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An introductory view on archaeoastronomy

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Abstract. Archaeoastronomy is still a marginalised topic in academia and is described by the Sophia Centre, the only UK institution offering a broader MA containing this field, as 'the study of the incorporation of celestial orientation, alignments or symbolism in human monuments and architecture'. By many it is associated with investigating prehistoric monuments such as Stonehenge and combining astronomy and archaeology. The following will show that archaeoastronomy is far more than just an interdisciplinary field linking archaeology and astronomy. It merges aspects of anthropology, ethno-astronomy and even educational research, and is possibly better described as cultural astronomy. In the past decades it has stepped away from its quite speculative beginnings that have led to its complete rejection by the archaeology community. Overcoming these challenges it embraced full heartedly solid scientific and statistical methodology and achieved more credibility. However, in recent times the humanistic influences of a cultural context motivate a new generation of archaeoastronomers that are modernising this subject; and humanists might find it better described as post-modern archaeoastronomy embracing the pluralism of today's academic approach to landscape and ancient people.

1. Introduction

In the first instance Archaeoastronomy is a word created by combining archaeology and astronomy. As such this subject area might initially be described as involving the comprehension of stars, Sun and the Moon as they move through the sky from the perspective of an astronomer using the material remains of people whose culture can be described as ancient and that does not exist anymore. However the given outline of archaeoastronomy is quite problematic very simplified and ignores many other facets of this subject [1, p. 226 note 93].

First it is necessary to describe some examples that acted as motivation towards the development of this field. A classic example is the Stonehenge monument in the south of England that will allow exploring aspects of archaeoastronomy. The impressive stone circle is a combination of several rings of stones and ditches [2]. Looking beyond the central moment the entire surrounding is littered with ancient remains such as burial mounds and other monuments [3]. Most importantly it includes a processional avenue that enters the central Stonehenge monument from the northeast (see figure 1). The orientation of the avenue is one example of an astronomical orientation included in the structure. The Sun will rise at midsummer in the direction of the avenue when viewed from the centre of Stonehenge. It also will appear to set behind the centre of Stonehenge at midwinter when walking along the avenue. Discovering and exploring such astronomically motivated alignments is the brief of archaeoastronomy. That this is not a trivial task becomes clear when realising that Stonehenge was

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constructed during the late Neolithic. The people of this era did not use any written records and their culture has not survived into modern day. Therefore no written records exist that document any discovered alignments or describe their intention. For example, to understand which direction might be the intended one for the avenue, it is essential to place the monument into its landscape and realise that the midsummer orientation might be impressive, but is only visible to a few that find space in the monument itself. However, the reverse midwinter alignment offers a large procession the view on the setting Sun behind Stonehenge. Additionally, the avenue slopes up towards the centre of Stonehenge allowing people that move up the slope to experience an apparent standstill of the Sun behind Stonehenge and acting as a potential symbolic and powerful symbol of how such a ritual procession might lengthen the days and hasten the coming summer season [4]. There are far more proposed alignments that will not be discussed here. The avenue will suffice to illustrate possible astronomical motivation in many other ancient monuments in England, described in more detail by Ruggles [1].

But there are far more such examples scattered all across the world illustrating that astronomical knowledge and such motivated alignments were recognised and valued by many different cultures. The passage grave in New Grange Ireland has its entrance lined up towards the rising midwinter Sun. Only once a year will the Sun's rays illuminate the back of the burial chambers [5]. In Germany the palisade ring at Goseck 4,900 BC, possibly the oldest solar observatory in the world [6], includes openings that allow the Sun to be seen at midwinter [7, 8]. Additionally, several temples and burial sites in America include astronomical orientations, for example buildings in Chaco canyon include possible solar and lunar orientations [9].

These examples are only few but show quite well the need for a subject area that tries to explore astronomical meaning in monuments. As briefly mentioned above, this subject might be called archaeoastronomy. But this name is not unique and is understood quite differently by many members of this community. For example, combining the words astronomy and archaeology might also result in astroarchaeology. The two variations on the name are seen as a distinction between either archaeologists working in the field of astronomy or astronomers working on the topic of archaeology. This case is ideal to illustrate that the subject area is sometimes seen as an area one cannot specialise in. Either one is an astronomer or an archaeologist. Or even blunter, the subject area is classed as a service subject that has no own identity [10; 11, p. 336]. This mistake might result from the extreme interdisciplinary character of the subject. It includes also aspects of anthropology, sociology and pedagogy which led Ruggles and Saunders [12], Ruggles [13] and Iwaniszewski [14] to use the term cultural astronomy to stress the additional aspects. Research might now include astronomical beliefs of current people exemplified in the recent 2012 Mayan apocalyptic prophecy and its contemporary reactions [15]. Silva and Campion [16] in the field have coined the term skyscape archaeology as describing their work. Here the term stresses the importance of the conjunction of monument, landscape, people and the sky above. This final realization of how these components interact will allow understanding an astronomical alignment.

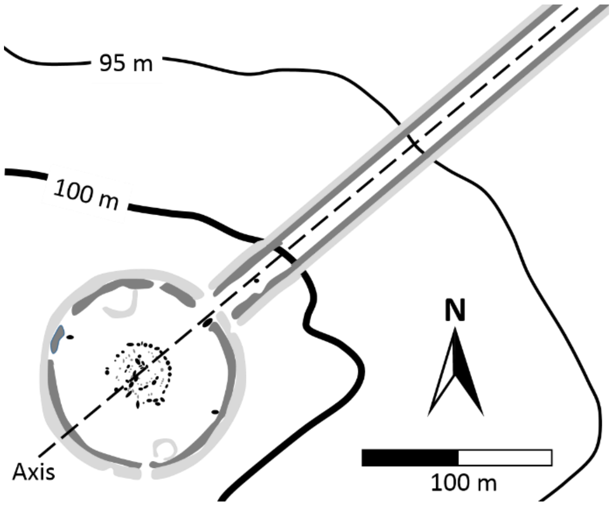

Figure 1. The structure of the central Stonehenge phase 3 monument as well as the avenue approaching Stonehenge are shown. The main axis is indicated oriented towards midwinter sunset and midsummer sunrise. Additionally landscape contour are pointing out the slope the avenue runs up to Stonehenge.

These different attempts show that this subject contains many researchers with a very different background that do not feel they are using archaeoastronomy as a way to gain further insight of their own field. Such varied discussions related to many disciplines illustrates that archaeoastronomy is a subject of its own that thrives on the complexity of the different subjects contributing and defining it.
In the following section, some key concepts of the main contributors of the field: archaeology, anthropology and astronomy will be outlined. This will be followed by a description of how archaeoastronomy grew as a topic and highlights the challenges it had to face given its interdisciplinarity. These challenges are the fires out of which something is rising that the author is terming modernised. Some have called their work modern archaeoastronomy due to the instruments used and the removal of old misconceptions leading the researcher to see their own reflection in ancient people and their beliefs [17]. The author however sees this newly emerging field as modernised. It fully embraces rational scientific facts and reasoning exemplified by Thom's [18] and Ruggles' [19] work making it modern from the point of view of a humanist. But it also now introduces the dimension of meaning explored through new methods and embracing anthropological ideas.

2. Key concepts

Archaeoastronomy's main three contributing fields of research are Archaeology, Anthropology and Astronomy. The following will describe some basic concepts as perceived by the author that are required to understand the development of archaeoastronomy and its current status. By no means are they or can even attempt to summarise the complete context and entire background in these areas. They set the stage for the following other contributions in these proceedings putting them into context and allowing the reader to see the greater picture into which the narrative of each paper fits.

2.1. Archaeological context

Archaeology as a discipline has undergone a long development until it arrived at the status we are familiar with today. These developments impacted upon dating, archaeological theory used to understand the material record and finally also upon the picture of the people that created the material record [20].

Firstly, the material record analyzed in archaeology does not come with an associated time of creation. Each artifact or monument has to be seen in its context of associated finds to derive a probable date or period during which the artifact was created or the monument erected [20]. Therefore in some instances only a reliable time sequence can be determined for a site without being able to determine an absolute age. From such work the three periods of Stone, Bronze and Iron Age were derived as periods spanning times from several 100,000 years up to only decades after the birth of Christ. The periods are as their names suggest based upon the predominant material used. However, such a dating method is flawed in a sense that for example stone tools were not immediately dropped in favor of bronze. The usage of materials undergone a subtle change that also very much depended upon the location of the area of interest [20]. But such a dating system is still in place as an easy reference and table 1 gives an overview over the periods from the end of the last Ice Age up to the arrival of the Romans in Britain for the British Isles. Additionally, figure 2 illustrates the coastline in western Europe during the end of the last Ice Age and just before Britain became detached from main land Europe.

Table 1. Periods, dates and associated key events for the British Isles from [21]

Period		Date (years)	Key events
Stone Age	Palaeolithic	500,000 BP	First humans in Britain End of Ice Age
	Mesolithic	10,000 BP	Britain becomes detached from mainland Europe 5,900 BC
	Neolithic	5,000 BC	Early farming Causewayed enclosures and long barrows Stonehenge and Avebury
Bronze Age		2,150 BC	
Iron Age		750 BC	Ends with the arrival of Romans 43 AD

The advent of carbon dating brought a new approach to dating artifacts that contain organic remains and allowed to introduce absolute dating [22, pp. 65—96]. However this brings with it a whole new set of challenges such as the influence of modern atomic tests distorting the isotopic reference of today as well as having to ensure that the sample has not been polluted. The method also requires the presence of organic remains at a site. This specific remain can be dated and its context with regards to either monument or artifact of interest.

There are other contemporary methods [22] that use magnetic rearrangement within the material caused by fire or the luminescence of material to determine the amount of time the sample has been buried and removed from sunlight. Overall the challenges remain the same and give us a probable date including a more or less broad range of error.

Secondly, also the theoretical standpoint upon which archaeology is based, has undergone

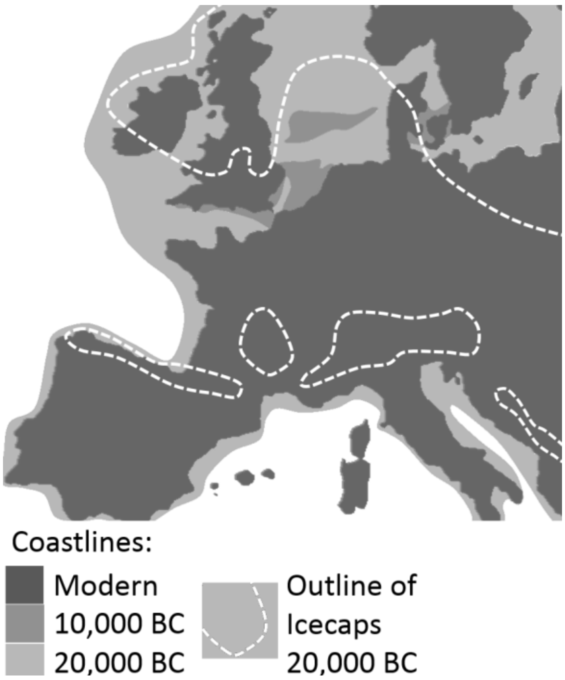

Figure 2. The approximate distribution of coastlines from their current location to 20,000 BC including the rough location of the remaining icecaps at the end of the last Ice Age. Note that until 6,900 BC Britain was still part of the European mainland.

significant changes from the early times of the development of this field. Archaeology was born within the realm of collectors and 'treasure' hunters not too different from the Indiana Jones depicted in Hollywood movies [20, p. 21]. The focus lay upon creating a map and list of the entire world within the Victorian idea of natural history [23]. This included treasures often displayed in cabinets of curiosity [24]. This approach left little interest upon how the site actually looked like, the context in which the artifact was found and the conservation of the actual site. Some classical examples of what is called antiquarians of these times were individuals such as Thomas Bateman [25, 26] and Hayman Rooke [27] that excavated many ancient monuments across the Peak District in England during the end of the eighteenth century to the middle of the nineteenth century. But archaeology moved on; the creation of site plans, as well as the realization that the sequences of deposits within a site can allow for a relative dating, made this field become what we are used to see at modern excavations. The theoretical concepts to interpret the material record were described from the 1860 onwards as Cultural-Historical [28 p. 235]. Each culture was identified by distinct methods and symbols used in their craftsmanship. Cultures would then evolve when ideas diffuse from one group of cultures to another. Vere Gordon Childe expanded on this idea of diffusion by adding the concept of revolutions that for example introduced farming to ancient people (Neolithic Revolution) [29]. As can be imagined such a cultural fixation lent itself to nationalistic approaches to explain the superiority of one country or race especially given definitions of culture in that period, for example Raymond Williams' proposal of culture as civilization [30]. Eagleton states that it still remains a challenging and complex word to define [31]. Different aspects of this problematic idea are exemplified in the extreme by the Third Reich and their obsession with the Arian race or through the imperialist and colonial views of Britain illustrated for example in the first interpretation of Great Zimbabwe and its origin not being African but from middle eastern cultures [32]. From 1960 a new kind of archaeology was promoted which called itself new-archaeology or processual archaeology [33]. It based its work strongly upon new scientific analysis introduced into archaeology such as carbon dating. The idea of the scientific method was applied to archaeology. Archaeology started to rely heavily upon testing hypothesis with scientific facts. It also became clear that the emphasis had to move away from general culture towards the people themselves, since anthropology had shown that different ethnics groups cannot always be discerned using the material record. From the 1980 onwards the extreme reliance upon scientific method alone was starting to be criticized. Individuals such as C Tilley, I Hodder, M Shanks and D Miller called for a change to a new theoretical approach which they called post-processual archaeology now known as interpretative archaeology [34]. The absolute objectivity of the researcher interpreting the scientific facts is questioned and the importance of self-reflection is highlighted. Interpreting a site becomes self-interpretation and a realization of the prejudice an archaeologist brings with them when interpreting the material record, for example the realization that the male perspective of interpretation needs to be dropped. As such they stress that there is no single interpretation of the material record but many that depend upon the researchers stand point.

The last shift in archaeology can be seen in how ancient people were described by archaeologists. In the early periods of archaeology, prehistoric cultures were described as primitive and basic containing no complex rituals or the ability to conceive complex buildings. In this picture dominant during the Victorian period the light of civilization expressed through farming was brought to the brutes in Europe from the East [35]. Overall, pre-Neolithic people were seen as barbarians. However, our current understanding is quite different to this picture drawn in Victorian times. The excavations at Göbliki Tepe in Turkish Mesopotamia uncovered the oldest stone temple erected [36]. It has been dated to 9,000 BC and consists of several ellipsoidal stone sanctuaries built by a hunter gatherer society, ie pre-Neolithic. The impressive T-shaped stones used for the buildings as well as the complex symbols used for decoration belie the image of barbarians. Even though this is a singular monument and not sampling people from the geographic region discussed here, the sheer existence of the monument and its complexity illustrates the mental and physical ability of such ancient people. Furthermore, anthropology has also strengthened the idea that such pre-Neolithic societies had complex belief systems based upon a lunar template [11]. Overall, the notion of brutes and barbarians has to be abandoned that describes ancient people predating the period labeled Neolithic Revolution that are the focus of the papers in these proceedings.

2.2. Anthropologically influenced context

Gosden states that ‘Archaeology is Anthropology or nothing’ [37], illustrating how close these two subjects are linked. Gosden lists contributors to archaeology being archaeology, social/cultural anthropology, physical anthropology and linguistics. Therefore the influence of anthropological work in archaeoastronomy has to be substantial. Given such a vast subject area the author can only focus on some for him and the proceedings relevant areas that allow speculating upon the meaning of monuments for ancient people. More specifically it supports the existence of a complex belief system as described previously. It allows exploring and explaining how lunar rituals embed into hunter gatherer societies outlined by Sims [38] and based upon ideas of sex strike and dark Moon [39]. It also helps to shed light into the transition from lunar to solar beliefs associated to the Neolithic Revolution. This is also referred to as the agricultural revolution and expresses the change from hunting and gathering to agriculture [40]. Especially the idea of the Neolithic Revolution and its impact will be described here in more detail since it is part of several narratives in these proceedings.

Initially it was thought, the people moved in from the East as shown in figure 3 bringing farming and civilisation into the area to become the British Isles that was just becoming habitable after the last Ice Age. They were to find either an empty land or few barbaric uncultured people. In a sense, V G Childe argues that they found a clean slate onto which new rituals and beliefs could be inscribed [41]. It has been demonstrated through DNA research that such a simple explanation is incorrect and a result of outdated DNA analysis methodology. Modern DNA methods can trace the lineage of the people of Europe to several regions. One does indeed include a people originating from the middle east, but there is also a lineage apparent of a people that originated from a Franco-Cantabrian region as shown in figure 4 [42, 43, 44], therefore illustrating that the true picture is far from simple. This is further underlined by current research showing that there is a third lineage from a west Siberian population that has been added as well [45].

These results are important since the Franco-Cantabrian region has been identified as one of several refugia of the last Ice Age 20-25,000 years ago [46]. The people of the late Palaeolithic would have been able to survive in these regions and then repopulate Europe bringing with them their whole complex cultural belief system and culture. Therefore, Europe would have been already populated by a cultivated people and would have not represented V G Childe’s clean slate. The existence of refugia has also been supported by the analysis of the material record through Clive Gamble and his S2AGES project; it has determined the same region from which 19,000 years ago Europe was repopulated [46]. Combining all this evidence Frank [47] developed a narrative that describes the European culture drawn from its ancient Palaeolithic routes which survived the last Ice Age and she coined this Palaeolithic Continuity / Refugia Theory.

The resulting impact upon archaeoastronomy was outlined by Silva and Frank [48] and criticises the interpretation of the Neolithic Revolution as either a replacement of people or their ideas. Neither were the people in Europe replaced by eastern people proficient in farming, nor were their beliefs (probably based upon a lunar mind set) simply replaced by solar orientated beliefs through a one-way accculturational process. What is put forward is rather a smoother continuous change that included the adoption of farming in a slow process including setbacks and adaptations. It also incorporated the gentle merging of the two belief systems to a new set of beliefs that can be supported for example through the pottery introduced into Mesolithic Scandinavia still containing patterns previously popular [49] as well as by anthropological research of colonized peoples that show elements of the world view of colonisers and colonised to merge [50]. This means overall, that megalithic remains in Europe are not the evidence of a sudden change in culture but illustrate old ideas using new methods to express them [51].

2.3. Astronomy

To uncover belief systems of ancient people within the material record for example in monuments such as Stonehenge, several astronomical key concepts are needed that can point out lunar, solar, or stellar alignments. Many of the key concepts of astronomy related to archaeoastronomy will be only briefly outlined since it is assumed that the reader will have a general understanding of astronomy. First the idea of alignments will be described including its problems; this will be followed by dates that structure the yearly rhythm of the passage of the Sun for example Solstices and Equinoxes. An overview of the movement of the Moon will be given mentioning the idea of lunar standstills. Finally, stellar events are outlined described as stellar phases.

The concept of alignments is a fundamental idea within archaeoastronomy and has shaped the development of this field. It is one way of including astronomical meaning within a monument. Alignments most commonly point out a direction towards the horizon where a celestial body, for example Sun, Moon or a star, rises or sets. An alignment is defined by a minimum of two objects, a straight wall or a constricted view from a defined location. In general it can point towards two equally valid directions 180 degrees apart in azimuth. However this duplicity can be clarified given the context of the setting, for example a burial chamber with a single straight entrance passage will have only one alignment pointing out of the chamber, with its narrow opening defining a range surrounding this alignment. The determination of the azimuth of the alignment, most commonly carried out using a magnetic compass, needs to take into account the local magnetic North as well as possible other site specific deviations. However, the value of azimuth will not allow comparing alignments between different sites since it points to rising and setting directions on the local horizon. Therefore, the geographic latitude of the site needs to be taken into account as well as the contours of the local horizon. These parameters allow the transformation of an azimuth into a declination of objects that rise or set in this direction for the site of interest. The knowledge of the horizon profile is essential since an error of 3 degrees in horizon altitude at our latitudes can lead to an error of 5 degrees for the rising or setting of the Sun at its Solstices illustrated in figure 5. Furthermore, other aspects such as lunar parallax (regarding the lunar alignments only) and atmospheric refraction can also alter the exact declination associated to an azimuth [1, p. 22].

Alignments allow tracking the passage of celestial objects such as the Sun as their rising and setting locations on the local horizon change during the seasons. Such observations allow developing a calendar identifying important times during the year. The extremes (Solstices) and symmetry points (Equinoxes) of the solar movement are especially of interest. Solstices occur midwinter and midsummer when the declination of the Sun reaches its minimum or maximum respectively. The Equinoxes occur initially due East or West independent of geographic location but can vary given the local horizon profile. The finer details regarding non equal separation of the year in time by the equinoxes or the introduction of quarter days is left to the reader to investigate and will not be relevant for this paper [1, p. 54]. However it is worthwhile pointing out the slow change of the obliquity of the ecliptic that has led to a general decrease in obliquity to the current value $\boldsymbol{\varepsilon} = \mathbf{23.45}$ degrees. A typical value for 2,000 BC is $\boldsymbol{\varepsilon} = \mathbf{23.95}$ and for 4,500 BC $\boldsymbol{\varepsilon} = \mathbf{24.15}$ (taken from Laskar [52]).

A similar pattern could be determined for the movement of the Moon along the local horizon. However, the lunar orbit is tilted to the ecliptic by $\boldsymbol{i} = \mathbf{5}$ degrees resulting in the Moon's extremes varying each month. Therefore, we can only determine a most northern major or minor limit when the Moon has a declination $\boldsymbol{\delta} = \boldsymbol{\varepsilon} + \boldsymbol{i}$ and $\boldsymbol{\delta} = \boldsymbol{\varepsilon} - \boldsymbol{i}$ respectively. A similar definition can be done for the most southern major and minor limits when the Moon has a $\boldsymbol{\delta} = -\boldsymbol{\varepsilon} - \boldsymbol{i}$ and $\boldsymbol{\delta} = -\boldsymbol{\varepsilon} + \boldsymbol{i}$ respectively. The overall declination of the Moon is given in figure 6 and follows an envelope wave with the upper and lower envelope showing a period of 18.6 years and the wave itself showing a period of 27.3 days. Analysing the lunar movement to high precision can allow determining eclipses. But the precision required is of the order of arcminutes and needs to take into account further lunar nutations and refraction. Additionally it requires the observation of full Moons at the extremes [53]. All these constraints make such a practice highly challenging and very unlikely [1, p. 49].

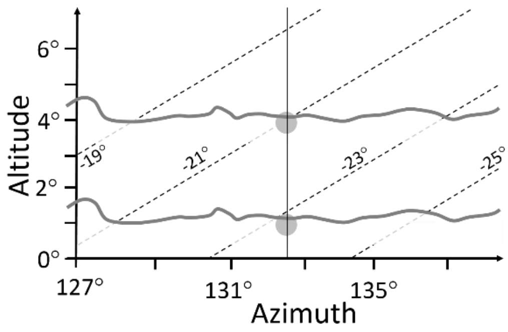

Figure 5. The impact the local horizon altitude has upon transforming measured azimuths into declinations. Two different landscape profiles are indicated with an altitude difference of 3 degrees between each other. The Sun's disc is indicated for the same azimuth but clearly two different azimuths.

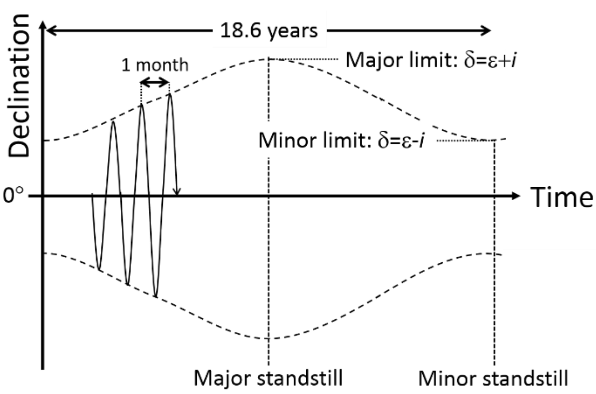

Figure 6. The motion of the Moon in declination over a period of 18.6 years illustrating the envelope wave apearance of its motion and the definition of Major and Minor standstills.

An established alignment can point out not only the Sun or Moon but also denote the rising or setting position of a star on the local horizon. This might initially seem as if we have a plethora of possible positions of stellar significance, however the amount of stars visible while rising on the horizon is very small. Assuming a local horizon has possible altitudes of not more than 2 degrees and extremely good viewing conditions comparable to modern observatory sites such as the Cerro Tololo Inter-American Observatory, only the rising or setting of stars with a visible magnitude brighter than 1 mag can be observed [54, p. 34]. This limits the amount of possible stars to sixteen of which only nine stars can rise or set at latitudes typical to the British Isles. Given that alignments were established several millennia ago the effect of precession would have to be taken into account that can alter the declination of the rising and setting positions considerably [55]. But even if a date for the alignment was known, varying atmospheric conditions would alter the effect of refraction by several degrees; as well as transparency impacting on visibility [54, p. 36]. Therefore, using possible stellar alignments as a dating method is not trustworthy [1, p. 52]. It should be mentioned though, that stellar alignments can still be of interest when drawing a precise date from other methods. Then the use of certain stars can be included in the narrative describing the meaning of the monument.

Furthermore, a stellar narrative can be included in a belief system through its naked eye observation that does not require any alignments but expresses the general visibility of the star. Ptolemy described different visibility patterns of stars as star phases. A description by Brady [56] is outlined as follows: At our latitude the visibility of stars can initially be classified into three categories: the star is never visible, it is always above the horizon ie circumpolar, or its apparent movement across the sky includes rising and setting. However, Brady points out that the latter group of rising and setting stars can be further classified into two groups. The first group displays a long period of invisibility in the night sky typically weeks or months, which starts with its final setting just after sunset and ends with its first rising just before sunrise. The beginning of the long period of visibility is usually labelled as heliacal rise; Ptolemy called this star phase Arising and Laying Hidden (ALH, [57, p. 5]). A common misconception, as Brady continues, is that this is the only star phase possible for a rising and setting star, but as Ptolemy describes there is a second group that never has a long period of invisibility at night. Rather it will either be visible all night or set in the evening and rise in the morning of the same night. This star phase is labelled Curtailing Passage (CP, [57, p. 5—6]) and stars that show this behaviour lie in declinations between ALH and circumpolar stars. For a more detailed definition of this star phase see Brady [56, p. 79]. Brady point out that the CP has been overlooked and ignored starting with Ptolemy himself in his further work but also includes current researchers such as Ruggles [58] and others. One reason could be the difficulty and confusion arising from naming the different rising and setting possibilities for star phases. Brady [56] introduces a more systematic nomenclature and highlights in more detail the impact of overlooking CP star phases; she interprets Old Kingdom Pyramid texts as containing a narrative based upon star phases including ALH and CP. This is especially interesting since it adds a larger variety of naked eye stellar observations beyond the heliacal rising, classically exemplified in 'When the Pleiades (...) are rising, begin to harvest' from Hesiod's Works and Days [59], therefore offering the basis for a greater richness in a stellar narrative.

3. A developing field

Having now an overview of the basic concepts essential in understanding archaeoastronomy, the historic development of this field of research can be described. This will in some parts mirror previously mentioned developments in archaeology, but most importantly illustrate the large rift between the two disciplines of astronomy and archaeology that had to be to some extent overcome. A description of the first solution of this disciplinary divide will then be briefly outlined that has initially led archaeoastronomy to be termed modern. However some outstanding issues still remain unsolved and more recent attempts solving these issues will be introduced making this field (from the perspective of the author) modernised.

A detailed introduction to the development of what was to become archaeoastronomy can be found in Ruggles [1, pp. 3—10] and will be summarised here. Initially the subject of prehistoric astronomy was only touched upon by early British antiquarians that were amazed by the intricate structure of stone circles and their widespread distribution throughout the British Isles dating back as far as the beginning of the eighteenth century. Some of the key figures were William Stukeley first proposing a midsummer alignment at Stonehenge [60], John Wood postulating a lunar alignment at Stonehenge [61], and John Smith describing Stonehenge as having a complex astronomical layout [62]. All these statements were only loose descriptions without accurate measurements. This changed in 1906 with Sir Norman Lockyer when he published a book on his detailed survey of several megalithic sites proposing alignments with the Sun, Moon and several stars [63]. Archaeologist in general responded rather sparsely to these discoveries and if at all were not unsympathetic to the ideas of such alignments [64, 65, 66]. However, the upcoming problems were already apparent through Childe's critique of early works by Thom [67] in which he expressed doubts that primitive cultures could include complex astronomical knowledge given their 'primitive subsistence-farming'. Apart from hints that the general concept of prehistoric people at that time did not allow for such advanced skills to set up alignments, a further problem was appearing. Childe comments that archaeologists dealing with astronomical data and explanations of alignments felt intimidated by the mathematical formulism used [68]. Astronomers on the other hand seemed to ignore the framework upon which a social framework had been developed by archaeologists.

At this point the scene was set for the publication of a book that had wide reaching impact upon the field in general but also how it was perceived by the general public. It was the key trigger for more than twenty years of intense debate and still impacts the current perception of archaeoastronomy. In 1965 Gerald Hawkins published *Stonehenge decoded* [69]. This booked claimed to have solved all the mysteries of Stonehenge using the then rare and powerful help of computers to support the claims of solar and lunar alignments. Its impact was immense given its use of computer to link ancient monuments to space, at a time where the society was mesmerised by the race to the Moon. It also was published during a time when the 'alternative movement' emerged and archaeology with its strict scientific methodology had become dry and removed from the people it was analysing [70]. Stonehenge with its possible alignments as well as prehistoric astronomy became something the general public got involved in. This led to a need for archaeologist to respond. Richard Atkinson did so in a strong and passionate manner, condemning Hawkins work as arrogant and unconvincing [71].

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In general, responses from the archaeology community were rhetorical or nonexistent. The large public interest however required a more detailed debate and this opportunity was created by Glyn Daniel the editor of Antiquity, inviting both Atkinson and Fred Hoyle and hoping both would criticise Hawkin's work. However, Hoyle supported the findings of Hawkin and further developed the ideas using more complex mathematical methods [72, 73]. At this point it became clear that Stonehenge had become the focus of a clash between astronomy and archaeology clearly expressed by leading figures in these fields.

With the work by Thom [18] on megalithic sites in Britain, the focus swiftly moved away from Stonehenge and to general stone circles. Thom's work was different in that it used a large sample of monuments and removing the most common issue raised so far that one example of a theory does not prove its validity. But Thom's work only further strengthened the idea of ancient people being highly versed in geometry and using well developed units. This became even more problematic when Thom outlined the arcminute precision of lunar alignments [74] illustrating that ancient people had knowledge quite similar to seventeenth and eighteenth century astronomers. The statistical basis Thom placed his work on was seen as a strong argument by some that 'Thom's evidence that megalithic man observed the Moon is so strong that it may be accepted without hesitation' [75]. But the debate raging after Hawkin's book was published a decade earlier still showed that there was no real communication and constructive debate between astronomers and archaeologists. Hawkes argues that many archaeologists saw the idea of the megalithic people being adapt in astronomy and geometry as seeing your own reflection in the past [76].

Only in the mid seventies and early eighties did the rift slowly close. Researchers had noted that Heggie [75] had raised some points regarding accepting high precision alignments and international meetings were organised bringing together both British and American researchers discussing not only prehistoric astronomy but placing it into a worldwide context including pre-Columbian and indigenous American astronomy. At this time the term archaeoastronomy was coined. Both fields started constructively criticizing each other including researchers in their field. Most importantly anthropology was included in the interpretation developed by archaeoastronomy especially through what is known as 'brown' (american) archaeoastronomy for which ethnographic or ethnohistorical material exists. Only now after more than 20 years, collaboration and critical analysis started to join both fields and develop a rich interdisciplinary subject area. An area initially called archaeoastronomy saw aspects of ethnoastronomy and more inform its discipline that led it to be termed cultural astronomy by for example Ruggles and Saunders [12].

The resulting contemporary discipline of archaeoastronomy is marked through a substantial technological advance in equipment and a rigid use of archaeological fieldwork. It acquires and analyses digital landscape models to help assess local horizon profiles [77] or uses GPS equipment to survey sites and alignments. It is also based upon a very rigid foundation of statistics in which only large samples of similar monuments can yield the answer to the question: is a discovered alignment towards a certain azimuth or declination intended or not [1, p. 76]. Overall it includes the archaeological context of surveyed sites. In its attempt of interpretation it is also wary of making old mistakes again and finding our society reproduced in ancient people. Examples of such modern methodology based upon large samples are: The analysis of the recumbent stone circles of Scotland carried out by Ruggles [78], covering an area of 4,000 square kilometres and containing 100 surviving monuments of which 64 were included; as well as the survey of Hoskin [79] of over 1,500 Dolmens across the Mediterranean with subsamples in Iberia based on river basins or modern political provinces.

However, this archaeoastronomy has now reached a point at which prominent figures such as Ruggles are finding that it has still not managed to ground itself in a solid theoretical framework including testable hypothesis of interpretative anthropology. In short it seems to be 'running around the same circles' [80]. It appears to controversially only be useful as a service discipline for archaeology [1, p. 11] which is made easy since archaeoastronomy steps back from stating possible meanings of its findings; an understandable result given the previously outlined reactions caused by over interpreting findings. But, this frame of mind is unfortunately equally problematic since we again project our own prejudices and experiences into the past [1]. Including meaning and basing this explanation in anthropology was a call raised by Ruggles himself [81] years before. The need to include meaning has become far more prominent and complex now since aspects such as genetics and linguistics have illustrated that we have to seek the origins of beliefs of ancient European people in the Palaeolithic hunter-gatherers; and common sense interpretations usually including calendrical theory based upon the debatable idea of the Neolithic Revolution, as described previously, are insufficient. In many cases this contemporary archaeoastronomy has been a success in hunting for alignments only relying on the rational scientific machinery. An alignment, azimuth or declination is just a bare number that cannot express by itself what celestial object was the target and gives no indication of the narrative expressed by its instatement. It also still assumes levels of precision and of observation similar to a naked eye astronomer today, ignoring that experiencing, watching and anticipating are also key factors of engaging with the monument, landscape, and celestial bodies in the sky above. And most importantly this contemporary archaeoastronomy only accepts findings resulting from statistical analysis and drawn from sample, making the analysis of single monuments very difficult or impossible [77, 82].

The described challenges, a result of what humanists would understand as modern archaeoastronomy, can be overcome by truly modernising archaeoastronomy and have been outlined in Sims [11]: All theories relevant to prehistoric monument building cultures need reviewing to complete a thorough scientific process. Furthermore, initial research and its resulting debate in the wake of Hawkin’s work have to be included and discussed, for example lunar standstills and their meaning as debated by Heggie [83]. And finally, leading figures, allowing the rift in archaeoastronomy to be bridged and developing this modern discipline, have to support the inclusion of overlooked issues that should characterise a modernised archaeoastronomy and humanists might then understand as post-modern embracing the pluralism of today’s academic approach to landscape and ancient people. These should be not only theoretical issues allowing an engagement with the broader archaeological record, but also four key methods stated by Sims:

- (Land/Sky)-scape Phenomenology: This can be described as the experience of the land/sky-scape and how it engages with a viewer [84]. It is one approach to analysing land/sky-scapes and allows explaining the location of a site of archaeoastronomical relevance.

- Monte Carlo Simulations: In this context it is used as a statistical approach to draw at random possible positions for a monument of archaeoastronomical relevance within its local land/sky-scape. Thereby, it creates an artificial sample of possible monuments and enables an explanation of why a unique monument was located in such a way in its land/sky-scape [85]. It also can allow the calculation of the probability of a random alignment and compare them with actual alignments in the monument.

- Computer Modelling: Creating a fully three dimensional computer model of a monument, its landscape, and the sky above enables the researcher to test different hypothesis [86]. This approach includes for example the appearance of the monument and celestial bodies when approaching the monument using different paths. One might be reminded of the effect of approaching Stonehenge along the Avenue.

- Explaining Special Features: Singular unique monuments or monuments within initially similar groups might show detailed features. A possible hypothesis put forward to explain the meaning of a monument might not be able to incorporate this and will allow testing for an astronomical property [1, 87, 88].

Tying all these approaches together and presenting a new way forward to break out of running around in circles is proposed by Silva [77] who has called for a Skyscape Archaeology. This approach is a reaction upon the challenges archaeoastronomy still faces and acknowledges, as Brown outlines, the importance of meaning and including the entire monument, landscape, and sky together with the viewer into an overall skyscape experience [82].

Over half a century archaeoastronomy has come a long way and has defined a field that is interdisciplinary in nature. It has become a modern discipline through embracing modern technological advances and to a certain extent advancing its theoretical standpoint. However, recent researchers are now shaping an archaeoastronomy that has become modernised from its basic roots of theoretical grounding up to its applications in archaeological fieldwork. It therefore realises phenomenology and other approaches typical to the pluralism of today's academic engagement with landscape and ancient people, shifting it towards what humanists would define as post-modern. As a scientist the author feels that at this stage archaeoastronomy has become fully modernised.

4. Conclusions

While introducing the notion of a modernised archaeoastronomy, the author has given some attempts at outlining what the term archaeoastronomy means, including its description as cultural astronomy and skyscape archaeology. The different names for this field derived from the realisation of the multiple disciplines and methodologies included. Stonehenge was used as a blueprint towards understanding archaeoastronomy and highlighting some of the challenges the discipline has faced in its past and is still struggling with, mentioning for example that alignments are by themselves meaningless pointers towards an abstract declination and need to be filled with astronomical meaning. To develop a better understanding of the historic developments in this field and its problems, a set of key concepts were introduced covering aspects of archaeology, anthropology and astronomy, followed by an overview of the development archaeoastronomy has undergone. The emphasis was placed on the rift between archaeology (a humanist discipline) and astronomy (a science discipline) that then led on to being bridged but only to a certain extent. It is argued, that to create a discipline that has its own identity and does not function as a pure service discipline, it should include the interpretation of meaning into its remit. Having been burnt through the past experience of over interpreting alignments and astronomical motivated features, archaeoastronomy has shied away from this challenge. As an initially modern discipline it has focused more upon alignment hunting and establishing a strict statistical approach with sometimes debatable sample composition. Sims [11] and Silva [77] have offered a promising new approach described by the author as truly modernising archaeoastronomy. It includes not only testable theories originating from interpretive anthropology and a solution to the unique monument problem, but also aspects of phenomenology and experiencing skyscape.

Several Authors such as Brown, Armstrong, Pritchard and others have also successfully included these methods and approaches into their archaeoastronomical research [89]. Additionally recent national and international meetings of archaeologists have included contributions and sessions illustrating the opportunities of this new approach to archaeoastronomy. Its appeal has not only led to the publication of *Skyscapes: The Role and Importance of the Sky in Archaeology* [16] and the establishment of the *Journal of Skyscape Archaeology* [90], both dedicated to skyscape archaeology. It also led to the inclusion of a special session dedicated to archaeoastronomy at the National Astronomy Meeting 2014 of the Royal Astronomical Society with several contributions contained in this volume.

Overall these responses exemplify the scientific validity and success that this truly modernised archaeoastronomy has achieved.

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