	18	6.25	18.04	7.22	8.20	9.18	-0.17	-0.11	-0.17
-35958	1353145	-1008	SEP	16	15	5.68	18.21	22.42	22.76	23.10	-0.32	-0.32	-0.32
-35947	1353470	-1007	AUG	7	40	5.01	19.12	5.65	6.76	7.87	-0.15	-0.08	-0.14
-35911	1354533	-1004	JUL	5	23	4.76	19.11	12.35	12.68	13.01	-0.32	-0.31	-0.32
-35906	1354681	-1004	NOV	30	51	6.97	16.78	1.62	2.74	3.86	-0.14	-0.07	-0.14
-35870	1355744	-1001	OCT	29	34	6.30	17.40	10.05	11.10	12.15	-0.11	-0.03	-0.12
-35865	1355891	-1000	MAR	24	1	6.21	18.08	20.91	21.81	22.71	-0.21	-0.16	-0.21