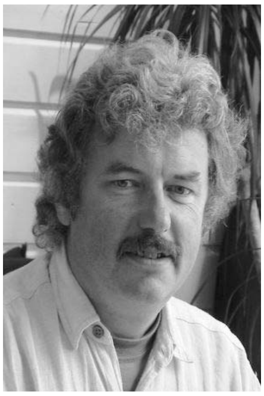
A PROPOSED ITINERARY FOR MEGALITHIC ASTRONOMICAL DEVELOPMENT



This paper will show how megalithic culture could study astronomy and make significant discoveries without modern numerical techniques or equipment. This should overcome the natural disbelief in megalithic capabilities whilst advancing a realistic itinerary to megalithic achievements. Through the counting of natural time periods, the measurement of synodic periods, the creation of a subtle metrology and the use of simple geometrical tools such as the right angled triangle, a discovery window on the sky was possible. This produced some unfamiliar results that are of interest today and Nature is shown to have nurtured early astronomers with the provision of the 19 year Metonic period and 18 year eclipse period, the Saros, just 12 lunations shorter than this.

Introduction

Astronomical observation begins with the observation of spatial organization of stars and planets, the moon largely by night and the sun by day. The organization of time can seem quite fascinating since the sky generates changes which run parallel with those of the terrestrial environment. It has been claimed that early scratches and notches on Stone Age bones and other artifacts could represent counting of the moon's phases [MARSHAK]. The later megalithic culture was obviously able to count and so proof of this Stone Age capability any further back is not especially relevant.

The Month's Approximate Length

Whilst not the accuracy of the actual measurement the half day excess over 29 days adds up to a whole day over two periods. Such good fortune means that some astronomical measurements could be achieved quite easily and these specifics need to be taken into account when assessing any Stone Age ability to progress to the Megalithic. To achieve greater accuracy for the month's duration requires more sophisticated techniques but having a good figure brings early understandings and a subsequent search for greater accuracy, as will be seen.

The Year's Approximate Length

The next achievable goal is to measure the length of the year, which is 365.242 days long. This is also, quite accurately, 365.25 days long, a quarter day longer than 365 whole days. The quarter day manifests in the fact that, on the horizon, the rising or setting sun on the same day of the year has four different positions on the horizon in four consecutive days. This fact enables a period of four years to be counted in days so that the sun will again appear to rise or set on the same distant horizon mark almost exactly. The count would be 1461 days to give an accuracy over one part in 45,000 {1 in 45655}. However, the problem of keeping tally, that is of notating a long count must be considered in the next section.

The Problem of Notating Long Counts

It is a well established fact that cultures readily develop horizon calendars since the sun moves to north and south during the year. The width of such calendars, calibrated by features on a local horizon, grows in angular extent with increasing latitude from the tropics. It is also well demonstrated that megaliths were employed; both as central marker (from which observations are made), and also to provide long sightings to supplement natural features on the horizon.

The keeping of such long counts would require techniques for the recording of large numbers. Inevitably, sophistication must grow from marks on bone to the use of knots, counters, the use of grouping patterns and so on. In later historical cultures these developed into representational symbols and now-familiar mathematical techniques including arithmetic, techniques that have proved crucial to modern scientific culture. Records of early arithmetic exist because of the parallel development of written records paralleling writing with numerical notation on clay, stone, leather and paper media. An alternative mechanism enabling megalithic astronomers to do calculation and measurement is required, since there is no evidence of megalithic notation. It seems more likely that abstract notation arose as the megalithic period was coming to an end and so, how could numbers be handled otherwise?

One promising alternative is a development of metrology or system of measures. Every ruler and tape measure indicates numbers and a unit of measure can usefully subsume a wealth of fractional measures within it such as inches in a foot, eighths of an inch within that. A series of marks on a line or knots on a string are suggestive of numbers and indeed counting involves the notion of number. Counting is a natural precursor of metrology in which number notation is sublimated within an easily manipulated system of measures.

Once measures arise there is a natural use for them within primitive geometrical methods.

1. Measures can be subdivided into one another to achieve the division of one number by another.
2. Larger numbers of a unit can be aggregated to indicate multiplication, such as with a fathom of six feet.
3. Addition and subtraction are simply available through adding or removing a length.
4. In many respects, the concept of measure demonstrates the power of gears and clockwork, themselves an oft-used and natural metaphor of cyclic time periods.
5. There are psychological impacts too in that, knowing the relative frequency of astronomical periods allows for the notion of exact future and past celestial situations.

This proposal, that metrology enabled Stone Age calculation, is supported by the fact that metrology is found to be a chief characteristics of megalithic building. Such constructions invariably employ measures that are precise and often astronomical in their specifics. The measures found in megalithic sites prove to be directly related to the later “historical” measures, described in later periods through writing.[1]

Metrological notation is a very similar technique to the aggregation found within our positional notation of numbers, in the use of miles, furlongs, fathoms, yards, cubits, feet, etc. Each larger unit consists of a known number of smaller ones that in turn contain known quantities of smaller units. Both horizon calendars and metrology are evident phenomena at megalithic sites.

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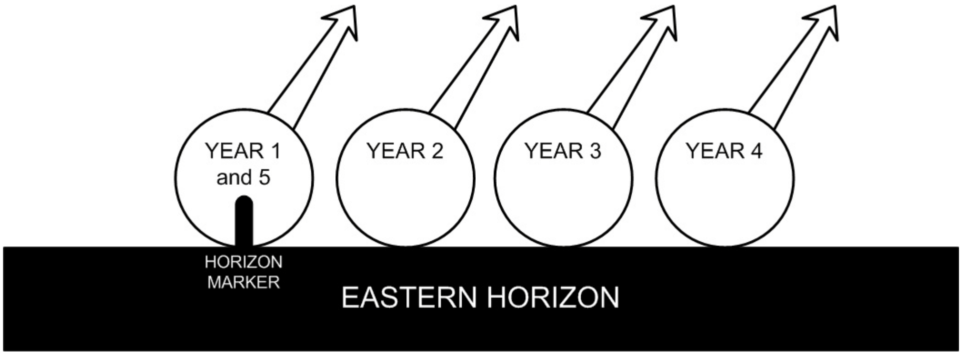
[1] One clear indication is that all of our historical measures, whilst in use in various parts of the East and Europe, were clearly developed within a single interrelated system of measures: they are all related by way of integer ratios between them, ratios involving the first four or five prime numbers. The use of low prime numbers indicates that the originators of the system had appreciated the primary concern of metrology which is that of dividing one length by another. This commensurability of different lengths parallels exactly the problem posed by the division of one celestial period by another and it is likely that the need to relate celestial periods that would have been the initiating cause of this ancient metrology.

Counting the Year’s Length, again

To improve the accuracy in counting a year one can go through a series of natural steps.

Step One: One can count the days between sunrise on the same point of the horizon to realize there are 365 days in a year. Playing with the count can reveal the characteristic that 365 is 73 times 5.

By establishing the 365 day year, one has a direct relationship to the 5:8 relationship of this year to the Venus synodic period of 584 days. There are five 73 day periods in the 365 day year whilst the Venus synod is made up of eight 73-day periods making Venus and the solar year commensurate to considerable accuracy {one in 7300}. Venus is the brightest and most systematic planetary recurrence for the naked eye astronomer whose cycle has an evening star and then a morning star phase which repeats 5 times every eight years of 365 days.



Step Two: When engaged in this activity it becomes clear that the sun “creeps” ahead slightly between years. However every four years there is a sun again on the same horizon marker.

Step Three: The visualization of 365 days, four times, plus an extra day, reveals the true length of the solar year as 365 plus a quarter day.

There is therefore no need to count four years, and in any case how would you know that every four years the sun is accurately on the same marker? It is the observations themselves that develop what to do and “four positions on the horizon” gives the clue to what to measure and how to measure it: that is to say a phenomenological approach would indicate how best to proceed. The sun returns to the same marker after four years meaning one quarter of a day extra per year.

Having achieved the improved 365.25 days as the year length, longer and more accurate measurements are available through observation of a 33 year period which yields a very respectable 365.2424 figure for the solar year as 365 plus 32/132 days.

As with modern science, mechanisms for achieving higher accuracy open the door to new discoveries. In the megalithic world it would have been the lunar month that needed to be more accurately measured and the key to this proved to be nature’s provision of a moon whose orbit creates eclipses.

The Importance of Eclipses

This is expressed very well by E.G. Richards:

"The mean synodic period [of the moon] may be measured by counting the days in a large number of lunations and taking an average. This is facilitated by the fact that the earth, moon and sun are exactly in line, during an eclipse. Thus, counting the number of days between eclipses and dividing the result by the number of new moons observed would give an accurate estimate of the average duration of the lunation or lunar month"[2]

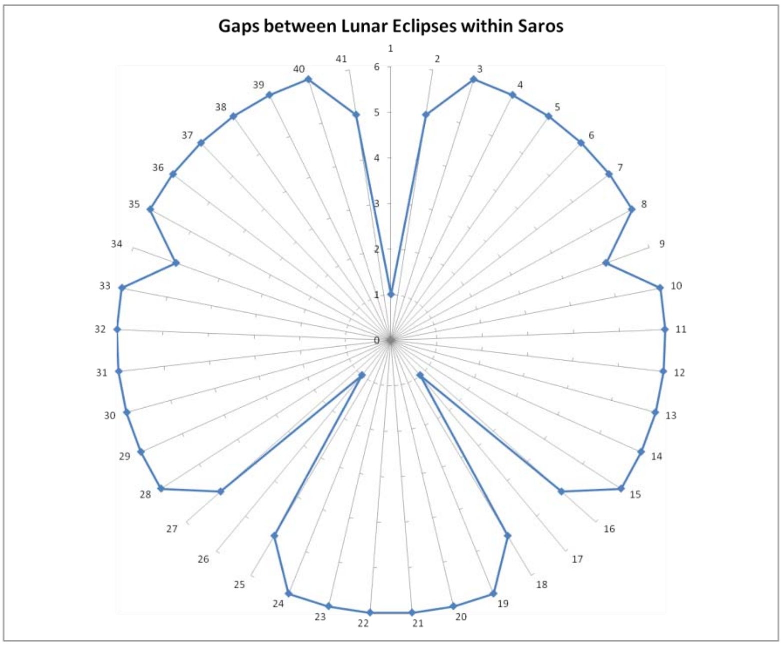
An eclipse can be of two sorts.

1. A solar eclipse, visually the most arresting, is a new moon that occurs when the moon, and hence the sun behind it, is sitting on one of the lunar orbital nodes where the sun's path crosses that of the moon. The moon then stands between the sun and the earth and the shadow created touches a region of the earth. When the moon is lower in its orbit, this can completely mask the solar disk, but only for a very limited region of the earth's surface. This makes solar eclipses quite exceptional as observations and also, quite unpredictable to megalithic astronomers.
2. A lunar eclipse places the Earth between a full moon and the sun, again with these bodies sitting on lunar nodes but one on each of the lunar nodes rather than the same one. The shadow of the earth is about three times wider than the extent of the moon and this causes regular eclipses to occur whenever the sun is near a lunar node since the moon, moving thirteen times fast, will pass through the other node during its orbit and be eclipsed when when full.

Lunar eclipses are common and are also visible when they take place on the same side of the earth as an observer. Some might be missed during the day, especially when partial or "penumbral", that is not fully within the earth shadow. Almost every six lunations an eclipse will occur and this allows counting between eclipses as these accurately mark an opposition between sun and moon and hence the exact moment of a full moon.

As such counts were developed over many years, it would be noticed that there were either 6, 5 or 1 lunar months between them, or multiples of these (when eclipses were not observable or simply missed). A typical pattern is shown below, for 2002 to 2020.

[2] *Mapping Time, the Calendar and its History* by E.G. Richards, OUP, 1998



The pattern is symmetrical because of an 18 year period called the Saros, whose chief characteristic is that an eclipse, solar or lunar, at any moment will recur in similar fashion 18 years, eleven days and 8 hours later, because of the way the moon's tilted orbit precesses. In any recurring cycle, what happens at the beginning is mirrored by what happens at the end and fortunately the 5 and 1 month eclipse gaps allow there to be a recognition, using symmetry, that the pattern of eclipses repeats.

The Saros pattern of lunar eclipses is created by the fact that the sun meets a node every 173.31 days whilst six months add up to 177.18354 days. An eclipse at one node, opposite the sun, can only happen once after which the sun will have to move to the other node before a further eclipse can occur. However, six lunar months are four days longer than the time the sun will take to change node, and this leads to a gradual advance in where the two bodies will stand opposite each other again.

If the six month period is going to overshoot the eclipse condition, a fifth month's full moon will instead manifest an eclipse, usually generating a partial eclipse instead. If this happens early enough, the sixth month can also find a partial eclipse condition, leading to the occasional incidence of just one month between eclipses. If an eclipse occurs after just one month then a further 5 month gap will bring the moon and sun to the opposite nodes in suitable condition to being a further set of six, mainly total eclipses.

Another benefit in viewing lunar eclipses arises when they occur at night for at that time the location of a lunar node can be determined relative to the familiar star constellations, specifically relative to the ecliptic and the sun's yearly path. After counting the eclipse periods, in lunations and in days, over 36 to 55 years it would become apparent that there was some sort of order in them, because of the gaps of 5 and just 1 month, that punctuate the series as the difference between six lunations and half an eclipse year is naturally adjusted for.

When the Saros period is thereby resolved, a whole number of lunar months can be defined for its duration of 223 lunar months, made up from five sets of 6 month gaps, eight 5 month gaps and just 3 1 month gaps; 180 + 40 + 3 = 223.

Having reached such a point then not only would the duration of the lunar month have been accurately measured but also, a predictable schedule of expected eclipses would be available and the total length of the Saros would be known, the knowledge of which being passed down to later astronomers.

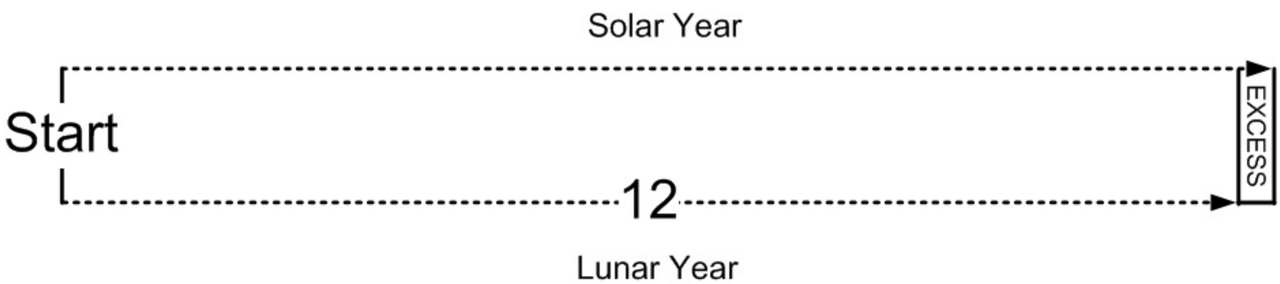
Around 500 BCE a Babylonian called Naburinos published an estimate for the lunar month of 29.530614 days using the Saros period. The figure of 29.53058885 used today is little different showing the high degree of accuracy possible. There is no reason to think that such accuracy was not possible in prehistory using long counts of days and the counting of lunar months in between eclipses. Sufficient accuracy is probably just one hundredth of a day's length, because 29.5300 is only one part in 50,000 different from the actual figure, relaxing the accuracy required for long counts between the many Saros eclipses

It is easy to establish that there are twelve lunar months in the year which we call the lunar year. Nearly eleven days difference exists between the lunar and solar years. This extra part of a month is nearly a third meaning that in three years there are 36 plus one lunar months, i.e. 37.[3] This initial approximation of 12 and one third months in a year can be improved on through conducting long counts between Saros eclipses.

The Importance of Right Angled Triangles

To achieve more accuracy in the relation of the month to the year, attention must focus on this excess of the solar over the lunar year. Having developed an accurate measure for the lunar year then metrology can represent the count for the lunar year as a length that can be superimposed upon the day count of the solar year as a length.

The number of months in a year is then 12.36855 months, in modern positional notation not available during the megalithic. Instead, this could have been expressed by employing the properties of right angled triangles and megalithic metrology which is naturally suited to defining and measuring the side lengths of such triangles. If the year is established in day lengths, as a baseline, then it is possible to measure, as lengths, the twelve months of the lunar year from one end. This then leaves the excess of the solar over the lunar year, exposed as a length which can be measured in days.



The question then arises: how does the excess compare with the month?[4] By dividing the excess length into the month length, two whole excesses leave just less than ¾ of the excess but more than 5/8ths or 2/3rds of it. Logically, to find a closer division invites us to try 5/7ths and to do this a method to obtain sevenths of a unit of measure has to be available.[5]

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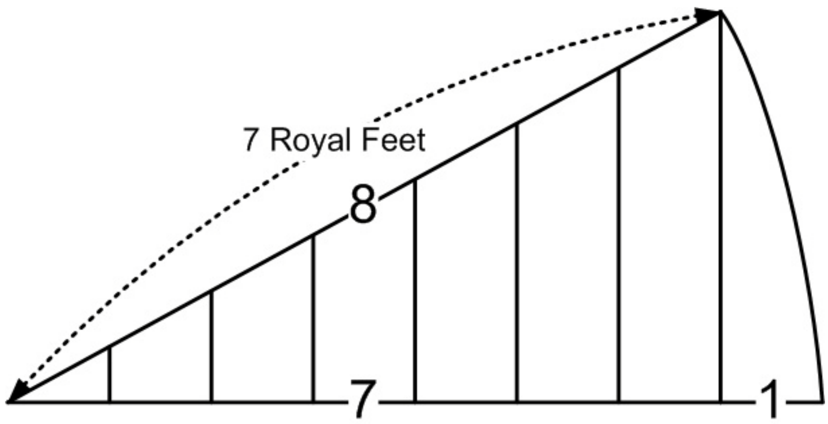
[3] This relation has been noted by Robin Heath as the median diameter of the Sarsen Circle of Stonehenge which is 37.10 megalithic yards.

[4] We can preempt the discussion by noting that the lunar excess is, in days, closely 10.875 which as a fraction is 87/8 days whilst the month as 29.5 days is 236/8. The 236/87 = 2.713 which is close to 19/7 to one part in 1652 and this, it turns out, is the very accurate whole number relation to be found here.

[5] Such simple fractions are to be preferred before advancing to division by larger numbers, partly because the simplest ratios, where possible, are the most representative.



Metrology and triangular geometry make this possible because the interdivision of numbers within measures can be achieved by creating a base and hypotenuse in the same unit. If the base is seven units and the hypotenuse eight units as in the above figure, then the base divisions, *at points directly above each division*, divide up the hypotenuse in seven parts because of the proportionality between the two lengths. Seven feet on the base would generate seven royal feet of 8/7 feet in an 8 foot hypotenuse, causing the required 1/7th of a foot to emerge on the hypotenuse between the first foot and the one seventh division projected upwards from the base of seven feet.

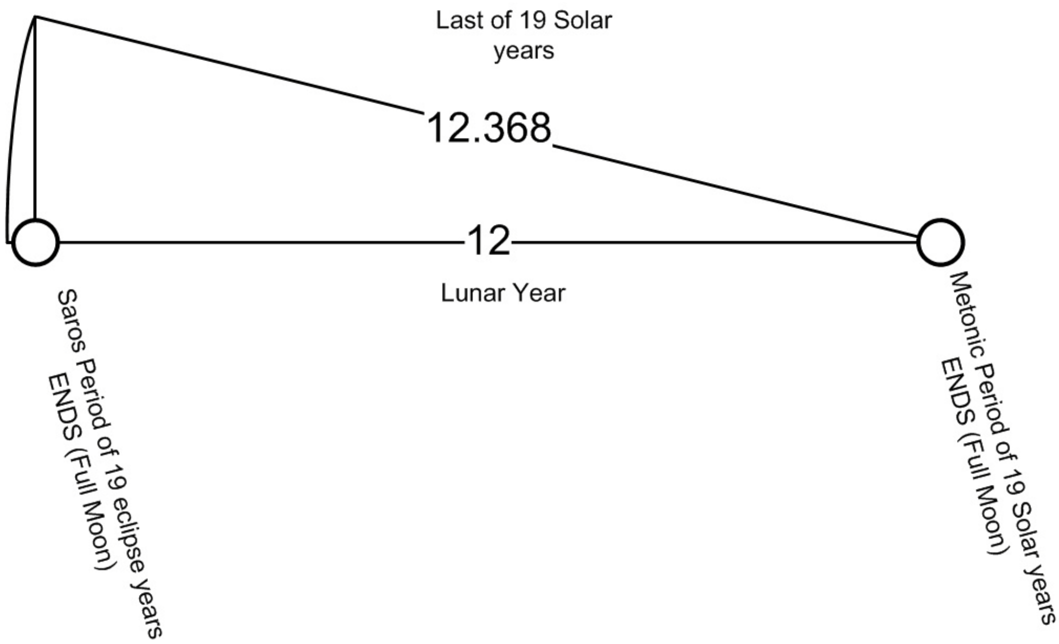
The month as a length would then be revealed as being 2 and 5/7th units in terms of the lunar excess per year or 19/7 to a high accuracy. The excess is then revealed as being the inverse or 7/19th of a month which is 0.368 of it. The month can then be seen as 19 units long and the excess as 7 units long. The required unit is known as the megalithic yard identified as being about 19/7 English feet long.[6] The lunar year of 12 months is added as 12 times 19 over 19 or 228/19 and the metrological result is a year seen in units of length as 235/19 feet or 12.368 megalithic yards equivalent to 12.368 months per year.

The Importance of Nineteen

Something extraordinary is revealed: that in 19 years the sun, moon and stars return to the same relative configuration within 19 years. This period was known to Greek astronomers as the Metonic period but it is far less obvious than the Saros period because the Saros announces itself in spectacular form with eclipses whilst the Metonic period requires a more attentive *noticing*, that the lunar phase and its starry backdrop are identical to how they were nineteen years ago. It therefore seems most likely that numerical counting to determine accurately the lengths of solar year and lunar month revealed the existence of the Metonic period.

Once the Metonic period of 19 years is known, then a lunar eclipse at any (suitable) moment will ensure a full moon (and similar lunar eclipse) after the Saros period of eighteen years and, further, a full moon, if not an eclipse, at the end of the Metonic period of nineteen years. Should counts have been established to accurately predict eclipses, it would soon become clear that there were exactly twelve lunar months between the ending of the Saros and the ending of the Metonic, relative to the starting point. That is, an exact lunar year separates the Saros from the end of the 19 year Metonic; for 235 – 223 = 12.

[6] The term English foot refers to its location in historical times as being in use in England.



The triangle above can be constructed to represent this, the last year of any Metonic period. It recapitulates the aforementioned activity that leads to establishing the excess of the solar over the lunar year based upon 7/19. This triangle illustrates the end of the Metonic, it's last year, very clearly. It is unavoidable that the phase of the moon at the end of the Saros and Metonic periods will be same as its initial phase and it is surprising that a full lunar year should lie between them and even more unlikely that the moon should have a synodic return with the sun exactly on the nineteenth anniversary. Heed must be given to what is a fortunate circumstance for an astronomy using counting and hence for megalithic achievements..

For the Saros to happen, a lunar node has to have reached a position, twelve lunar months before the Metonic. In fact it takes just less than 18.618 years for the nodes to retrograde fully around the ecliptic and as the nodes return to their starting position for a given Saros, the sun meets with the node responsible for an initial eclipse as it has nearly completed one orbit, 11 days and 8 hours into the 19th year of solar motion.

We have already established that lunar eclipses happen whenever the sun, moon and nodes are aligned, during eclipse seasons that last many days, if the sun is crossing a node and the moon goes through either one of its nodes. These nodal points came to be called dragon points because of the idea that sun or moon could be swallowed in some way.

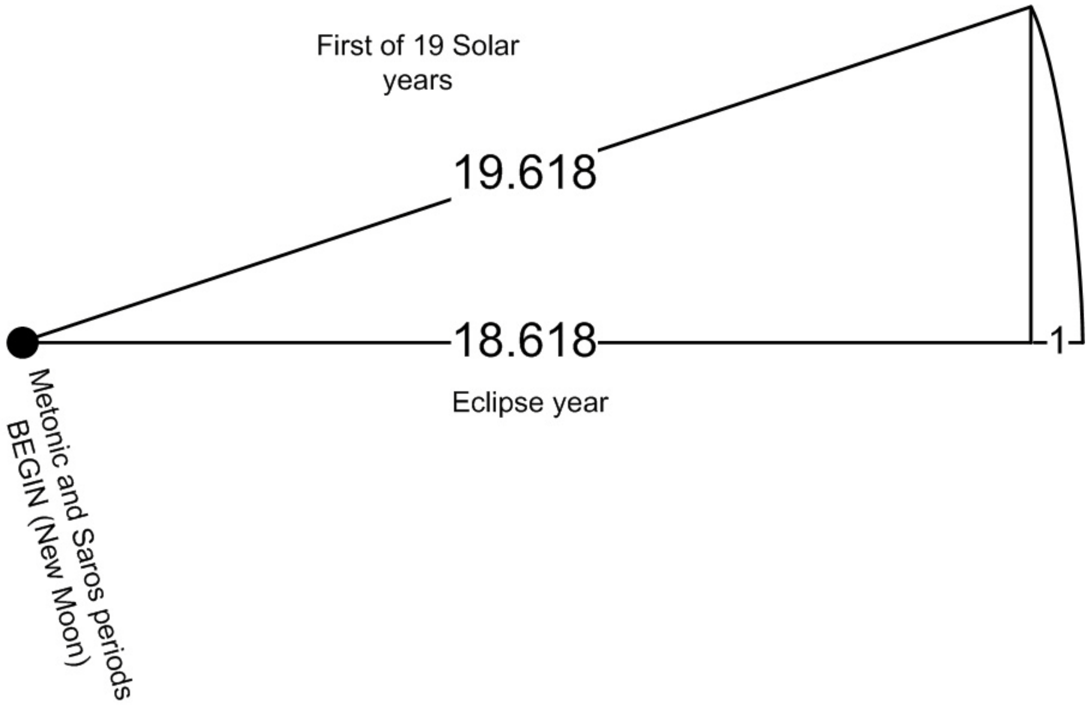
Because the nodes retrograde and the sun defines forward motion in the sky, a node and the sun meet again in less than a year, a type of year called the eclipse year (of 346.62 days). Because there are two nodes there are two eclipse seasons in a year, each marking the minimum time possible between two eclipses.

Since prehistoric people counted eclipses, this behavior and these seasons could be inferred despite the fact that the nodes themselves cannot be seen. Because of the occasional nature of suitable eclipse conditions, it is very easy to deduce that the number of eclipse years in the Saros has to be exactly 19 eclipse years.

At this point, there is a very significant structure to time appearing, that after 19 eclipse years there is a lunar year before the end of 19 solar years. As happened with the solar year and the lunar month, it is inevitable that the movement of the nodes themselves would become a subject deserving accurate measurements. The counting of days between eclipses yields a known and accurate number of lunations in between. Even though eclipses are sporadic, the common unit (of half an eclipse year) would soon become clear and known using the time of day for an observable eclipse to estimate within at least 1/8th of a day. In fact, determining the length of the eclipse year is the complementary aspect of measuring the length of the lunar month from eclipses.

Once the length of the eclipse year is established to this accuracy, then the same technique used above for the lunar excess can be applied to establishing how much shorter the eclipse year is than the solar year. This figure is about 18 days and 5/8th of a day which is 149/8 days. The eclipse year is about 346 and 5/8th days which plus 18 and 5/8th days equals a 365 and 1/5th day solar year which is slightly short of 365.2424 days.

Constructing a triangle for the eclipse and solar year reveals something extraordinary if the triangle is normalized according to the unit of difference between the two years. To do this the unit (in this case, the excess of 18.625 days) is divided into both the base and the hypotenuse leaving the difference as “one”, the unit within which the triangle is now calibrated.



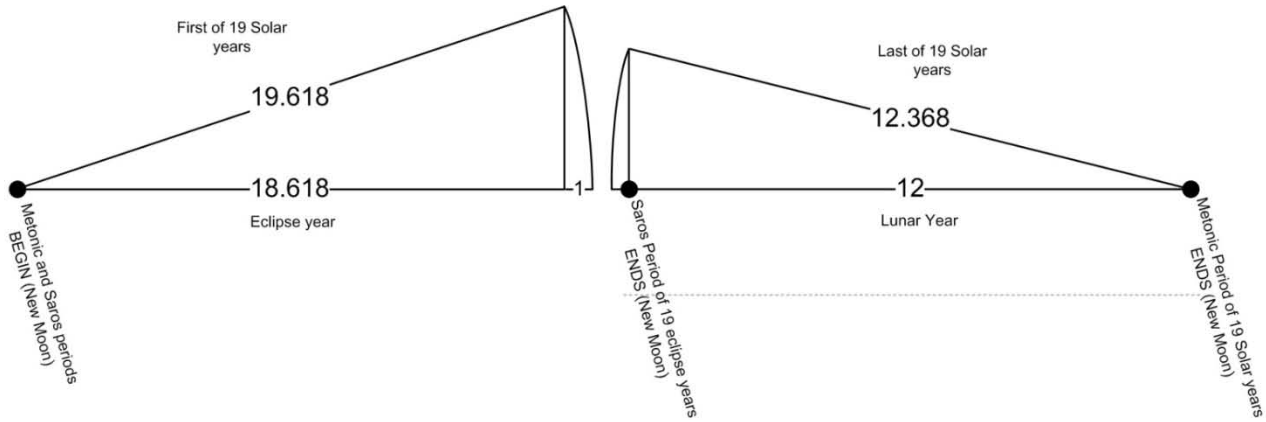
The result would be a triangle with a hypotenuse 19.625 long and base 18.625 or thereabouts. Of immediate interest would be the fact that the eclipse year divided by the unit of 18.625 yields 18.625, meaning that the eclipse year, in days, is the square of the unit whilst also being the “one” that makes the solar year 19.625 rather than 18.625.

These figures could have been improved upon so that they would approach the true figure of 18.618 days as the natural unit of the normalized triangle. For the eclipse year to be the square of the difference between the years, the unit involved must be slightly smaller and is found to be slightly less than 18.618.

The mysterious nature of this triangle emerges from the fact that the moon’s nodes move one DAY in angle during 18.618 days or 18.618 DAYS of solar motion. This DAY in angular motion is the earth rotation required to catch up with the sun so as to begin every day at the same solar time on earth.[7] The whole Metonic period can be summarized with these two

[7] It is important to note that DAYS of angle are the natural units for a people who count astronomical periods whilst the later degree system is natural for a people who measure angles directly using equipment that can be calibrated. The use of 360 degrees obfuscates the natural structure of time measure in the same way that using the non-native metre measure obfuscates the numerical content of megalithic sites.

triangles, the 18.618/19.618 at the start showing the Node day relationship in the year and the 12:12.368 triangle at the end to see the last lunar year that separate the Saros and Metonic completions, as below.



Some simple number relations then emerge. The lunar excess is, as shown, closely 7/19 whilst this new length of 18.618 days is 12/19 of the lunar month and also 12/7 of the lunar runon. Both these new relations are useful but inaccurate in the opposite sense { one in 750}.

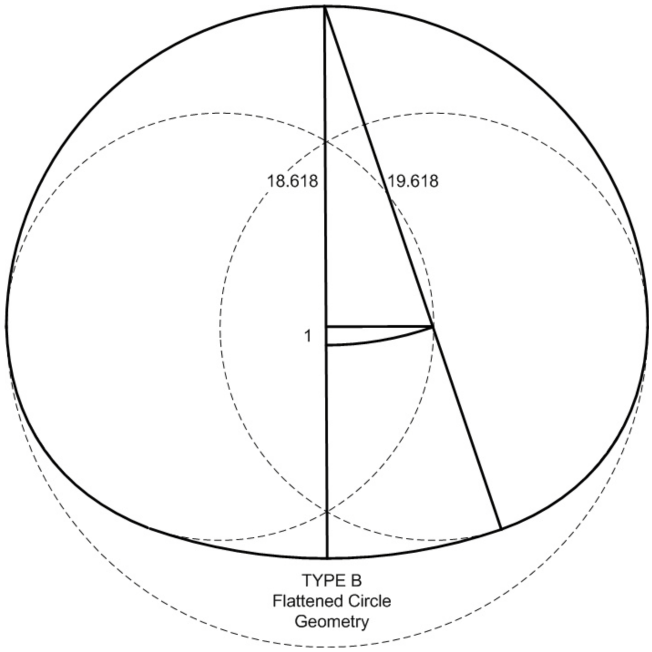
This carries great meaning with regard to historically received measures. If one developed a base measure and subdivided it into seven parts, then 19/7, that is nineteen such parts, this would make a measure that then, naturally, operates to enable the lunar excess and the lunar month to co-habit in the right hand triangle. Moving on to the unit 18.618, which can usefully be called the Node Day, then in the same context it can be shown with a unit 12/7.

These two values are found in historical measures as the royal cubit of 12/7 feet and the Drusian step (of 2.5 Drusian feet) whose value is close to 19/7 (being 19.008/7) and is within the range of measures found for the "megalithic yard" by Thom and verified since at various sites. The 7/7th of a foot is the English foot itself, which appears to have been the root unit for a developed metrological system around which fractional variations were created (such as the Drusian foot of 27/25 feet). It has been found recently that almost all of the known historical length measures were based of the English foot with the implication that metrology was originally developed in pre-history. The applicability of megalithic measures to their astronomical activities whilst being present within megalithic constructions fairly confirms such a lineage for metrology and points, in the absence of other evidence, to the innovation of metrology in the megalithic.

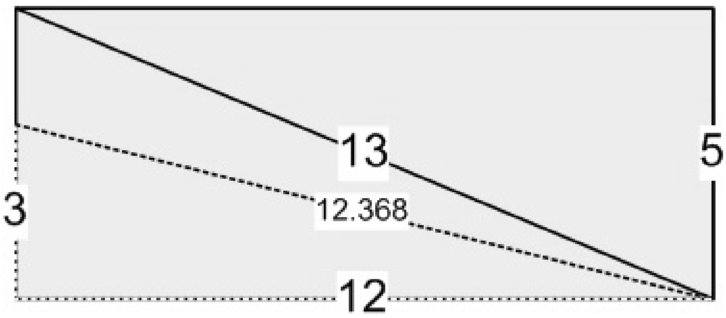
The Importance of Geometrical Symbolism

With regard to the Node Day of 18.618 which manifests in the $(18.618)^2$ eclipse year and 18.618 year nodal orbital period, the 18.618:19.618 triangle has been discovered[8] within the Type B flattened circles built by megalithic peoples in Britain and Brittany. The radius of the non-flattened semicircle can be taken to be 18.618 units long whereupon the central vesica construction has a half width that then defines a hypotenuse of 19.618. The "eclipse triangle" is therefore available through the Type B construction, demonstrating (a) that the triangle was likely known by the builders and that (b) through geometrical flattening of a circle, an origin for such a triangle was found by them, in pure geometrical terms.

[8] Robin Heath, Sun, Moon and Earth pp 54-55, Walker, NY, 1999.



The same story of geometric discovery is true of the 12:12.368 lunation triangle, whose third side is three units. The Station Stone rectangle is 12 units by 5 units in size and if the 5 side is divided at the 3:2 point then an intermediate hypotenuse forms this “lunation triangle”. Meanwhile, the diagonals of the Station Stone rectangle are 13 units long and form the second Pythagorean triangle having 12:13:5 side lengths. Since the Station Stone rectangle is 96 by 40 megalithic yards, then the twelve side is already available in units of 8 megalithic yards and these yards are closely 19/7 feet long.



Also at Stonehenge I and around the Station Stones is an out-scribed circle, the Aubrey Holes within which the Station Stone rectangle was constructed[9].

This has been shown to be capable of operating a sidereal clock in which the sun, moon and lunar nodes are moved according to a simple schedule based upon the moon. The ring represents the ecliptic and the nodal positions can be progressed based on the movements of the moon so that, alignments of sun and moon with the nodes can be identified directly and even predicted through an artificial advancement in the schedule of movement.

[9] Illustration From John Wood’s *Sun, Moon and Standing Stones* OUP 1978. See also the original work *On Stonehenge* by Fred Hoyle. For further development of this idea see *Sun, Moon and Stonehenge* by Robin Heath, Bluestone , 1998

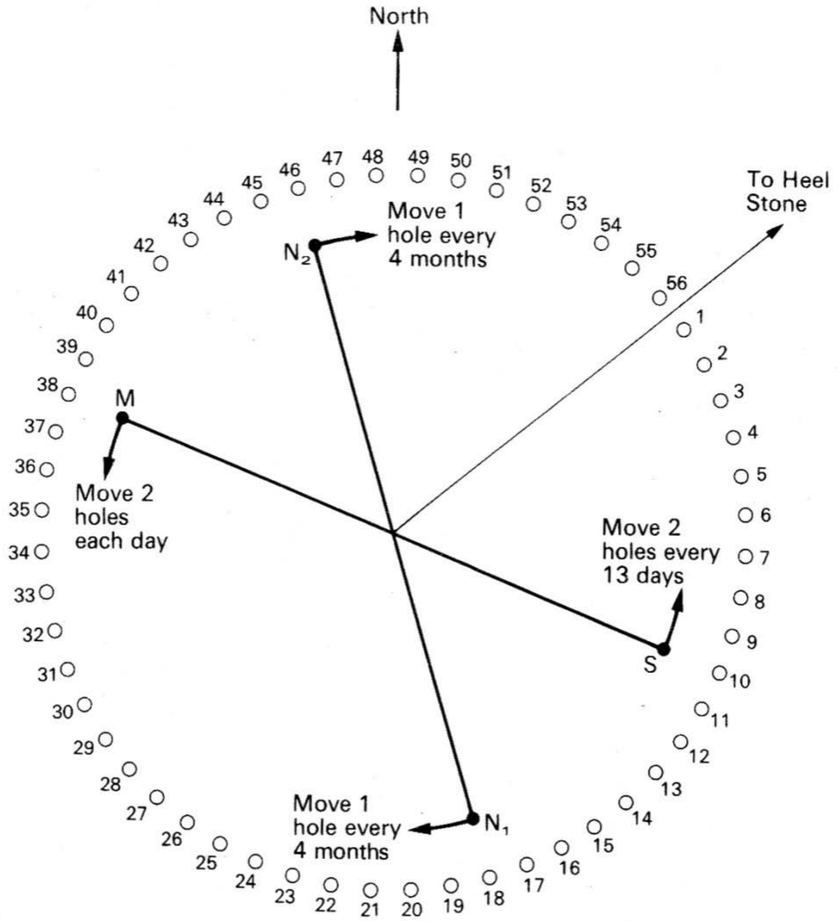


FIG. 4.11 Hoyle's method of using the Aubrey Holes as an eclipse predictor

Conclusions

It has therefore been found that accurate geometrical constructions, the Type B flattened circle and the Station Stone rectangle, contain frameworks for building the two triangles that best characterize the Saros/Metonic periods of 19 eclipse and solar years. The primary unit of length measure used in megalithic times to build these structures, the megalithic yard, is found to exhibit exactly the ratio required to map in lengths, within such triangles, the ratio of the lunar month to the excess of the solar over the lunar year which is 7/19 lunations. By using a 19/7 foot "yard", the excess becomes the root measure, the English foot by cancellation.

There can be little doubt therefore that metrology applied to geometry enabled the counting of celestial periods to be transformed into an exact science without the mediation of later numerical techniques. This science would of necessity have been literalistic since it was not able to abstract numerical measures but could only translate them, from time counting into length measures. However, the right angled triangle enabled equivalents to multiplication and division so that the system of fractional measures could contain all manner of divisions and aggregations based on different prime number bases. Problems of relative length could be solved geometrically or through simple division of a given measure by different units of measure so as to discover common units, that is to find these commensurate and rational with respect to each other.

The problems in accepting the full range of astronomical capabilities demonstrated in megalithic monuments and their alignments has been the absence of an itinerary to explain how Neolithic peoples could have developed such sophistication. The reporting of concrete proofs of achievement has caused those reporting them to be accused of proposing an anachronistic flowering of abstract mathematics in prehistory. Meanwhile, the proposal that an ancient metrology existed as a precursor to historical metrology similarly presents hard to accept assumptions.

This is a Neolithic itinerary whereby the Megalithic could achieve what it did without later mathematical methods. The hypothesis *requires* an evolution of metrology so as to notate counting, develop counts as accurate lengths, find differences between astronomical periods and develop geometrical techniques to identify numerical relationships between these periods. This *requirement* then fits with the evidence within monuments and their geometries containing exactly the right measures and system of metrology.