SEAC XXXII Annual Meeting

Volos, Greece, 4–8 September 2026

Book of Abstracts

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Cover Photo:
Skyscape over the ancient theatre of Stratos, Akarnania. © 2026: Constantine Tassolampros

SEAC XXXIII ANNUAL MEETING

Star Lore in the Land of the Centaurs

Book of Abstracts

Volos, 4–8 September 2026

Edited by
Ilaria CRISTOFARO & Themis G. DALLAS

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THE CONCEPT OF TIME IN ANCIENT PERSIA

Hodar ATAOLLAHI

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Ancient Persia, Achaemenid Empire, Zoroastrian Calendar, Seven planets, Eschatology

The concept of time is often treated as a universal, natural given. However, this paper argues that structured, measurable, morally charged, and eschatologically oriented time was a specific cultural achievement of ancient Persia (Achaemenid, Parthian, and Sasanian periods, *ca.* 550 BCE – 651 CE). While neighbouring civilisations such as Egypt and Babylon developed sophisticated techniques for measuring time (solar calendars, lunar months, astral divination), none produced an integrated system that unified astronomy, agriculture, social hierarchy, mythology, and the end of history into a single temporal framework. The Persians were the first to achieve this synthesis, creating a concept of time that still shapes the modern global calendar, the seven-day week, and the eschatological structures of Judaism, Christianity, and Islam.

This research combines philological analysis of primary sources with comparative historical and archaeoastronomical methods. The primary corpus includes *Avestan Yashts* (hymns to celestial deities such as Mithra, Tishtrya, Anahita, and Verethragna), Achaemenid royal inscriptions (Bisotun, Persepolis), Elamite administrative tablets from the Persepolis Fortification archives, Babylonian astronomical diaries from the Achaemenid period, and Middle Persian cosmologies (*Bundahišn*, *Dēnkard*, *Mēnōg ī Xrad*). Archaeoastronomical calculations are used to correlate conjunctions. The research also examines material culture, including Achaemenid seal impressions, Sasanian rock reliefs (Taq-e Bostan), and the Luristan bronze bowl (8th c. BCE). The yields five major findings.

First, the solar calendar: The Achaemenid Persians developed a fully computed solar calendar (12 months of 30 days plus 5 epagomenal days) independently of Egypt, as evidenced by the Bisotun inscription and Persepolis Fortification tablets.

Second, the four seasons as structural template: Unlike Egypt (three seasons) or Mesopotamia (two seasons), the Persians organised the year into four symmetrical seasons (spring, summer, autumn, winter). This fourfold division was not merely agricultural, but was structurally isomorphic with: (a) the four Zoroastrian cosmic eras of 3,000 years each (totalling 12,000 years of world history); (b) the four social classes (farmers, warriors, priests, artisans); (c) the four zodiacal triads (fire/spring, earth/summer, air/autumn, water/winter); and (d) the four major Persian festivals (Nowruz, Maidyoshahem, Ayathrima, Maidyarem).

Third, the seven-day week: With each day named after a planet, was first systematically named after Avestan deities in Persia (Mithra/Sun, Mah/Moon, Tishtrya/Mercury, Anahita/Venus, Verethragna/Mars, Ohrmazd/Jupiter, Zurvan/Saturn), not in Babylon. The week was adopted in Mesopotamia only during the Achaemenid period.

Fourth, eschatological time: The 12,000-year Zoroastrian history of the world was deliberately modeled on the 12-month solar year divided into four seasons. Each of the four cosmic eras (creation, mixture, heroic age, renovation) corresponds to a season, making the annual ritual calendar a microcosmic reenactment of the entire history of the universe.

Fifth, individual time: The earliest known reference to celebrating birthdays comes from Herodotus's description of Persian customs, confirming that the Persians were the first to ritualise individual time within the larger framework of cosmic and seasonal time.

Concluding, the Persian concept of time was unique among ancient civilisations. It transformed time from a passive background of human activity into an active, morally charged, and perfectly structured force. The four-season framework was the linchpin of this system, connecting the farmer's plow to the king's throne, the rising of the sun to the final renovation of the universe. This Persian synthesis directly influenced Islamic calendars (Biruni, the Jalali calendar of Omar Khayyam), and the global standardisation of hours, weeks, and years. Recognising the Persian origin of structured, eschatological, and morally charged time is essential for any global history of the concept of time.

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SHIELD OF HERACLES: A POEM, A TEMPLE AND A CELESTIAL BATTLE

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Apollo Pagasaeus, Cycnos, Heracles, Shield of Heracles

In this paper, data from the poem *Shield of Heracles* will be analysed and compared with geodetic data, directions and features of the ritual landscape, as seen from the archaic temple of Apollo south of today’s Volos.

The poem has been attributed to Hesiod (7th c. BCE) since ancient times although it is not certain that he is its author. The events described in the poem are: Cycnos (“Swan”), the son of Ares, offended Apollo Pagasaeus. The god calls on Heracles to punish Cycnos. Heracles arrives to Pagasae together with Jolaius, his nephew and his coachman. Athena warns Heracles to focus his attention on Ares’ anger after killing his son. Soon after, she warns Ares that he will not succeed in killing Heracles “for it is not ordained...” A fight ensues in summer (after the morning rise of Sirius); Heracles kills Cycnos and is attacked by Ares. Athena turns Ares’ spear aside, and he fails to hurt Heracles but is wounded himself. Wounded Ares goes back to Olympus; Cycnos is dead and buried by Ceyx, his father-in-law.

All the actors in the poem can be understood as divine personifications of celestial objects. Apollo is clearly the divine personification of the Sun. Cyknos (“Swan”) could personify the eponymous constellation; Heracles could be the personified constellation Hercules, Iolaus would be the personified constellation Boötes. It is certain that Hesiod knew when the star Sirius rose heliacally, and he also knew when Arcturus (α Boötis) rose, because he clearly stated this in his work *Works and Days*. These constellations were described by Eudoxus of Cnidus (4th c. BCE) and Aratus of Soli (3rd c. BCE). Astronomical knowledge is not acquired easily and quickly, so it is very likely that these constellations were known in the 6th c. BCE, when the temple of Apollo was built.

The temple was archaeologically investigated between 2004 and 2008. The research was led by Alexandros Mazarakis-Ainian. The main building was dated to the 6th c. BCE, that is, in the period of Archaic Greece, that it was (probably) roofless (hypaethral), and that ritual feasts were held there. To the northeast of the temple, there is a conical hill, the top of which is the highest point on the horizon, while the axis of the temple is oriented in the east-southeast direction. Mazarakis-Ainian is sure that the temple was dedicated to Apollo, but there is a lack of archaeological evidence that it was the temple of Apollo Pagasaeus mentioned in the poem *Shield of Heracles*.

A preliminary archaeoastronomical analysis was carried out in 2020 (BAJIĆ & DIMITRIJEVIĆ 2020, 159–175). Geographical and geodetic data from Google Earth were combined with animations from Stellarium 19.1 to check astronomical events. By the end of August or the beginning of September 2026, a solar-referenced geodetic survey is planned at the site. The direction of the longitudinal axis of the temple will be examined, as well as the direction towards the top of the conical hill (the sacred grove?). According to previous research, in the direction of the longitudinal axis of the temple in the 6th c. BCE, one could observe the rising of the star Sirius on the natural horizon, while the rising of the star Deneb (α Cygni, the “tail” of the Swan), as well as the rising of the star Vega (α Lyrae) could be observed in the direction of the top of the conical hill. In the early evening hours, at the end of July and beginning of August (after the heliacal rising of Sirius), Lyra could be seen at the zenith during the evening twilight, while the constellation Hercules was immediately to the west and the constellation Cygnus to the east (“the celestial battle”).

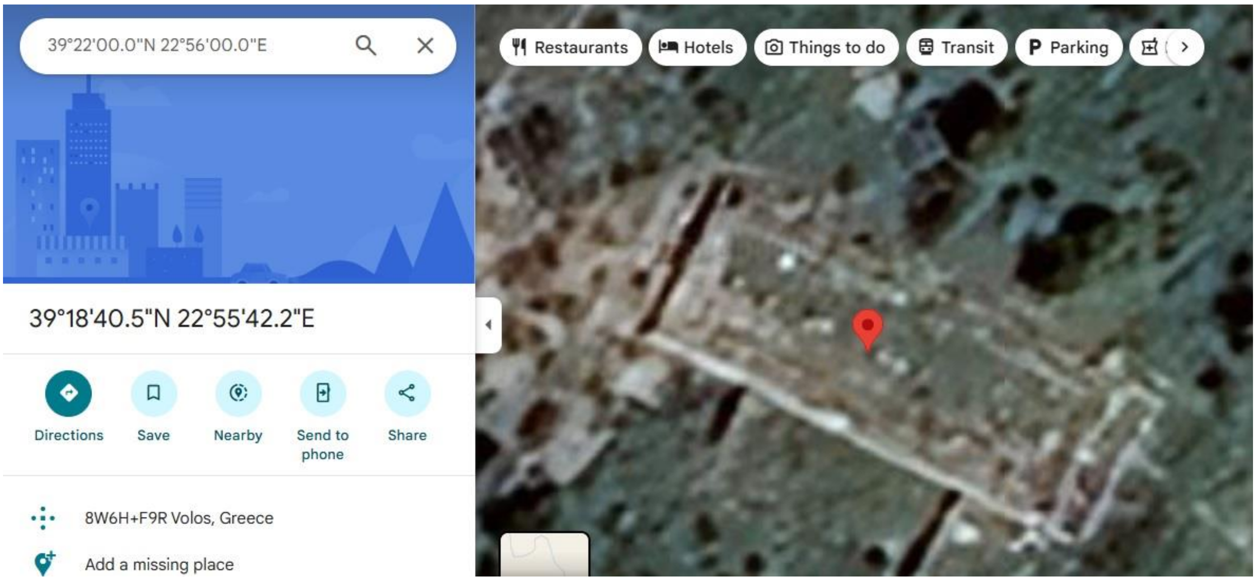

FIGURE 1. The Temple of Apollo to the south of Volos (Google Maps)

The timelines given in the poem are in excellent correlation with the sequence of astronomical events that could be observed from the site. This would mean that the archaic Temple of Apollo south of present-day Volos could be the very same temple mentioned in the *Shield of Heracles* poem.

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The First Stratospheric Ascension Project of the Southern Hemisphere (1938) and the Scientists' Questions

J .Nicolás Balbi

Museum of the Cosmic Physics Observatory of San Miguel, Argentina

Stratospheric Ascension, Astronomical Heritage, Restoration

The scientific steps to achieve space exploration presented a series of doubts, questions that today seem both trivial and complex. The pattern of questions that scientists of the last century asked themselves regarding the physical possibility of a human being leaving the surface and venturing into the atmosphere is similar to those we continue to ask ourselves regarding future special projects in environments to which humans cannot adapt. In addition, the construction materials, and the design of the experiments that would be done during the ascent, have a pattern; calculations of weight, resistance of the materials and convenience of use.

By 1938, stratospheric ascents had been attempted in the United States, Russia, Poland and Belgium, with the North American and Belgian attempts being successful, the latter under the command of Professor Auguste Piccard, who in 1932 had ascended to 16,201 meters, although his instruments were damaged, which only allowed the scientist to experience an extreme ascent. The North American fly one came later (Paolantonio 2015).

It was Piccard, at that time a pioneer in the subject, who due to the European conditions in the 1930s, had no possibility of making a new flight, and who was tempted by the Jesuit Father Ignacio Puig, Director of the San Miguel Cosmic Physics Observatory in Argentina to move to the southern hemisphere, make a new ascent, and finally be able to collect data that he could not in 1932, using his previous experience in the ascent. The flight was to be carried out by Eduardo Olivero as pilot, an Argentine air ace who had fought in World War I for Italy (Castelnuovo 1988), and Auguste Piccard, scheduling the flight for 1938–1939, although the start of World War II prevented the experiment from being carried out. The details of the ascension can be partially completed from reports mainly in newspapers and scientific magazines around 1940 (Bulletin AAAA 1940), when the experiment had been officially cancelled.

Figure 1. Restoration process of documents at San Miguel Observatory Museum.

One of the tasks related to Cultural Astronomy carried out by the Restoration Office of the San Miguel Observatory Museum is precisely the obtaining of new information from restored documents that were considered lost and that is the case of what we call the “Puig-Olivero Report” (OLIVERO ca.1938); made around 1938, printed on paper similar to that of a newspaper, eight pages long, containing all the information about the project and mainly the questions that scientists were asking themselves at the beginning of the century about the atmosphere and the chances of survival of a human being on a flight at such altitudes. The unique document, found in very poor condition, was completely restored and transcribed, and the study of its content is the basis of the present research.

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THE THEORY OF CELESTIAL IMBALANCE: ON THE QUESTION OF THE RELATIONSHIP BETWEEN THE PLEIADES AND THE BIG DIPPER IN THE MYTHOLOGY OF EURASIAN STEPPE

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Pleiades, Ursa Major, mythology, Central Asia, missing star, cultural astronomy

The constellations of the Pleiades and Ursa Major played an important role in the traditional calendar, navigation, and mythology systems of the peoples of Eurasia. Of particular importance is the stable set of plots that connect the two asterisms: the abduction a star from the Pleiades, the heavenly marriage, the eternal chase, or the conflict between the celestial groups. These plots are recorded on a vast territory from the Altai and Central Asia to the Caucasus.

Despite the variety of interpretations, their structural similarities point to a common observational basis. The present study explains this phenomenon through the concept of "celestial imbalance", which reflects the cognitive response of traditional society to the difference in the number of visible stars in the Pleiades and Ursa Major.

The methodological basis of the research is the principles of comparative mythology, ethno-astronomy, and structural anthropology. A comparative analysis of folklore and ethnographic data from the Turkic-Mongolian peoples of Central Asia and Southern Siberia, as well as from India, is used. Conceptually, the study is based on the ideas of structural analysis of myth, which holds that mythological systems are formed as ways to resolve cognitive contradictions between observed reality and cultural expectations.

Astronomical basis of mythologem: In popular beliefs, the Pleiades are almost universally perceived as a group of seven stars. However, only six bright components are usually visible to the naked eye. This creates the feeling of losing one star. In contrast, in the Big Dipper, the faint star Alcor, next to the bright star Mizar, is visible, giving the impression of an additional element. Thus, the observed asymmetry arises. Pleiades as incomplete seven (six instead of seven); Ursa Major is a seven with an additional companion. This discrepancy underlies the cognitive strain requiring explanation.

Mythological Interpretation of Celestial Imbalance: In the Turkic-Mongolian tradition, asymmetry is interpreted through the scene of the abduction of Urker's daughter (Pleiades) by the Seven Heroes (Big Dipper). The movement of asterisms in the sky is understood as a cosmic chase. In the Altai versions, the motif can be transformed into matchmaking, but the structural basis remains the same: the star's transition from one group to another.

A similar pattern is found in other cultures. In the Indian tradition, the weak star Alcor is interpreted as the wife of the sage Vasishtha, Arundhati. In all cases, a single structural model is reproduced: a seven and an additional element.

Social Symbolism and Cosmic Kinship: A feature of the myths under consideration is the interpretation of an astronomical phenomenon in terms of social and domestic relations. The star becomes a servant, a bride, or a wife. Mostly, the star's transition is legitimized through marriage, which symbolically restores the disturbed cosmic balance. Such a projection of social models on the cosmos is characteristic of traditional societies and reflects the relationship between social organization and cosmological thinking.

The Eurasian Archetype of the Celestial Seven: A comparative analysis allows us to identify the ancient Eurasian archetype of the “heavenly seven”, the cultural transformations of which are manifested as follows:

- The Turkic peoples are the seven bogatyrs or khans;
- The Indian tradition is the seven rishis;
- The seven deities or elders of Buddhist Central Asia.

The differences arise from the cultural adaptation of a single structural model to the social and religious systems of different societies.

TABLE 1. Perception of the Seven Stars and redistribution of members.

Tradition	Big Dipper	The Pleiades	Optional Element (Alcor)
Turks	Seven heroes	Seven stars; sisters; Ulker’s daughter	Stolen Star / Ulpuldek, Altyn solona / cook
Mongols	Seven elders	Seven stars; sisters; Ulker’s daughter; seven boys	Stolen Star / Ulker's daughter / cook / Clever Boy
Indians	The Seven Rishis	Former wives of six rishis	Remaining star / Arundhati

The proposed theory of celestial imbalance shows that mythology can be considered a cognitive mechanism for interpreting astronomical observations. The discrepancy between the expected and observed number of stars necessitates an explanation, which is provided through social and cosmological categories. Thus, myth acts as an instrument for the logical reconstruction of the cosmos, translating astronomical observation into an understandable cultural form.

To conclude, the relationship between the myths of the Pleiades and the Big Dipper is based on the observed asymmetry in the number of visible stars. The inferiority of the Pleiades and the redundancy of the Big Dipper form a cognitive contradiction that is resolved by mythological plots. The star’s transition is interpreted in terms of theft and marriage, reflecting the social symbolism of traditional societies. The mythologem under consideration represents the cultural transformation of the ancient Eurasian archetype of the heavenly seven. The theory of celestial imbalance helps explain the stability and widespread presence of these plots in Eurasian mythology.

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USING A LEAST SQUARES *ΔT* MODEL TO REFINE THE CHRONOLOGY OF THE AMARNA PERIOD

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Amarna, Eclipse, ΔT, Conjunction, Akhenaten

Identification of radical, sudden departure from conventional Egyptian New Kingdom temple iconography —in combination with observations of monarchal, sociological, and / or theological deviations from traditional behaviour— suggests a recurring pattern of royal responses consistent with the cultural salience expected of total solar eclipses, which are used here as selection criteria for candidate anchors. Under this assumption, a pattern of behavior suitable for constructing an approximate model of Earth's rotation for the period 1523–709 BCE materializes.

Applying the method of least squares to the parameter $\Delta T(i)$ required for totality at site (j) for given, known-dated eclipse (k) yields an overall expression for $\Delta T(x)$. Using these criteria, an anchor set of fifteen (15) total solar eclipses is identified. The resulting expression of $\Delta T(x)$ achieves an RMSE of 21.9 seconds with random error distribution and smooth curvature.

Thus derived, the cubic model $\Delta T(x)$ allows useful prediction of umbral paths for all global eclipses over the defined temporal span. An example application places a total solar eclipse over the Shang capital of Zhengzhou on 14 June 1330 BCE, temporally consistent with archaeological evidence for site disruption dated from human remains (FENG *&al*. 2022).

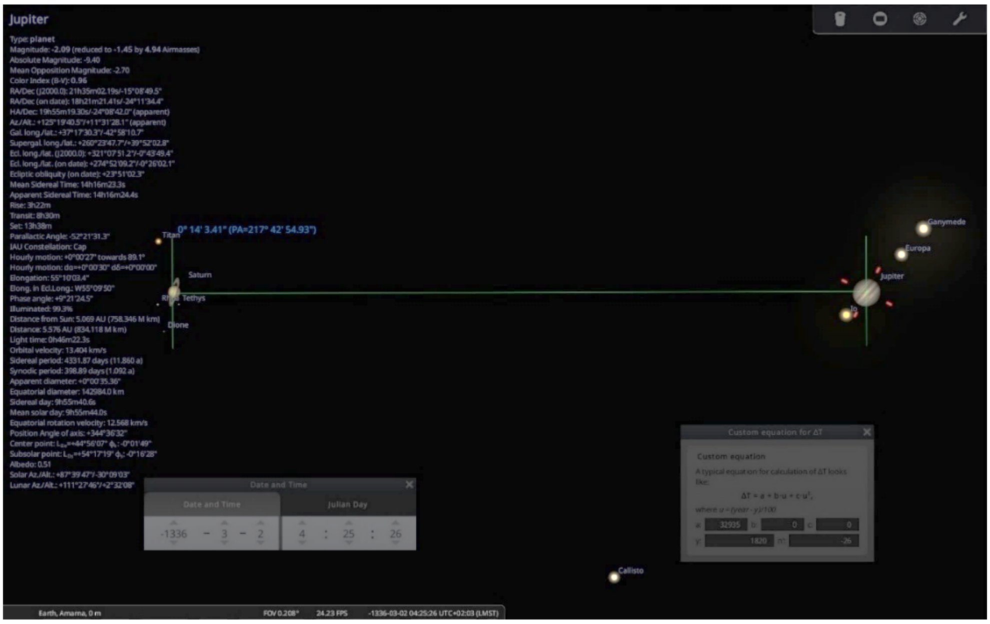

FIGURE 1. Morning sky at future site of Akhetaten, 2 March 1337 BCE = IV Peret 13, Year 5.

Application of the model to the Egyptian New Kingdom establishes a relationship between pharaonic actions and known eclipse dates. When considered holistically, a logical series of these associations leads to refined dates for the Amarna Period. Critically, the dates so determined do not conflict with lunar month requirements established for the reigns of Tuthmosis III or Ramesses II. Support for the model and its related methodology stems from the appearance of two chronologically linked planetary conjunctions: (1) a "Great Conjunction" of Jupiter and Saturn with separation 14″ of arc on the derived date of Akhenaten's "Early Proclamation"; and (2) a locally-predicted conjunction of Venus and Mars with separation 2.34° on the subsequent date of

Akhenaten's Durbar celebration. The first of these conjunctions is shown as FIGURE 1. Importantly, these planetary configurations result from model prediction rather than serving as input or boundary constraints.

The sky depicted by FIGURE 1 precedes the subsequent sunrise by approximately 2½ hours. That sunrise, dated here to 2–3 March 1337 BCE, occurs with azimuth 103.4° as solar elevation achieves ~1°, consistent with the alignment of the Amarna temples and the formation of the akhet-like horizon profile within the eastern cliffs. The subsequent conjunction of 26 and 27 December 1331 BCE follows from logical flow of the Egyptian calendar from Year 5, IV Peret 13 to Year 12, II Peret 8 (as given by TA1 and TA2). The predictive nature of the Durbar conjunction is further supported by an ultra-tight conjunction of the same two planets 714 days earlier (12 January 1332 BCE).

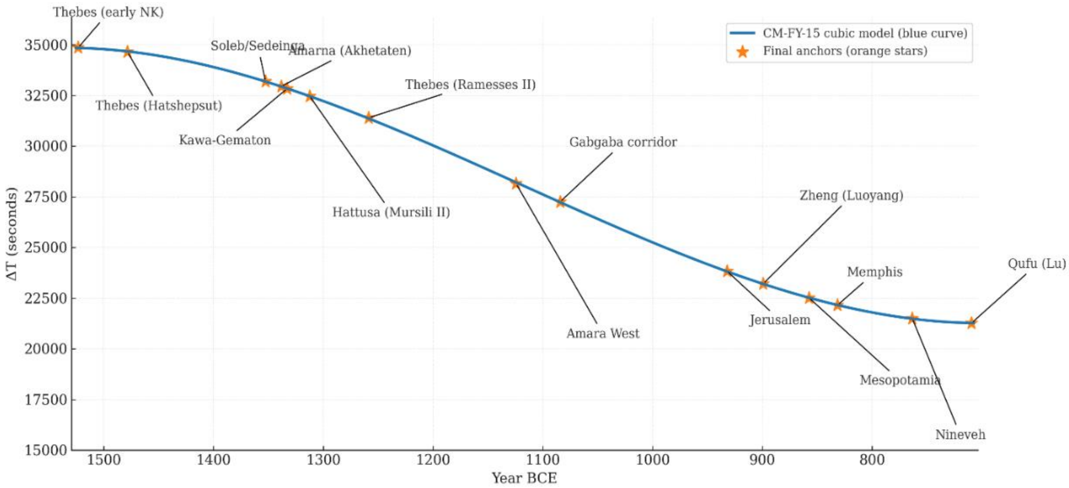

FIGURE 2. Anchor locations and response curve $\Delta T(x)$.

The underlying model $\Delta T(x)$ is presented, including statistical diagnostics and robustness tests, with review of the full set of (15) eclipse-anchors and brief comment on their individual justifications. The logical pathway pursued to the dates 2–3 March 1337 BCE and 26–27 December 1331 BCE is discussed, with the conclusion demonstrating the viability of total solar eclipses as quantitative constraints for refining Late Bronze Age chronology. Additionally, brief comment on the "Zannanza Affair" will be offered in view of derived dates for Akhenaten and the subsequent eclipse of Mursili II, dated here to 24 June 1312 BCE.

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CONCEPTUAL DEVELOPMENTS IN SKYSCAPE ARCHAEOLOGY IN SACRIFICIAL FESTIVAL CONTEXTS: THE SEASONALITY-TEST

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Archaeoastronomy, Skyscape Archaeology, Methodology

The discipline of Archaeoastronomy, redefined as Skyscape Archaeology and developed from Orientation Studies, has suffered much criticism and bad reputation within the Academic world during the course of its development. Some scholars still regard it as a belief more than a science. Liz HENTY has well analysed this phenomenon in connection with esotericism and pagan beliefs emerging from popular imagination. On the other hand, the discipline was shaped during the 19th and 20th c. by distinguished academics and scholars: astronomers such as Norman LOCKYER (1836–1920) (first editor of *Nature*); archaeologists such as Émile-Luis BURNOUF (1821–1907) who was Director of *l'École française d'Athènes* at the time; or the historian of architecture William BELL DINSMOOR (1886–1973) —just to mention some of those focusing on the ancient Mediterranean world. The major criticism is that celestial alignments cannot be proved, casting doubt on the discipline's whole credibility.

FIGURE 1. Conceptual reasoning for the integration of seasonality evidence in skyscape archaeology in ritual festive context.

This contribution aims to be an insight and understanding on the level of conceptual theoretical thinking on the potential advancement of skyscape archaeology. How shall we approach the discipline to advance its frontier knowledge? What do we need to know? What needs to be done? What insights do we need to have to enable the research community to move forwards? A critical review on the state of the art seems necessary to build the foundations of this reflection for shaping guiding principles and future developments, with a special focus on the context of Classical antiquity. To enhance its credibility, the emerging research paths of skyscape archaeology may need to cross the boundaries of disciplines on the level of knowledge or methodology. By combining approaches from different disciplines, we may able to potentially resolve the important scientific challenges of the discipline, as those highlighted by HENTY. One of the main challenges remains to prove the intentionality of the builders towards a precise astral event. Following SCHAEFER's proposal on a 4-criteria procedure on "proofs of intentionality" and POLCARO' 6-tests procedure for "credibility", it is here suggested to add another type of "test" which can be used to support astral alignments of cultic places. Apart from fortunate cases study where epigraphical, literary, or iconographical data may provide additional evidence, but which are again subjected to interpretation and circular thinking, the power of this evidence is given by the fact that it comes from the "hard sciences", specifically from natural sciences. Therefore, it is less subject to biases and cognitive distortions that may happen when a researcher is completely engaged in a research process. Being an "outsider" or "independent" proof, it may help to validate —or not— the skyscape identification of a monument. However, in order to apply such test, it is first necessary to implement a paradigm shift, turning the question from spatial coordinates to annual time and seasonality. In this sense, it is necessary to consider "timing" as the main decisional factor of an orientation, so that statistics might be also performed on that category, not only on azimuth or declination. The additional proof proposed here is provided by Seasonality Studies and Zoo-archaeology and it is based on the season of sacrifices, mainly animals' sacrifices. This type of ritual was one of the most characteristic features of the religious experience in the ancient Hellenic and Roman world. The ritual of burnt animal sacrifice, called θυσία, involved the ceremonial slaughter of a domestic or wild animal with the ritual burning of the god's portion in the altar fire and a communal meal at which most of the meat was eaten by human worshippers. For cultic spaces, sanctuaries, and temples, celebrations and sacrifices might have happened at season-specific moments, for instance during festivals. The remnant of such ritual can be analysed for determining the season of the celebration, especially when a recurrent sacrifice was performed many times over years. Bones, teeth, oxygen isotopes analysis can give a good estimation of the age of animals at its seasonal sacrifice, setting the timing of frequentation of the cultic monuments and thus providing a reliable comparison test for astral alignments.

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THE ORIENTATION OF THE THOLOS TOMBS IN DIMINI

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Dimini, Tholos Tombs, Mycenaean Civilization, Late Helladic Period

Dimini is a village and a famous archaeological site near Volos, which is believed to be ancient Iolkos. Two Mycenaean tholos tombs are located in Dimini: Lamiospito dating in the 14th c. BCE and excavated in 1896 (MCS 2012a), as well as Toumba dating in the 13th c. BCE and excavated in 1901 (MCS 2012b).

Orientations to important solar days have been found in seven elite Mycenean tholoi (DAVIS *&al*. 2017). However, this is not a general trend (MARAVELIA 2002) and the explanation is usually the response to practical considerations, especially the local topography (natural or artificial). After his visits in the archaeological site, the third author hypothesized that Toumba is oriented to the summer solstice sunset; more recently, the first author calculated that Lamiospito might be oriented to the northern major moonrise. However, visits to the location on astronomically relevant days, showed that the orientation in both cases was close, but not accurate.

This study uses D-GPS measurements in combination with 3D scanning to recreate with accuracy the alignments during the epoch that the tholoi were build. This will enable us to check if the ancient masons aimed for some kind of light effects (REIJS 2009), and not for an actual alignment to the moonrise or sunset.

FIGURE 1. Summer solstice sunset from "Toumba".

FIGURE 2. Northern maximum moonrise from "Lamiospito".

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DESCRIPTION AND ILLUSTRATION OF SOLAR AND LUNAR ECLIPSES IN MEDIEVAL AND RENAISSANCE TIMES

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Solar and lunar eclipses, medieval, history of astronomy

Descriptions and analyses of solar and lunar eclipses in the Middle Ages and the Renaissance reflect a complex interplay of traditional classical astronomy, theological interpretations, and increasingly sophisticated mathematical models. Throughout these centuries, explanations of eclipses gradually shifted from symbolic or moralising frameworks toward approaches based on observational and predictive scientific astronomy.

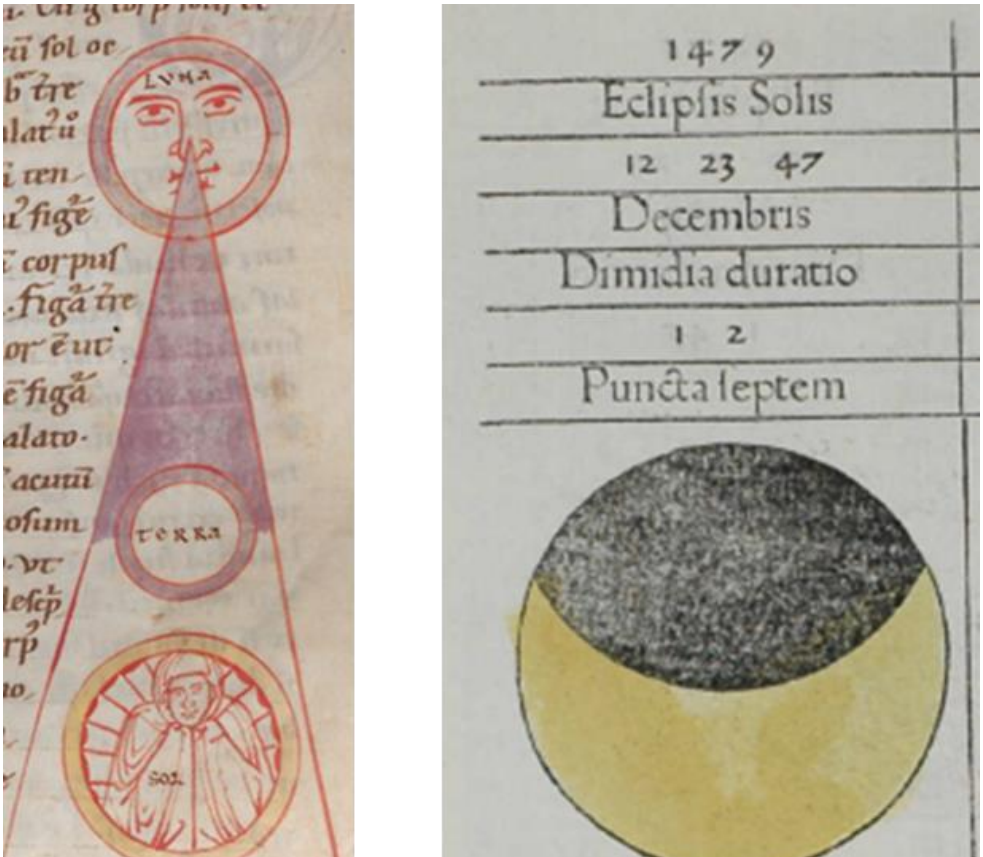

FIGURE 1. Eclipse drawings: (a) Vienna ÖNB, Cod. 507, Reiner Musterbuch, 1208 – 1213, (b) Regiomontanus, Kalendarium 1476, Univ. Library Vienna

In the Middle Ages, celestial events such as solar and lunar eclipses were regarded not merely as natural phenomena but as significant omens with potential implications for political authority, military conflict, famine, and other major social developments. Before 1200, descriptions of eclipses in Latin Europe emerged primarily from three intellectual contexts: monastic chronicles, computistic literature, and scientific treatises based on late antique sources. Compared with the later scholastic period, early medieval treatments were less mathematical and more closely linked to theology and calendrical calculations.

Early medieval knowledge relied heavily on Roman authors such as Pliny the Elder, Macrobius, and Isidore of Seville, who transmitted simplified versions of Greek astronomical concepts. Their explanations were typically qualitative rather than quantitative. The most influential scientific framework for understanding eclipses in early medieval Europe was computus, the discipline concerned with determining the date of Easter. In *De temporum ratione*, Bede discusses eclipses within the context of broader celestial cycles and explicitly points out that eclipses do not occur every month, as the Moon's orbit is inclined relative to the apparent path of the Sun. This demonstrates that key elements of Ptolemaic geometry were known, even though in a simplified form.

Historical chronicles represent another important source for medieval accounts of eclipses. These texts tend to record celestial events on the basis of their apparent significance rather than their physical causes. Eclipses were often described as divine warnings, precursors of political instability, or omens announcing battles or the deaths of rulers, with little emphasis on astronomical explanations.

Before the 12th c. translation movement, the accurate prediction of eclipses in Latin Europe was extremely difficult. Key obstacles included the lack of precise astronomical tables and the fragmentary or incomplete transmission of Ptolemy's *Almagest*. More advanced prediction techniques only found their way into Western Europe following the adoption of Arabic astronomical texts.

The Renaissance brought significant changes in visualization techniques, the availability of printed materials, and the mathematical precision of astronomical practice. Astronomers began to compile ephemerides and systematic predictions of solar eclipses. Figures such as Regiomontanus used improved planetary tables to calculate eclipses with greater accuracy, and these tools were used by both scholars and astrologers. This period thus marks a decisive transition toward a more empirical and mathematically grounded understanding of eclipses.

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NEW TOOLS FOR STANDARD AND GIS-BASED ARCHAEOASTRONOMICAL ANALYSIS

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Archaeoastronomy, GIS, Python

Archaeoastronomy has benefited in recent years from the development of digital tools that help with the interpretation of orientation patterns. Among these, skyscapeR (still available through GitHub; SILVA 2022) has become a key reference for researchers. However, it is designed for researchers already familiar with R, and it assumes a level of programming expertise that many archaeologists, heritage professionals, and students do not possess. There are also other utilities such as Clive Ruggles's online declination calculator (RUGGLES, n.d.) or HeyWhatsThat (KOSOWSKY 2013) for horizon profiles, which address one part of the problem and therefore they require users to manually combine outputs across the platforms. For individual cases, Stellarium is the most accurate one, helping to interpret many of the sites through the reconstruction of the sky in a given time and location (ZOTTI *&al*. 2021).

We thus present an open-source toolkit for archaeoastronomical analysis. Following the example of SkyscapeR, the core Python package 'astrocult' performs the basic transformation from azimuth, altitude, and latitude to declination, the associated uncertainties and generates different types of diagrams for identifying and visualising orientation patterns. It is installable via PIP from https://test.pypi.org/project/astrocult/. This is currently being implemented in a web interface to make it user friendly (FIGURE 1) for researchers unfamiliar with Python programming. The interface currently allows users to input a list of declinations or azimuths for specific latitudes and generate density plots for statistical analysis.

A complementary QGIS plugin (FIGURE 2) integrates these capabilities directly into an open-source GIS environment. Users can select archaeological features and automatically compute azimuths, declinations, and retrieve horizon profiles either by querying HeyWhatsThat or by using local SRTM data. The plugin also suggests potential solar, lunar, or stellar targets and produces plots to support interpretative analysis. The plugin will be available after testing on the QGIS repository for installation.

For large-scale surveys the toolkit includes an optional, currently experimental, machine-learning pipeline capable of detecting objects (prior labeling) in aerial imagery and estimating their principal axes. These orientations are then passed to the analysis module for plotting the diagrams. The entire pipeline is fully automated from object detection to diagram plotting. A web UI also enables users to train their own machine-learning models for specific objects.

Some limitations should be noted. The accuracy of horizon profiles depends on the resolution and quality of the underlying elevation data and imagery, and astronomical interpretations remain sensitive to contextual factors. The machine-learning component, in particular, requires further validation before it can be reliably applied across different landscapes.

The Python library plus web interface and the QGIS plugin aim to support a broader community who might require userfriendly solutions. We invite researchers from different backgrounds to test the tools, report issues, and suggest new features so the toolkit can continue evolving with the needs of the community.

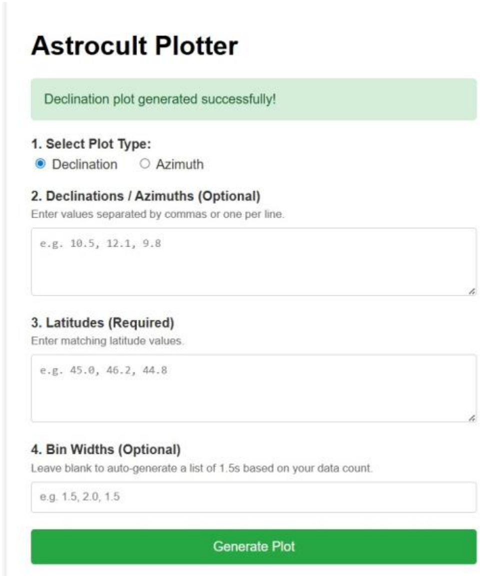

FIGURE 1. The Astrocult web UI.

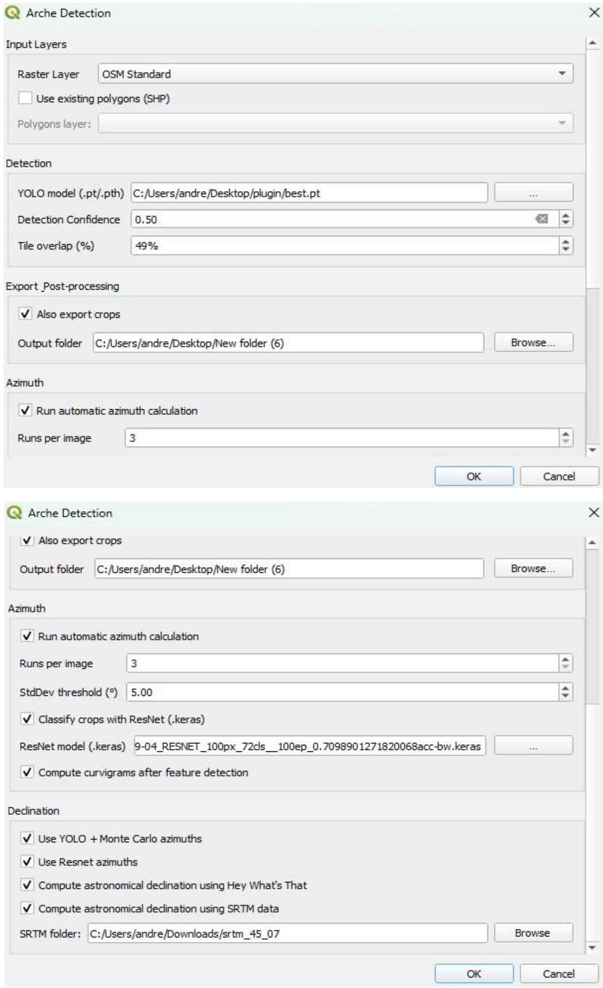

FIGURE 2. Example of the QGIS plugin, where the user can select several options for the analysis.

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ARCHAEOASTRONOMY IN THE BOLIVIAN HIGHLANDS: A PRELIMINARY ANALYSIS OF THE ORIENTATION OF THE FUNERARY TOWERS OF TAMA CHULLPA, CULLI CULLI

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Funerary tower orientation, Archaeoastronomy, Aymara culture

This paper analyzes the orientation of a compact group of *chullpa* funerary towers built mainly between the 13th and 16th centuries and located in the present-day Culli Culli region of the Department of La Paz, in the central Bolivian highlands (KESSELI & PÄRSSINEN 2005). Despite their great cultic relevance and the main role they have played over the centuries in the funerary customs of the local populations, little is known about the relationship of these mortuary monuments with the sky.

The chullpas of various regions of the central Andean highlands were described by several chroniclers of the colonial era from the mid–16th c. onward, and their possible practical function and distribution across the Andean landscape have interested more modern archaeologists and explorers. In general, all these chronicles and studies indicate that the tomb-towers of these regions are oriented in such a way that their openings point toward the east, so as to receive the first rays of the Sun each day.

FIGURE 1. Image of a group of funerary towers of Tama Chullpa. The tombs are built with a mixture of mud and straw. They vary in size and height and generally have a rectangular floor plan. Most have suffered great erosion and some are completely collapsed. Photograph by the Authors.

However, recent archaeoastronomical surveys at chullpa sites in the extensive Lauca River valley region, also in the Bolivian highlands, show that the towers follow an orientation pattern that does not cover the entire eastern arc of the sunrise at those latitudes (GANGUI 2024). These chullpas show a clear tendency to orient their entrances towards the east, but mainly towards north-east, and it was found that none of the towers that were studied direct their openings towards directions close to the southern hemisphere summer solstice.

The Tama Chullpa site in the Culli Culli region, southern highlands of La Paz, which we present in this work (FIGURE1), on the contrary, currently occupies only an area of approximately 10,000 m^2 (1 hectare) and the 35 towers in relatively good condition that we have measured *in situ* and analyzed are oriented —without exception— in a narrow range of azimuths towards the south of due east (some even have solstitial orientations).

This striking difference between the orientations of the funerary towers in the Lauca River region and those of Culli Culli suggests that, perhaps as expected, the entrances of the chullpas, in general, were not only guided by the positions of the sunrise throughout the year, but that, in the case of Tama Chullpa, there must have been very relevant topographical and cultural reasons.

Archaeological studies conducted in the past in the vicinity of Culli Culli (RIVERA CASANOVAS 1990; HEREDIA ZABALA 1991,1993) suggest that the Tama Chullpa complex could represent a kind of territorial boundary marker (HYSLOP 1977), or perhaps a "defensive line" for some settlements controlled by different families, lineages, or regional organizations (*ayllus*) of the Aymara culture located in the northwestern region of the site. Our preliminary results indicate that the orientation of these towers, unlike what was found in previous studies, combines solar and topographic aspects equally.

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HELIOS IN ATHENS: FROM THE CITY OF THESEUS TO THE CITY OF PLATO

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Classical Athens, Helios cult, solstices, Plato, urban layout

Helios is a unique god in the Greek pantheon. His Indo-European antiquity is recognised, and Hesiod already mentioned him among the first divine generations. There is a certain contrast between two different observations. On the one hand, from the point of view of Greek religious practices, Helios was not widely worshipped, as only the city of Rhodes had him as its patron deity. On the other hand, from the point of view of the history of ideas, Plato attributes a very prominent role to this god. In the dialogue *Timaeus*, he presents his cosmogonic and cosmographic reflections, and in the dialogue *Laws*, he conceives of a virtuous city where the priests of Helios are among the principal magistrates with the mission of keeping the city united. In this paper, we argue that these proposals by Plato do not arise exclusively from his imagination.

FIGURE 1. Sunset on the summer solstice over the east pediment of the Parthenon, depicting the birth of Athena, as seen from the precinct of the Temple of Olympian Zeus.

On the contrary, the presence of Helios at different points in the Athenian topography shows his constant relationship with the goddess Athena, the patron goddess of the city, and with the summer solstice, the date of Athena's birth. In this way, the association between Helios and the solstices defines the holistic understanding of the urban area of classical Athens as a privileged sphere of action for the goddess. We start in the southeast of classical Athens, between the Acropolis and the temple of Olympian Zeus. It was the oldest part of the city and was known as 'the city of Theseus'. There is a solstice relationship between the temple of Zeus, the father of Athena, and the Parthenon, on whose eastern pediment the birth of the goddess was represented. Next, the axis between the Acropolis and the Hiera Pyle in the Kerameikos is marked by the solstice festivals, *Skirophoria* and *Dipolieia*, attended by the priest of Helios. Furthermore, from the area of the Agora where the Boule and the tholos, centres of institutional life, were located, the solstices occur over Lycabettus, brought there by Athena, and the point on the Acropolis where the temple of Athena Polias stood. Finally, the solstice on Lycabettus is also fundamental to the observations of the astronomer Meton from the Pnyx, the meeting place of the assemblies.

FIGURE 2. Sunrise on the summer solstice on the southern flank of Lycabettus Hill, seen from the base of the heliotrope built by Meton on the Pnyx, the meeting place of the Athenian assembly.

When Plato conceives of a renewed role for Helios in the design of the pantheon of the ideal city he describes in *Laws*, he is inspired by the Athenian events mentioned above. He conceived a 365-day solar calendar imported from Egypt, with the priests of Helios occupying all the time and space of the new city, and he maintained the summer solstice, dominant in Athens, as the fundamental date for the ordering of time in the city.

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REPRODUCIBLE ARCHAEOASTRONOMY: STRUCTURED WORKFLOWS FOR ASTRONOMICAL CHRONOLOGY IN THE DIGITAL HUMANITIES

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University of Basel, Switzerland

Chronology, Workflows, Reproducibility, Galaxy Platform

Astronomical phenomena have long played a central role in the establishment of ancient chronologies. Eclipses, planetary conjunctions, heliacal risings, and other celestial events have been used to anchor regnal years, synchronise king lists, and stabilise historical timelines across cultures (see e.g. BELMONTE 2013; GAUTSCHY 2014). While such approaches often appear mathematically precise, the underlying process of astronomical dating is rarely as straightforward as it seems (see e.g. KRAUSS 2025). Chronological arguments based on celestial data typically rely on a chain of interpretative, astronomical, and computational assumptions that are not always fully documented or reproducible.

In order to improve this situation, I suggest that archaeoastronomical chronology could be understood not merely as a calculation, but as a structured workflow. The dating of an ancient ruler based on an astronomical reference involves multiple steps: the philological interpretation of a textual source; the identification of a plausible astronomical phenomenon; the retro-calculation of celestial events; the modelling of visibility conditions; possibly a calendar conversion; and finally the integration of results into an existing chronological framework. Each of these stages entails methodological choices that can significantly influence the final outcome.

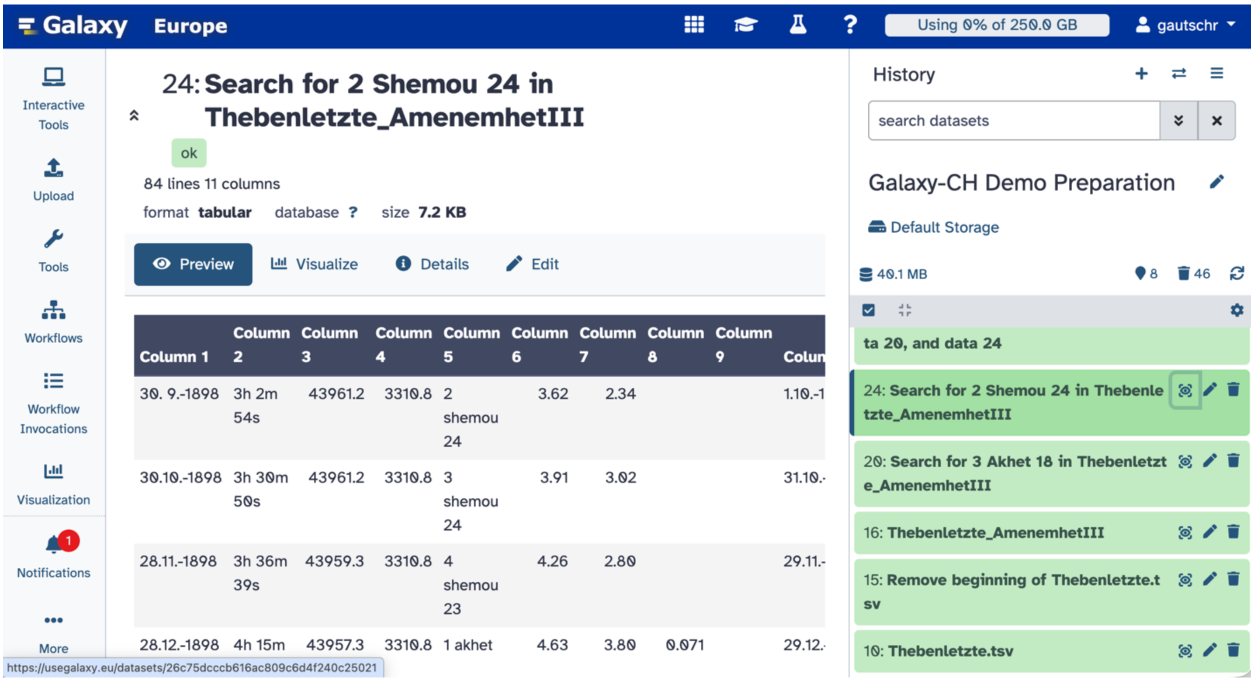

FIGURE 1. Snapshot of an archaeoastronomical data analysis on the Galaxy platform.

Drawing on recent work in the digital humanities, I propose a workflow-based approach to archaeoastronomical dating that emphasises transparency, documentation, and reproducibility. Using the Galaxy Platform (THE GALAXY COMMUNITY 2024; GALAXY PLATFORM n.d.) as a web-based research infrastructure, it shall be demonstrated how the individual components of astronomical chronology can be formalised into modular, shareable pipelines. This enables an easier replication of results, but may also allow for sensitivity analyses that reveal how dependent chronological conclusions are on specific assumptions. Competing models —such as alternative eclipse identifications or differing delta-T reconstructions— could be tested side by side, and their chronological implications compared transparently. Moreover, workflows can be shared, reviewed, and reused by other scholars, fostering methodological dialogue and cumulative refinement.

I argue that digital workflow infrastructures provide a framework in which decisions taken during the process of analysis can be documented, structured, and critically assessed. The Galaxy platform provides the additional benefit that histories and workflows can be shared, published, and tutorials be created. In collaborating on such a platform, it is possible to move from isolated calculations toward standardised, interoperable research practices that align with broader principles of reproducibility and fair data management.

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RITUAL PROCESSION ON PELION AT THE HELIACAL RISING OF SIRIUS

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Pelion, Cheiron, Zeus Akraios, Sirius

Herakleides Kritikos, provides the only surviving testimony of a ritual procession to the summit of Mount Pelion. He describes a procession of selected young men to the cave of Cheiron and a *hieron* of Zeus at the time of the heliacal rising of Sirius. Archaeological investigation of this area is extremely limited: Arvaintopoulos hastily conducted an excavation in 1911; later, access to the mountain peak has been strictly limited, because it was declared a military area. The present study seeks to address the following questions: at which specific location on the mountain summit were the cave of Cheiron and the sanctuary or temple of Zeus Akraios situated? What activities were carried out there by the ritual officiants, and for what reason did the cultic procession occur during the heliacal rising of Sirius? Using Arvanitopoulos' description in the combination with remote digital tools (*i.e.* Google Earth Desktop, Peak Finder and Stellarium), this research aims to identify the most plausible area on the mountaintop where the sanctuary of Zeus may have been located, based on the astronomical conditions of Sirius' heliacal rising. Then, using Herakleides' description and the limited archaeological finds (inscriptions and coins), we will make an attempt to determine the duration of this specific cultic activity over time and the identity of those who participated in it.

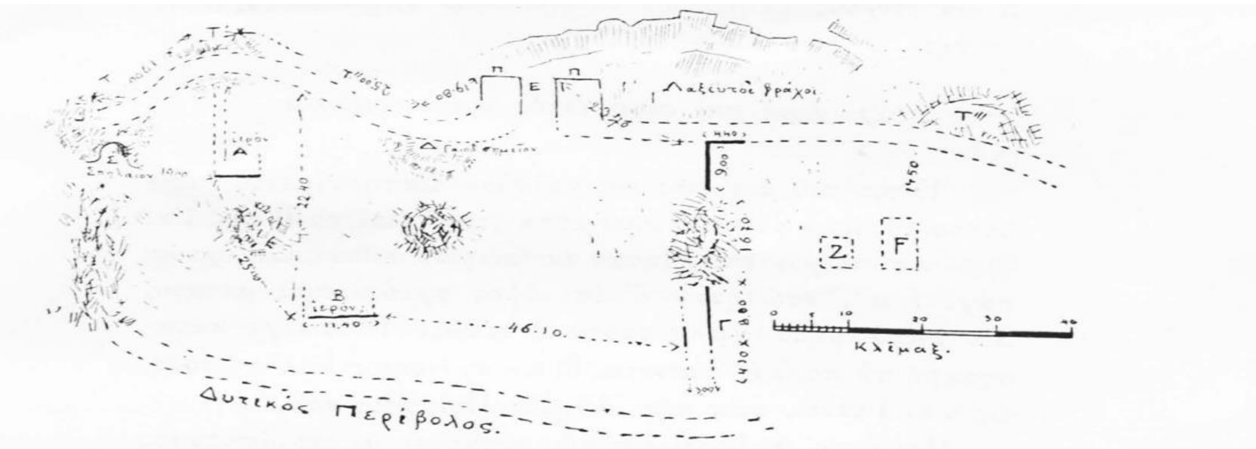

FIGURE 1. 1911 excavation plan (after ARVANITOPOULOS 1912).

The study subsequently undertakes a religious and ritual analysis of the procession within its broader mythological and cultic context. More specifically, the only detail the author provides about the ritual is the attire of the prominent citizens, who wear the fleece of sheep that have just been sacrificed. A comparison will be made between this cultic practice and the symbolism of the myth of Aktaion, the hero who was raised by Cheiron, in order to offer a possible explanation for the symbolism of this particular form of attire. In the absence of any surviving description of this ritual, we will draw a parallel with the earliest documented ritual associated with the heliacal rising of Sirius, which took place on Kea. According to the myth, the dog Maira, who was transformed by Zeus into the constellation of Canis Major, caused drought on the island. The heatwave was brought to an end by Aristaios, the father of Aktaion, who offered sacrifices to Sirius and to Zeus Ikmaios. The ritual on Kea displays several similarities to the case under examination: it takes place on the mountains at the time of the heliacal rising of Sirius, the principal deity honored is Zeus, and in each case, there is a healing deity, namely Aristaios and Cheiron respectively.

Moreover, the written testimonies of the ancient Greeks explain the significance of the heliacal rising of Sirius and how it affected people and their activities. The study of these sources will contribute to providing a possible explanation of the cultic purpose for which the procession during the heliacal rising of Sirius was conducted, namely the control of the weather and the protection of human agricultural activities.

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TOWARDS A COMPREHENSIVE STUDY OF MEGALITHIC ASTRONOMY IN GALICIA (SPAIN)

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Megalithism, Archaeoastronomy, Spatial Studies, 3D modelling, Illumination Phaenomena

In the Iberian Peninsula there are five families of orientations of megalithic monuments (GONZÁLEZ-GARCÍA 2025). One of them, and possibly the one with the clearest astronomical connection, is that of the northwest (including Galicia, Asturias, Castile and Leon and the north of Portugal), which seems to reflect HOSKIN's (2001) hypothesis: orientations possibly related to the sunrise and therefore to the date of construction or celebration linked to very specific times of the year. Although this hypothesis has been much contested (e.g., IWANISZEWSKI 2009), when considering the overall sample measured up to today, comprising more than 300 megalithic tombs in this area, the image that appears is strikingly in accordance with such idea.

FIGURE 1. Mamoa do Rei in the Necropolis of Castiñeiras (Pontevedra, Spain). This is one of the megalithic passage tombs in the region of Galicia that best represents the evolution of megalithism in the region. The use of different stone material (granite and quartz) to emphasize location within the tumular mound and link it to light and shadow, and the possible existence of illumination phaenomena may be also linked to the chosen location of the site. Picture by the author.

Within this region, the megalithic monuments of the area that is now Galicia stand out. In this presentation, I want to focus on three points:

- Orientations of monuments considered globally, and differences between the coast and the interior, or according to their relative chronology and typology.
- Location of the monuments in the landscape, with four specific cases, the necropolises of Ferrol, Leboreiro, Barbanza, and Costa da Morte (HIGGINBOTTOM *&al*. 2022).
- Particular cases that inform us of details by translating the above into specific cases: Dombate; Mámoa 5 from Forno dos Mouros; Forno dos Mouros do Bocelo; Altar do Sol; Mámoa do Rei.

This exercise complements the traditional studies of the orientations of these megalithic monuments. On the one hand, in addition to having the general pattern, we try to understand how this pattern is generated, if it is an effect of time or if there is a typological or regional evolution. On the other hand, we try to understand whether, as other archaeological studies seem to indicate, the space is understood in a global way, considering not only the optimal location in economic but also in symbolic terms. And finally, we try to see how the three-dimensional configuration of the monument allowed and perhaps stimulated the use of (solar-lunar) light as one more ritual element in these monuments.

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COSMIC WORLDVIEW OF THE INKAS

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Inca, Inka, Solar worship, Inka cosmovision, Inka cosmology, Inka astronomy, horizon astronomy, light and shadow, Inka oral traditions

Civilizations create their own culture, their own ethos, and their own worldview, and this was certainly true of the Inkas. The Inka Empire (in Quechua, the *Tawantinsuyo*) in its evolution developed customs, habits, ways of being, and ways of behavior. The Inkas as well sought to answer fundamental questions such as “how to be” (*Imaynakay*), and “how to live” (*Imaynakawsay*).

Like other ancients, the Inkas tried to interpret and understand the cosmos —its origins, its primordial stages, and to seek a sense of its existence. They developed a worldview centered with *Kawsaypacha,* where everything in the cosmos is sentient. The Inkas conceived principles of life and standing out among them was *Ayni*, the force of reciprocity and help.

Kawsaypacha as well corresponds to energy in both time and space. Andean culture is based on beliefs distinct from those found in the West —the principles that govern Andean thought are based on transversal concepts and principles of rationality, integrality, and cyclicality. Thus, proper understanding and interpretation of the Inka legacy in the fields of astronomy and archeo-astronomy can only be carried out properly when viewed within the context of Inka culture and its worldview.

A general understanding of the nature of the Quechua language is also an essential element for sensing cultural context. This presentation uses Quechua spellings while it explores Inka worldview and culture, including their perception of space and time.

The Inkas organized their civilization with *seq'es* and *waqas* and both figure prominently in their cosmology. Waqas were shrines that often were thought to be sentient with great power and influence (*Kawsaypacha*: everything in the cosmos lives). These living waqas needed to be cared for and thus were located on seq'es which were organizational lines, not always straight, with responsibilities for their care assigned to extended family lineages. There were 41 seq'es surrounding Cusco.

Again, fundamentally important is placing what is found into cultural context because without doing so collected data can be easily misunderstood. This talk presents a fascinating blend of astronomical and archaeoastronomical knowledge with insight passed down from one Quechua generation to the next via oral traditions emanating from the time of the Inkas up to today. The Inkas worshipped the Sun and thought their emperor to be the son of the Sun and his wife to be the daughter of the Moon.

Elements of Inka culture converge with science and astronomy, but the worldview of the Inkas is conceptually different from that found in the West. Not only does Inka astronomy have a different orientation, but also it is important to take into consideration how the Empire was filled with many sacred sentient entities with great powers (everything in the cosmos lives). An understanding and appreciation of this cosmovision is discussed.

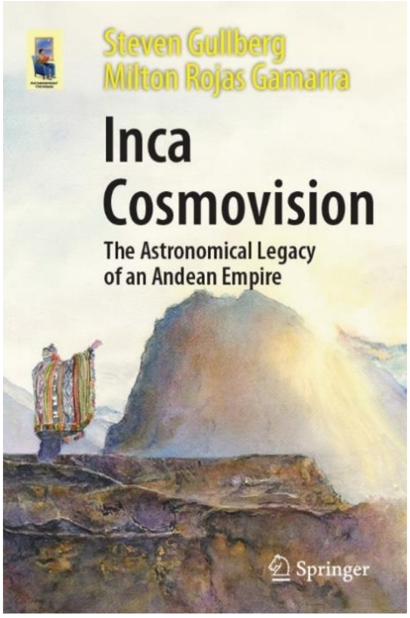

FIGURE 1. Cover of author's lastest book.

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CAESAR'S COMET IDENTIFIED AS COMET ENCKE II, A PART OF COMET ENCKE

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Caesar's comet, Augustus' Memoires, Chinese Chronicles, Comet Encke II

From the memoirs of Emperor Augustus one gives the impression that an earlier unknown comet appeared for the first time on the first day of the Funeral Games in honour of Julius Caesar. This comet was considered as a sign from the gods that Caesar has been accepted as a god. An important property of the new comet was its extreme brightness. It was so bright that it was visible during daytime for at least 10 days. The Funeral Games took place 20–27 July 44 BCE in the original Julian calendar (RAMSEY & LICHT 1997). In 325 the days in the Julian Calendar was shifted by three days to fit the dates of the solstices and equinoxes and the dates of the Funeral Games corresponds to 17–24 July in our calendar.

Two months earlier the same year the Chinese astronomers had discovered a comet with tail in their month from 18 May to 16 June. It moved later to their constellation *Shen*, mainly corresponding to Orion's belt (YOKE 1962). Some authors have considered them as two separate comets, but the probability that two different comets appear in the sky within two months is very low.

In fact it was one and the same comet. I have identified this comet as Encke II, the minor part of Comet Encke that was discovered by the Greek Historian of Science, Ephoros, after 9 January 371 BCE. Aristotle had observed a great winter comet just after sunset and he wrote that its tail reached up to the belt of Orion. This was Comet Encke and it happened on 31 December 372 (HENRIKSSON 2020). Some days later Encke had its perihelion passage, when it was closest to the Sun and its strong radiation and gravitational force. When it became visible again in the morning sky, about ten days later, it hade disintegrated into two pieces. This fact was observed and documented by Ephoros. I have called the minor part Comet Encke II.

Later, when Encke II was discovered, it was considered to be an ordinary comet. Its orbit was almost identical with its mother comet Encke, but its position along the orbit was shifted and appeared about 55 days in front of Comet Encke's position. This position of Encke II, in its orbit around the Sun, resulted in a close encounter with the Earth in 44 BCE. It reached its closest distance on 15 July, when its calculated magnitude was −7.3, more than 50 times brighter than the brightest planet Venus, with −4.0. This means that Comet Encke II maximum brightness happened to coincide with the Funeral Games for Caesar, 17–24 July, and it fulfills completely the criterion that it was visible at daytime during the Funeral Games. This is really a remarkable coincidence tat was interpreted as a proof that Caesar had become a god.

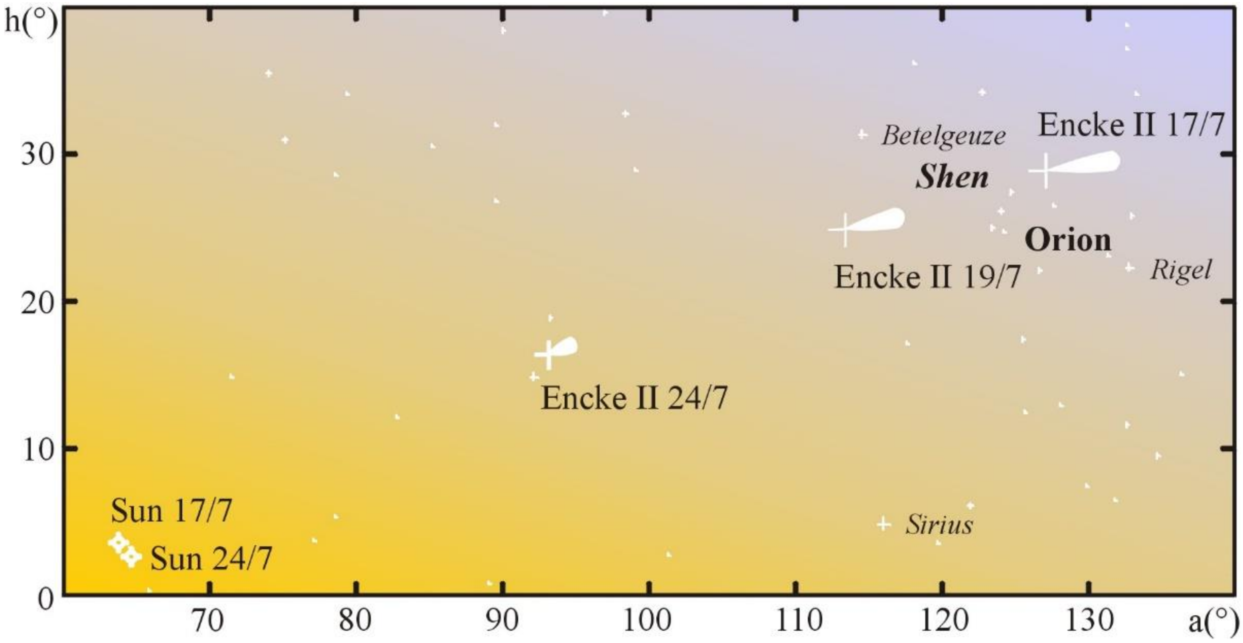

FIGURE 1. A theoretical view of the eastern sky at 05.00, local mean solar time in Rome, during the first 7 days of the Funeral Games given in 44 BCE to honour the memory of Julius Caesar. This game was organized by Octavianus, later emperor Augustus, and it took place on July 17–24, 44 BCE. An extremely bright comet appeared on the first day of the games and it could be observed even during daytime all the 7 days. This bright comet was taken as a proof, by Octavianus and other Romans, that Caesar had become a god. Caesar's comet is identical to Comet Encke II, the smaller of the two comets observed by Ephoros after 9 January in 371 BCE and was observed by Aristotle to have a tail that pointed up to Orion's belt at the sunset on 31 December 372 BCE. The time-shift relative to the gravitational orbit, ΔT, was −55.1 days. The situation in this figure is computed for $\Delta T = -55.0$ days. For the first day of the Funeral Games, July 17th at 05.00, this corresponds to mean-anomaly = 348.35°, distance to the Sun = 0.962 AU, and to the Earth = 0.140 AU. The closest distance to the Earth was 0.139 AU on July 15. The magnitude of the comet's nucleus was −7.25, and the computed length of the tail in the figure is 0.01 AU. It was believed to be a star because no tail was reported during daytime, only the extremely bright nucleus.

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INTERPRETING LOCAL COSMOLOGICAL SCHEMES THROUGH DOLMEN CONSTRUCTION

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Megalithic Art, Dolmens, Portugal, Landscapes, Nature, Cosmology

Discovering the meaning of dolmens has been tackled for decades, observed through various lenses, including: the dead and their personal effects; objects left for the dead, used by the living or intended for purposes unknown; architectural style; lighting; engravings and paintings (BUENO RAMÍREZ *&al*. 2016; SANTOS *&al*. 2011); as well as the positions of all of these within the dolmens (SANCHES 2006). The external environments in which dolmens appear —including what was seen by people in terms of scapes, such as topographical and/or astronomical views— have also been considered (SENNA-MARTINEZ et al. 1997, HOSKIN 2001; DA SILVA AND CALADO 2003, DA SILVA 2004, SILVA 2013; LOZANO RODRÍGUEZ et al. 2014; CLAUSEN 2014; VILAS-ESTÉVEZ 2016; ESTEBAN & BENÍTEZ DE LUGO ENRICH 2016; BENÍTEZ DE LUGO ENRICH & ESTEBAN 2018; GONZÁLEZ GARCÍA & CANOSA BETÉS 2023; HIGGINBOTTOM *&al*. 2022). Signs of activities close to or within the general vicinity of these monuments has also been folded into the understandings of these sites, like hearths or resource management (SENNA-MARTINEZ *&al*. 2008; CEBRIÁN DEL MORAL *&al.* 2011) as well as resource practices of the time more generally (OMS *&al.* 2017, in PALACIOS MARTÍNEZ 2023; CARVALHO *&al.* 2017). Their possible meaning(s) seems fluid and unending.

FIGURE 1. Map of Iberia, delineating Portugal and Spain. Pin shows the location of Anta da Aquinha de Moura.

Anta da Arquinha da Moura is located in the municipality of Tondela, district of Viseu, Beira Alta, Portugal, between the River Asnes and the River Dão (FIGURE 1**)**. It sits on a coarse to medium grained granite outcrop, with large feldspar crystals that are visible on the surface on the ENE periphery. The outcrop is situated on local high ground at *ca.* 324 m_{ASL}, similar to dolmens examined in Costa da Morte, Galicia (HIGGINBOTTOM *&al.* 2023). According to Ana Leite DA CUNHA (1995), the importance of this monument is due to its typological characteristics that make it part of a group of monuments well represented in the Beira Alta region, the existence of the two orthostat paintings, and the abundance of finds, including human remains. The bones collected were not anatomically connected, but were grouped by sets of bones: skulls on one side and long bones on the other. They represent eight individuals of both sexes: seven adults and one sub-adult (CRUZ 2001). Only one date is published: GRA-9573: 4160±50 BP, calibrated to 2σ, to a chronology between 2881 and 2583 cal BCE.

As part of a larger investigation into understanding dolmens of the western Iberian Peninsula based upon landscape and astronomical considerations, this work presents a novel combination of methods and results to consider an interpretation of the dolmen of Arquinha da Moura that includes one of its two singular, large paintings. In this way, this paper will demonstrate how this major piece of iconographic art is connected to the dolmen's seasonal astronomical orientation, entailing it within a local dolmen's meaning, whilst also being part of the greater cultural scheme in western Iberia, where Nature and Supernature are one and the same.

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CONSTELLATION CENTAURUS AS CASE STUDY

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Constellations, Centaurus, Digital Methods

The constellation Centaurus is one of the modern IAU constellations that had historically formed a super-constellation with some neighbouring constellations (Lupus and Ara), see HOFFMANN (2021). As far as is known today, Hipparchus' mathematical astronomy divided the super-constellation into the pieces used today, whereas for Aratus and Eratosthenes, Lupus was not considered a constellation in its own, but part of the centaur. However, the attributes that the centaur carries vary across the different sources, which may point to different interpretations of the image, even within the cultural sphere of scholarly writing in the Greek language.

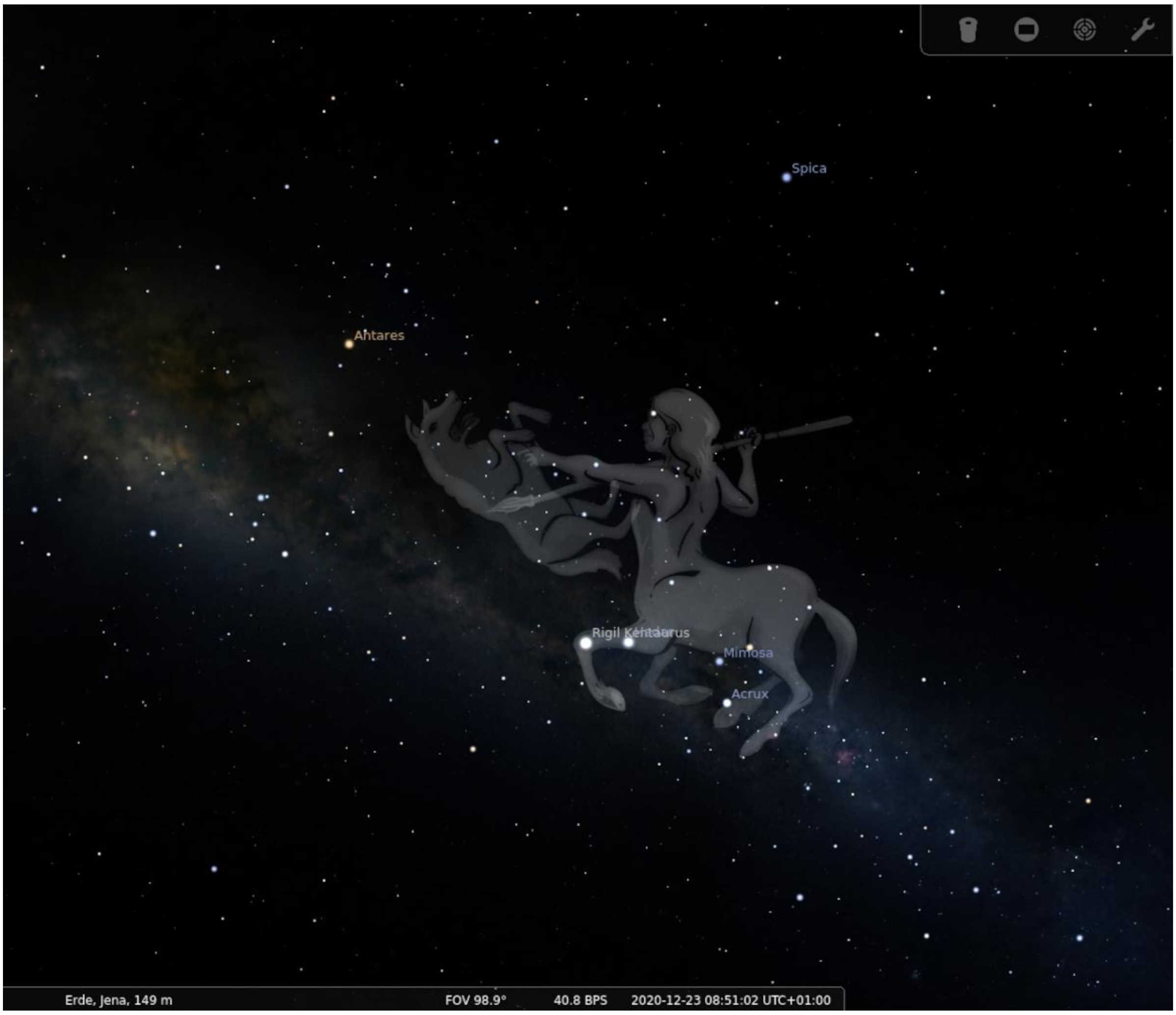

FIGURE 1. Constellations Centaurus and Lupus from Stellarium.

Centaurs are figures from Greek mythology with a human upper body on a horse's body. They represent masculine, impetuous, and lustful characters. Depictions of female centaurs are only documented in the late Hellenistic period. This is expressed in all myths about their origin as a result of the transgressions of the wicked king Ixion, their expulsion from Thessaly to the Peloponnese, their enemies, the virtuous Lapiths, and their combative encounters with Greek heroes such as Heracles. The origin of this hybrid creature is as controversial in research as the etymology of the word. A connection to ancient Indian lesser deities is under discussion, but there are no known references from Mesopotamia or Egypt. While W. HOROWITZ will submit a paper exploring various mixed creatures in Mesopotamia, and Asterios KECHAGIAS will study possible connections with Indian sources, my presentation will present the history of this constellation as far as can be documented from ancient Greek and Roman sources on the basis of the All Skies Encyclopaedia (ASE).

I will examine the historical development of the constellation with a data-driven method (see HOFFMANN *&al*. 2022), this way applying practices of "computational historical astronomy" to a research of cultural astronomy. Cultural Astronomy, defined as an umbrella term already, can actually build bridges between various disciplines, in particular as I make use of Stellarium (ZOTTI *&al*. 2020) for visualisation and distribution of knowledge. However, my main method is the collection of data (2D- and 3D-images, text), its mapping, and the investigation of its statistical distribution.

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INDIGENOUS ASTRONOMY IN THE SPACE AGE: A REPORT ON THE 2025 IAU SYMPOSIUM 399 / OXFORD XIII MEETING

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University of Melbourne, Australia

Jarita HOLBROOK
University of the Western Cape, South Africa
University of Edinburgh, UK

Cultural Astronomy, Conferences, Indigenous Participation

SEAC members are familiar with, and often participate in, the Oxford series of conferences on Archaeoastronomy, hosted by the International Society for Archaeoastronomy and Astronomy in Culture (ISAAC). In 2017, SEAC convened with Oxford XI in Santiago de Compostela, Spain. This presentation focuses on Oxford XIII which took place in Melbourne, Australia in 2025. The conference theme foregrounded Indigenous Astronomy, inviting those that currently engage with living cultures to present their research. It also expanded on the temporal scope of this work to look at how cultural astronomy links to sociological approaches to humanity's future in space. However, research in archaeoastronomy, with deep analysis of archaeological sites and ancient peoples, were represented as well.

FIGURE 1. SEAC Members Clive RUGGLES and Jarita HOLBROOK, with Indigenous participants from New Zealand Isaac WARBRICK and Jade KAMETA.

The conference hosted delegates from 30 countries, with strong representations from the Global South. The lead organisers focused on supporting scholars who are Black, Indigenous, and People of Colour from around the world to bring personal experiences, cultural authority, and elevate profiles and voices. The organizers focused heavily on raising funds to ensure the participation of Indigenous researchers, Indigenous Knowledge holders, Indigenous artists, and Indigenous students. This effort was successful with 20 participants that identified as Indigenous. The Cultural Astronomy community is small, with few opportunities to attend conferences, schools, or enrol in classes. Therefore, it becomes difficult to learn relevant research theories and methods. To mitigate this, Oxford conferences work to include a "school" to educate and train the next generation of scholars. In Melbourne, the School was held over three days during the week prior to the conference, and several SEAC members served as instructors including Gail HIGGINBOTTOM, Georg ZOTTI and

César GONZÁLEZ-GARCÍA. Other Oxford meetings that included schools were Oxford IX Peru, Oxford X South Africa, and Oxford XII Argentina. The School hosted 45 attendees in-person and online. As with Oxford X in South Africa, the lectures from the School, as well as all conference talks, were video recorded and made publicly available on YouTube. The motivation for this was to provide access to the content for those that participated remotely from different time zones, but also to ensure that students that are interested in doing cultural astronomy research are abreast of the latest research, theories and methods.

The conference expanded beyond traditional boundaries of cultural astronomy research, which tends to focus primarily on archaeoastronomy and ethnoastronomy, to explore the intersection of culture, history, society, and science in terms of past, present, and future. The purpose of this part, was to turn the lens inward to reflexively examine how scientists and cultural astronomers work and engage in research. This involves addressing how the astronomical and space communities can support and learn from Indigenous Knowledge, how we can engage collaboratively with First Nations communities, and how we can pave a future for the next generation of Indigenous astronomers. The program also considered the development of ground-based observatories and space ports on Indigenous lands in a more collaborative and mutually beneficial manner with Indigenous communities.

FIGURE 2. Group Photo with the participants in the Oxford XIII Cultural Astronomy School.

The conference framework also expanded into dark sky studies and space futurism, addressing how we can safeguard astronomical knowledge and heritage through the mitigation of light pollution, the moderation of micro-satellites and satellite constellations. The symposium addressed pressing issues to guide future synergies between Indigenous knowledges and astrophysics, and lead discourse about the sociological and philosophical challenges of humanity's shared future in space. Public events were held to share discussions and discourse about Indigenous astronomy, from the ancient past to space futures. Included was a public lecture by SEAC member Clive RUGGLES on *Pacific Star Knowledge* as the first of the annual July Lectures in Physics (with 400 attendees). We are currently preparing the proceedings for publication in an IAU edited volume to be published by Cambridge University Press, edited by Duane HAMACHER and Jarita HOLBROOK.

The dedicated website for the School and Symposium can be found here:
https://www.archaeoastronomy.org/iaus399.

MIXED BEINGS: FROM CENTAURUS TO THE SUMERIAN PIG-FISH

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The Hebrew University of Jerusalem, Israel

Centaurus, Ancient Mesopotamia, Constellations

Both the modern and ancient sky were filled with mixed creatures, among others: Centaurus (half man-half horse) and Mesopotamian UD.KA.DUH.A, "The Demon with the Open Mouth" (with one human-face and one lion-face, wings, and the lower body of a human). This paper will present one new possible member of this club: a Sumerian-Akkadian Pig-Fish, which we will argue is the name of an asterism whose stars match at least some of those of classical Delphinus, the Dolphin.

FIGURE 1. The Pig in Babulonian uranogaphy.

In the course of this presentation, we will review the main sources for the configurations for Ancient Mesopotamian asterisms (Sumerian and Akkadian named stellar features, large and small, ranging from super constellations, to classical constellations, to multi-star constellation parts, and individual points in the sky, including bright stars such as Sirius, and planets.

Passages to be discussed will be drawn from two major traditional compendia of cuneiform astronomy, the series MUL.APIN (HUNGER & STEELE 2018) known from first millennium BCE sources, and "The Three Stars Each"-group (HOROWITZ 2014), going back to a main source dating to *ca.* 1180 BCE that is commonly known as Astrolabe B (the Berlin Astrolabe). We will also make use of the Uranology Group (BEAULIEU *&al*. 2017), which gives descriptions of how asterisms are drawn, and the GU-text and DAL.BA.AN.NA text which presents linear and more sophisticated alignments of asterisms in the Mesopotamian sky (HUNGER & PINGREE 1999, 90–111).

Based on the findings of this paper we will make use of a new term "Aries Transformations" to describe the way that star-names interact with visualizations of asterisms in the sky over time and space, both in the Ancient World and down to the present. Participants will be invited to suggest a better term for such phenomena.

Further attention will be focused on the findings of Planetarium Babylonicum project, headed by the presenter and Dr. Susanne HOFFMANN, which forms part of the All Skies Encyclopaedia (https://ase.exopla.net).

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LIGHT PHENOMENA AND ARCHAEOASTRONOMY AT PONTE D'ERCOLE (ITALY): A 3D SURVEY AND DIACHRONIC SIMULATION APPROACH

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Archaeoastronomy, Light phenomena, 3D modelling

The site of Ponte d'Ercole, in the northern Apennines (Italy), is a natural sandstone arch embedded within a landscape characterized by long-term human occupation. From an archaeological perspective, the area has been interpreted as a possible rupestrian cultic context, based on evidence documenting a continuity of use from prehistory to the Roman period. The finds, predominantly non-stratigraphic, include ceramic fragments and metal objects attributable to votive deposits. The analysis of their topographical distribution suggests a possible connection with ritual practices related to water resources and to the morphological specificities of the site, within a natural landscape perceived as significant by the communities that inhabited it.

Despite the archaeological relevance of the context, the role of the rock formation —and in particular of its natural openings— in generating light-related phenomena has not yet been systematically investigated within an archaeoastronomical framework. Starting from interpretative hypotheses that attribute a ritual function to the site, this study aims to assess whether the geometry of the monolith may have been selected or modified in relation to its interaction with specific solar events. Within this perspective, archaeological evidence is considered not only as material data, but as part of a broader cultural system, in which symbolic and observational dimensions are closely interconnected.

Within the field of cultural astronomy, perforated stones are generally interpreted as visual alignment devices. The case of Ponte d'Ercole instead belongs to a less explored category, in which the relevant phenomenon does not consist in the direct collimation of the celestial body, but in the projection of light onto internal surfaces of a natural structure. The methodology integrates high-resolution laser scanner survey and diachronic digital simulation, using the three-dimensional model as an analytical tool to investigate the interaction between solar light and rock morphology throughout the annual cycle. Simulations were calibrated through systematic comparison with photographic documentation acquired *in situ*, in order to verify the consistency between simulated data and actual observational conditions.

The analysis identifies the winter solstice sunrise as the moment of maximum coherence of the system: under these conditions, a light spot with a geometry close to circularity is projected through the south-eastern opening onto the internal surface of the monolith. The phenomenon is strongly conditioned not by the theoretical astronomical horizon, but by the local micro-topography, which produces a significant temporal and spatial shift in relation to the expected solar parameters, highlighting the determining role of the immediate landscape context. A secondary, less defined interaction is associated with the north-western opening at summer solstice sunset, suggesting a possible functional asymmetry between the two apertures.

Overall, the site cannot be interpreted as an "observatory" in the modern sense, but rather as a light-mediated device embedded within a ritual landscape, in which the interaction between solar light and natural morphology contributes to structuring symbolic practices and, plausibly, forms of temporal organization. The study demonstrates how the integration of metric survey and

controlled simulation can transform episodic observations into analytically verifiable data, proposing a methodological approach applicable to the study of complex natural contexts within cultural astronomy.

FIGURE 1. Ponte d’Ercole. Left: winter solstice light phenomenon with a circular projection through the south-eastern opening. Right: site context, laser scanner survey, and 3D model used to simulate the interaction between light and morphology.

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THE ORIGINS AND SPREAD OF LUNAR SERIES IN THE EARLY CLASSIC PERIOD (*CA.* 250/357–600 CE), MAYA LOWLANDS

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Maya, Classical Period, Lunar Series

Lunar Series is part of the glyphic texts found on monumental Maya inscriptions from the Classic Period. They constitute a glyphic clause associated with an elaborate calendrical system, allowing for the determination of corresponding dates. This clause consists of six glyphs. Glyphs D and E indicate the age of the Moon at the specified Long Count date. The verb *huli*, "to arrive here", indicates how many days had passed since the Moon re-appeared in the sky, suggesting that the count began with the first observation of the lunar crescent after the New Moon. Glyph C indicates the position of the month in an 18-month cycle, and its sequence is subdivided into three groups of six months each. Glyph X is a variable element associated with Glyph C, and Glyph B indicates that Glyph X is the name of the lunar month designated by Glyph C. Glyph A determines the duration of the lunar month, either 29 or 30 days.

FIGURE 1. Stela E.

The earliest inscriptions in the Lunar Series include a clause limiting it to only three glyphs (Glyphs E, D, and C). They originated in the Central Petén region and southern Campeche during the 4th c. CE and contain information on the Moon's age and the position of the lunar month. Over time, the Maya added Glyphs A (Tikal, Ballcourt Marker at 8.18.17.14.9, or 414 CE; Río Azul, Tomb 1 at 8.19.1.9.12, or 417 CE) and X (El Zapote, Stela 5 at 9.0.0.0.0, or 435 CE). The last of the glyphs that make up the Lunar Series, Glyph B, comes from Cobá (Panel 7b at 9.7. 0.15.8, or 574 CE). Other transformations include the transition from the observational stage to the use of standardized months of 29 or 30 days that alternated regularly, the development of a fixed sequence of the patron gods attached to Glyphs C, and the naming of specific lunar months.

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AFTERIMAGE ARCHAEOASTRONOMY: A PHYSIOLOGICAL FRAMEWORK FOR ANCIENT SKY PERCEPTION AND MONUMENTAL ALIGNMENT

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Across diverse civilizations, constellations and celestial myths exhibit strikingly similar structural patterns despite geographical and cultural isolation. Traditional archaeoastronomical approaches often attribute these to cultural diffusion or coincidental symbolic invention. This paper proposes a novel alternative: “Afterimage Archaeoastronomy”, a theoretical framework positing that ancient mythologies and architectural alignments emerged directly from universal human visual afterimage responses to the night sky under dark-sky conditions.

Human vision does not perceive a starry sky as a collection of isolated mathematical points. Due to micro-saccades, brightness gradients, and physiological afterimage persistence, observers naturally organize star distributions into distinct perceptual structures. This framework categorizes these visual phenomena into four primary modes: (1) Line Image (e.g., Orion’s Belt, formed by micro-saccadic transitions between anchors); (2) Vessel Image (e.g., the Big Dipper's rectangular bowl); (3) Swarm Image (e.g., the dense clustering of the Pleiades); (4) Layer Image (e.g., the continuous luminous band of the Milky Way).

These physiological percepts served as the foundational cognitive templates. The framework introduces a four-stage process of cognitive evolution: Visual Afterimage, Cognitive Completion, Symbolic Stabilization, and Architectural Projection. Furthermore, this study proposes a preliminary quantitative model to calculate "Afterimage Salience", incorporating parameters such as stellar magnitude, variance, and atmospheric extinction.

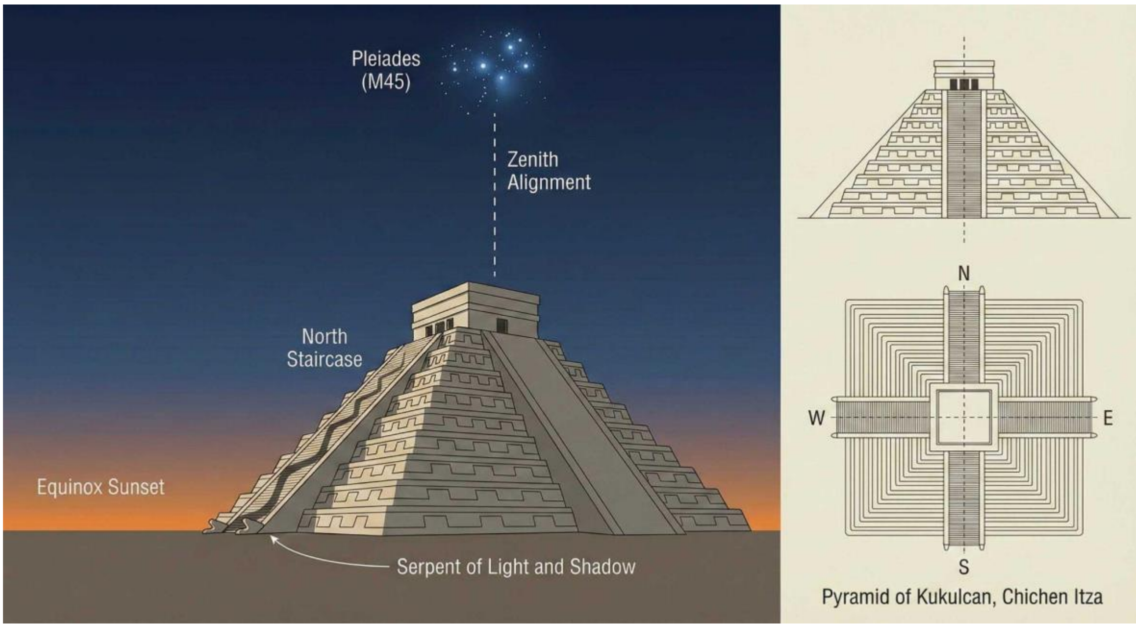

FIGURE 1. A diagrammatic simulation of the Pyramid of Kukulcan at Chichen Itza, illustrating the zenith alignment of the Pleiades (M45) synchronized with the solar “serpent of light” phenomenon.

Applying this physiological lens to monumental sites reveals that their alignments seamlessly materialize these perceptual structures rather than mere abstract geometries. At Teotihuacan (Latitude 19.7° N), the orthogonal east-west axis of the Pyramid of the Sun (285.5°) perfectly matches the setting azimuth of the Pleiades. As this “Swarm Anchor” descended through the ideal 20–40° perceptual range, its afterimage guided the city's foundational grid. At Stonehenge (Latitude 51.18° N), the Milky Way (Layer Image) aligns parallel to the solstitial axis, seamlessly extending the architectural path into the thickest region of the celestial luminous band. Crucially, at Chichen Itza (Latitude 20.68° N) around 900 CE, the declination of the Pleiades (+20.74°) precisely matched the site's latitude. This allowed the Swarm to cross the exact zenith (altitude 90°), mathematically minimizing atmospheric extinction and pushing the Swarm Score to its global maximum. Paired with the equinox sunset's “serpent of light”, this zenith swarm completed the mythic visual narrative of the feathered serpent descending to Earth.

The correspondence between afterimage-driven perceptual structures and iconic ceremonial sites demonstrates that ancient sky interpretations were deeply grounded in shared physiological perception. By consolidating archaeoastronomy, cognitive science, and visual physiology, this framework provides a new quantitative and interpretive lens to approximate ancient visual consciousness.

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HERCULES AND THE CENTAURS: MYTH AND ASTRONOMY BETWEEN ANCIENT GREECE AND INDIA

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Centaurs, Gandharvas, Sagittarius

Centaurs constitute one of the most enduring and extensively studied figures in ancient mythology and astronomical symbolism. Their hybrid nature —half human, half equine— has attracted sustained scholarly interest across multiple disciplines, including classical philology, comparative mythology, art history, and the history of ancient astronomy/astrology. The bibliography on Centaurs is vast, and yet, despite more than a century of research, there is no scholarly consensus regarding either their origin or their primary mythological function. A wide range of theories has been proposed: Centaurs have been interpreted as ancient water spirits, as “prickers of bulls”, as mythic beings inspired by the first encounters of sedentary populations with mounted nomads, or as the result of the evolution and adaptation of older Near Eastern and Indian hybrid figures.

In recent decades, the dominant tendency in scholarship has been to look eastward, particularly toward Mesopotamia, for the origins of Centaur-like figures. Indeed, Mesopotamian iconography and mythology preserve a variety of hybrid beings that resemble Centaurs in form or function, and these parallels have often been considered more convincing than earlier Indo-European comparative approaches. By contrast, the role of India in the formation or conceptual background of the Centaurs —once proposed by scholars such as Elard Hugo MEYER— has largely fallen out of favor and has been subjected to substantial criticism, often being dismissed as speculative or methodologically outdated.

This paper aims to reopen and reassess the question of the relationship between Greek Centaurs and Indian mythological figures, particularly the Gandharvas. Rather than simply repeating earlier comparative arguments, it seeks to provide additional evidence and a broader interpretative framework that integrates mythology with ancient astronomical and astrological traditions. The study argues that the marginalization of India in current discussions of Centaur origins may obscure important trans-cultural connections that operated alongside, and in interaction with, Mesopotamian influences.

A central methodological axis of the paper is the comparative analysis of heroic figures who interact with these hybrid beings. In Greco-Roman mythology, Heracles/Hercules occupies a pivotal position in narratives involving Centaurs, most notably through episodes of violent confrontation that establish boundaries between civilization and liminality, order and excess. In Indian mythology, a structurally comparable role is played by the god Indra and his relation to the Gandharvas in Vedic and post-Vedic traditions. By examining the mythic patterns surrounding Heracles/Hercules and Indra, this study explores shared narrative structures, symbolic functions, and cosmological implications that extend beyond superficial similarities.

The paper adopts an interdisciplinary methodology combining comparative mythology, textual analysis, and the history of ancient astronomy and astrology. It builds on the work of scholars such as David PINGREE, who have demonstrated the deep and complex interrelationships among Babylonian, Greek, and Indian astronomical and astrological systems. These interconnections suggest that mythological exchanges were often accompanied by parallel transfers of astral knowledge, symbolic constellations, and cosmological models.

FIGURE 1. Black-figure kantharos depicting Heracles and Centaurs.
Boeotia, ca. 550 BCE. Antikensammlungen, Munich.

The main conclusion anticipated by this study is that, alongside Mesopotamian influences, India played a significant and previously underappreciated role in shaping Greek conceptions of Centaurs. This influence operated not only on the level of mythological narrative but also within the domain of ancient astronomy and astrology. By reintegrating Indian evidence into the discussion, the paper seeks to contribute to a more nuanced understanding of Centaurs as products of a complex network of intercultural interactions spanning Greece, Mesopotamia, and India.

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SOLSTICES AND EQUINOXES. MONITORING THE POSITIONS AND MOVEMENTS OF THE SUN THROUGH THE EYES OF THE ANCESTORS

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Solar observatory, Kliszeczyk Petrota, summer solstices, equinoxes, Trypia Petra

This research approaches and deepens interpretatively, prehistoric or even historical monumental complexes, seeking to understand through cognitive archaeology "how" ancient peoples thought using material structures (MALAFOURIS 2013). Two examples of solar observatories in different locations in northern Greece —the first in Thrace (Kliszeczyk Petrota) and the second in North-western Macedonia (Trypia Petra, in the village of Pigi, Axioupolis)— develop a common view of the world and the purposefulness of human constructions, a product of intelligent and cultic behavior that highlights and contributes to the cultural progress of their group and the evolution of their material culture. The prehistoric solar observatory of Kliszeczyk is the first in Greece and Greek Thrace and is situated in the wider area of Petrota, 1120 m straight from the Mitroo of the akropolis of Petrota (Saint George). It was found in January 2019 by the archaeologist of the Laboratory of Folklore and Social Anthropology of the Democritus University of Thrace Stavros KIOTSEKOGLOU (2016). An archaeoastronomical research was conducted in October 2019 by Alexey STOEV and Penka MAGLOVA. The rock-cut monument consists of a central rock massif (sanctuary) and a circle of stones with a diameter of 40 meters. Two segments of the circle are built with a double row of stones. It is located on a smooth hillside near a river, northeast of the ancient settlement of Petrota, in the Rhodope regional unit. In this sense, the rocky peak of the acropolis of Mitroo Petrota, plays the role of a sacred mountain (like Olympus in antiquity) for the people who created the carved monument at its foot. The image of the sacred mountain invariably includes combination of several characteristic relief forms —peak, stepped slope, cave, presence of water (spring, lake, river)— in the neighborhood.

Methodology of Archaeoastronomical Research: The methodology of archaeoastronomical investigation (STOEV *&al*. 2007) includes

- determining of the geographic co-ordinates (latitude and longitude) of the rock-cut monument,
- determining of the structural elements and orientation of the rock-cut monument,
- preliminary study of the archaeological data obtained from excavations or surface survey,
- preparation of a high precision horizontal and vertical plan of the rock-cut monument,
- measurement of the basic sight directions on its territory,
- making a photo panorama of the local horizon from the place of observation supposed to the ancient observer,
- measuring of the azimuths of characteristic relief marks from the visible horizon line in order to find their relation to the structural elements and orientations at the investigated site,
- determining of the chronological boundaries of existence of rock-cut monument.

The method developed by LOCKYER (1906) is used to determine the chronological boundaries of the use of the object. The location has been associated with beliefs and traditions, known in the surrounding area to this day, with irrefutable proof in the small metal iconostasis placed at the base of the rock dedicated to Panagia Phaneromeni. This intense cult activity is due to the solar penetration at sunset on December 21st, through the transparent stone, forming a luminous effigy of a bird. The rays of the sun, as a phallic equivalent, symbolically fertilize the Great Mother

Goddess who "dwells in the rock" and is depicted on the ridge of the rock with human features, a result of the cult beliefs of the ancient Paeonians, inhabitants of the area, who have common cult beliefs with the Thracian Kikones of Kliszeczyk Petrota (*Herdt.* 5, 12–15).

FIGURE 1 (top left): Kliszeczyk Petrota, outdoor megalithic solar observatory: red arrow (bottom) of visual alignment with the rocky hill in the image and the sunrise of the winter solstice, purple arrow (middle) of alignment with the sunrise of the equinox, yellow arrow (top) of alignment with the sunrise of the summer solstice.

FIGURE 2 (top right): The sun's rays pass through the translucent stone, forming a luminous bird figure.

FIGURE 3 (bottom left): The ridge of the rock was shaped into a human face embodying the Great Mother Goddess. The red arrow shows the "Hole Stone".

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TIRESIAS AND THE WELL-MADE OAR: COSMIC ORIENTATION IN BRONZE AGE SACRED ARCHITECTURE

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Archaeoastronomy, Homeric Studies, The *Odyssey*, Mycenean, Minoan, Sacred Architecture, Bronze Age ritual, gnomon

Using different approaches, several scholars have identified a persistent solar theme that runs through the Odyssey. Douglas FRAME (1978) grounds it in the Indo-European etymology of the hero's *nostos*; Gregory NAGY (1990) finds an extended solar metaphor running through the poem's theme and diction; and Nanno MARINATOS (2001) reads the hero's journey as structured on the east-west solar cosmic journey of the Egyptian sun god Ra. This paper extends this interpretive route and, through textual and ritual sequence analysis, argues that the *Odyssey* both encodes astronomical *content* and preserves the memory of a technical *practice*. That practice is the use of a gnomon, or gnomon-like instrument, an upright, well-made shaft whose shadow is marked on the ground, to fix the solar or cardinal orientation of sacred architecture before construction begins. The premise extends Gregory Nagy's demonstration that the bardic tradition transmits implicit references to hero cult (NAGY, 2012, 52–60). In this paper, technical knowledge in sacred construction is also observed to be transmitted in the epic.

Book 11 of the *Odyssey* describes a detailed ritual at the edge of Hades. Circe's directions for the ritual are detailed and include the digging of a sacrificial pit (*bothros*) to a specified measure: a cubit in each direction (*Od.* 10.517). Tiresias's instructions belong to the same register of technical precision and warrant being read as functionally intentional rather than vaguely symbolic. Significant is the command to carry a well-made oar (εὐῆρες ἐρετμόν, *Od.* 11.129) inland and plant it upright in bare earth, which itself is the first act of founding, performed before the sacrifice to Poseidon which consecrates the site. Just before Tiresias's instructions, Odysseus's deceased (and still unburied) crewmate Elpenor appeared and gave instructions that an oar be planted as a last step, on top of his completed burial mound (τύμβῳ, *Od.* 11.75–78). Whereas Elpenor's oar is planted atop his finished tomb and is therefore commemorative, Tiresias's well-made oar is functional, planted in bare ground before anything is built (argued in the paper to be Odysseus's future tomb). Elpenor's appearance immediately before Tiresias is read here as a deliberate juxtaposition that foreshadows and "decodes" the prophet's enigmatic command. The paper proposes that this upright, well-made shaft (the oar), set first and to a true vertical, is not merely a symbolic *sēma*, or cult marker, but in essence functions as a gnomon: an instrument by which the cardinal or solar orientation of sacred architecture is fixed on the ground as a guide before construction begins.

A second episode may preserve a reference to a gnomonic procedure. After climbing to a height to survey Circe's island, which is located at the eastern end of the world where the sun rises, Odysseus stated he could not determine where the sun rises or sets or goes beneath the earth (*Od.* 10.190–195). For Odysseus to arrive at this conclusion suggests knowledge of a method for tracking the sun by observing the movement or orientation of shadows: a nod to gnomonic procedure.

Table 1. A sample of Aegean Bronze Age sites where a gnomon/vertical object was likely used to cast a shadow at the moment of sunrise or sunset. The shadow, once marked on the ground, served as a guide for the future orientation of architecture.

Site / structure	Culture / type	Orientation (solar target)	Researchers
Vapheio, tholos dromos	Mycenean tholos	summer solstice sunrise	DAVIS *&al.* 2017
Mycenae, tomb of the Genii	Mycenean tholos	summer solstice sunrise	DAVIS *&al.* 2017
Mycenae, tomb of Atreus	Mycenean tholos	equinox sunrise	DAVIS *&al.* 2017
Koumasa, tholos E	Minoan tholos	summer solstice sunrise	AYASH 2023
Knossos, corridor of the House Tablets	Minoan palace	equinox sunrise (autumn focus)	BLOMBERG & HENRIKSSON 2001
Petsophas	Minoan peak sanctuary	summer solstice sunrise + equinox sunset	BLOMBERG & HENRIKSSON 1996; 2001
Kangelisses, Kefalonia	Middle Helladic cemetery cist graves	equinox + summer solstice + cardinal points	KOKKOLIS 2025

The archaeological record of Aegean sacred architecture, in which deliberate solar and cardinal orientations have been documented, provides evidence of gnomon practice. The practice appears strongest in Minoan Crete and was adopted only selectively on the Mycenaean mainland. Although orientation in Mycenaean funerary architecture was largely governed by topography, slope, and access, solar-oriented entrances are attested at certain monuments (see Table 1) Where topography is the accepted determining factor, only a stratigraphic analysis can confirm that the topography itself was never manipulated. Crucially, while a solstitial alignment can be captured by horizon observation alone, only the marking of a cast shadow can provide the measurement, placement, and orientation of future specific architectural features, such as a dromos or entrance for light to pass through.

The paper concludes that the bardic tradition preserved, in the form of a ritual instruction, the memory of a gnomonic founding procedure. Furthermore, this practice belongs to a broader phenomenon of solar and cardinal orientation in Aegean sacred architecture that did not end with the Bronze Age but persisted into the historical period.

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ESTIMATING ORIENTATION IN ROMAN TOWNS: AN AI-BASED APPROACH

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Artificial Intelligence, Roman towns, Remote sensing

The connection between astronomy and the Roman landscape —evident in various myths— is reflected in the literature of the 1st c. BCE. Roman technical literature and writers, such as the *Corpus Agrimensorum* and Oribasius, describe the binary division of the Roman town into two principal axes: the *decumanus maximus*, running east-west and the *cardo maximus*, running north-south. Previous archaeoastronomical research has examined the orientations of urban and military settlements in both the western and eastern parts of the Empire. Some of these have been identified as compatible with astronomical phenomena, such as the winter solstice, as well as culturally significant dates in Roman society (RODRÍGUEZ-ANTÓN 2017). The expansionist policy of the Romans led to the creation and reconstruction of numerous military and urban settlements over the centuries. The original layouts of many sites are only partially preserved, obscured by vegetation or modern development, or being inaccessible for *in situ* measurements due to political conditions (RODRÍGUEZ-ANTÓN *&al*. 2018). In such cases, remote sensing and planimetric analysis using excavation plans can support the reconstruction of the orientation of ancient towns. However, excavation plans are limited in number and are not always publicly available. In recent years, artificial intelligence (AI) has been integrated into archaeological research. FUSCO *&al*. (2023) used aerial photographs in combination with traditional computational algorithms and deep learning architectures to detect the Roman centuriation system, a system of land division. However, the application of AI to orientation analysis in archaeoastronomy remains unexplored. Previous studies have shown that remote sensing tools, such as Google Earth Pro (GE) and Geographic Information Systems (GIS), are effective for archaeoastronomical studies, particularly in cases where access is limited. In such cases, orientation can be extracted using modern GIS techniques instead of *in situ* measurements. However, differences between traditional and digital methods have been observed, with errors of around 1–3 degrees (RODRÍGUEZ-ANTÓN *&al*. 2018). Although the analysis of sites using these methods can be time-consuming, this study explores whether AI can help automate the process.

Training AI models typically requires large amounts of data, which are often not available in satellite imagery of Roman towns due to the limited number of known sites. In such data-scarce conditions, augmented images can support model training for supervised learning tasks (NUNEZ JARENO *&al*. 2021). This work aims to train AI models for automated orientation (azimuth) extraction from satellite imagery, using Roman towns as a case study. In parallel, it evaluates the model by comparing its predictions with recent *in situ* measurements and previous GE measurements across different towns and castra of Dacia (FRINCU 2022), located in the eastern province of the Empire. Our evaluation dataset includes satellite images of Roman towns in Dacia obtained from GE. The dataset incorporates diverse preservation states and landscape conditions across different provinces, including ruins, vegetation, and modern urban layouts as well as varying orientations. Each site was identified based on the visible city walls; where the limits of the ancient town were not distinguishable, excavation plans were used as references to identify the original layout. Azimuth values were derived by georeferencing the plans and aerial imagery to true north using GE and through fieldwork measurements and compared against AI derived values. The aim of this research is to demonstrate the potential of combining AI and remote sensing for orientation analysis. In particular, it examines how accurately AI can predict azimuth values and compares the differences between *in situ* and remote sensing measurements. Through this analysis, the study assesses whether AI tools can support reliable orientation estimation, especially at sites where direct measurement is not feasible.

FIGURE 1. Satellite image of the Roman site of Drobeta (Dacia, Romania), showing the preserved urban layout and its visible axes. Image from Google Earth (© Airbus).

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ARCHAEOSKY: A COMPUTATIONAL PLATFORM FOR ARCHAEOASTRONOMICAL ANALYSIS OF THE ROMAN WORLD

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Software, Roman world, Archaeoastronomy

Astroinformatics, geoarchaeology, and computational archaeology are increasingly integrated into academic research, providing tools and software that enable rapid data collection and processing. Within archaeoastronomy, digital tools generally fall into three main categories: visualization and reconstruction of the sky and landscape, calculation of archaeoastronomical parameters, and statistical analysis of orientation data.

Current tools focus mainly on the deterministic nature of the analysis, placing greater emphasis on the mathematical aspects of astronomical calculations (e.g., RUGGLES's declination calculator) as well as on the modelling of the horizon profile via DEM data. However, in archaeoastronomical analysis, numbers have no meaning without context. Without astronomical and calendrical context, it is difficult to assess the cultural significance of ancient orientations. Historical calendrical systems, such as the Julian, Greek, and Egyptian calendars, are not always integrated within the same environment in existing tools. Furthermore, calendar conversions are often performed using separate tools or custom scripts. As a result, researchers or students who are not familiar with computer science do not have direct access to such environments. To address these limitations, we introduce ArchaeoSky, a computational archaeoastronomical platform that integrates astronomical calculations with calendrical context in an accessible environment within the context of the Roman world.

The system was implemented in Python to support integration into external analytical pipelines through an API and to ensure reproducible analyses. Users without programming experience can access ArchaeoSky via a web version. Each analysis is defined by a set of user-defined input parameters: azimuth (A), latitude (φ), horizon altitude (h), angular tolerance, and chronology (year or century), following the standard mathematical formula for declination (δ):

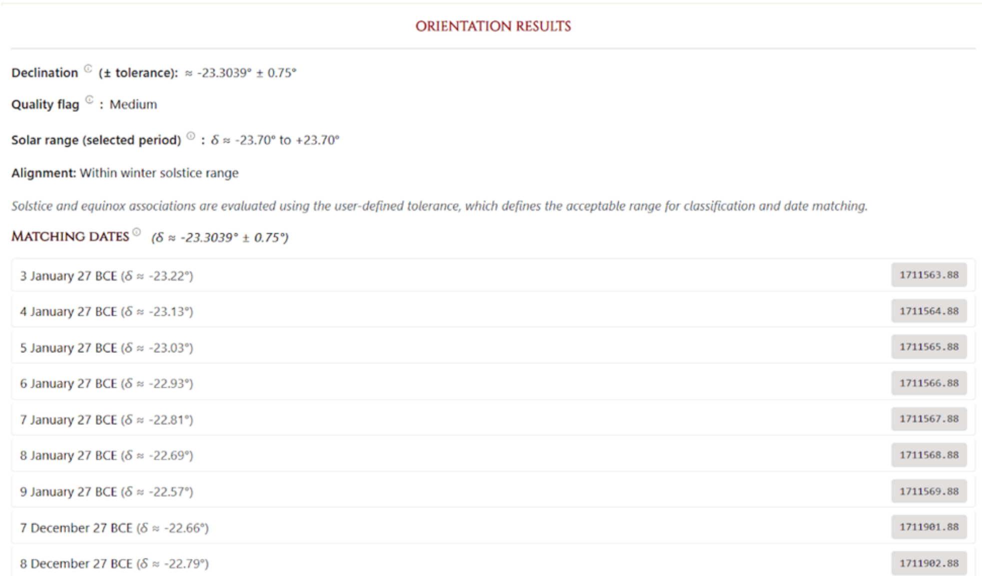
$$sin\ \delta = sin\ \varphi\ sin\ h + cos\ \varphi\ cos\ h\ cos\ A$$

as applied in previous studies (RUGGLES 2015). Angular tolerance, represents a value that reflects the combined effect of multiple sources of error arising during the analysis.

ArchaeoSky's astronomical dataset was created from the NAIF DE431 file of NASA's Jet Propulsion Laboratory, which is considered suitable for historical astronomical research (FOLKNER *&al*. 2014). The dataset contains geocentric solar δ values for the period 27 BCE – 476 CE, corresponding to the Roman Empire. The final dataset includes the Sun's declination for each day, the Julian Day Number (JDN), and the corresponding date in the Julian calendar in historical format. JDN values were derived using the *Skyfield* library, while Julian calendar dates were generated based on the algorithm of MEEUS (1998). The Sun was selected as the main celestial body, as ancient testimonies (e.g., *Corpus Agrimensorum*, *De Architectura* of Vitruvius) and previous research suggest symbolic connections between Roman planning, festivals, and the Sun (GONZÁLEZ-GARCÍA *&al*. 2019). For each case, the system computes the target δ and evaluates whether it falls within the annual solar declination range for the corresponding input year by comparing it with the maximum and minimum solar δ values from the dataset. If the target δ falls within the solar range, the platform presents the corresponding temporal windows. These windows include all the Julian calendar dates within the selected chronology whose solar δ satisfies the specified tolerance.

The orientation results table (see FIGURE 1) includes the *δ* value and the user-defined tolerance, the annual solar range, and the matching dates (temporal windows). The latter incorporates calendrical and astronomical data, including the historical date, the JDN, and the declination value for each day. Users also have the ability to export the results via a CSV file, which includes the matching dates and the input parameters.

The aim of ArchaeoSky is to provide an accessible computational environment that standardizes archaeoastronomical analysis by combining both astronomical and historical data, while following standard and well-defined practices. The option to export the results provides transparency, while its speed allows users to verify and reproduce published results and perform preliminary analysis of understudied sites. As the platform is accompanied by a user guide, it is easy to use and enables quick experimentation, and can be used by researchers or students who are not familiar with computational methods. Future applications of ArchaeoSky include an interactive map that will incorporate potential orientations across the Roman Empire, as well as the expansion of the dataset across different historical periods and calendrical systems.


ORIENTATION RESULTS

Declination (± tolerance): ≈ -23.3039° ± 0.75°

Quality flag : Medium

Solar range (selected period) : δ ≈ -23.70° to +23.70°

Alignment: Within winter solstice range

Solstice and equinox associations are evaluated using the user-defined tolerance, which defines the acceptable range for classification and date matching.

MATCHING DATES *(δ ≈ -23.3039° ± 0.75°)*

3 January 27 BCE (δ ≈ -23.22°)	1711563.88
4 January 27 BCE (δ ≈ -23.13°)	1711564.88
5 January 27 BCE (δ ≈ -23.03°)	1711565.88
6 January 27 BCE (δ ≈ -22.93°)	1711566.88
7 January 27 BCE (δ ≈ -22.81°)	1711567.88
8 January 27 BCE (δ ≈ -22.69°)	1711568.88
9 January 27 BCE (δ ≈ -22.57°)	1711569.88
7 December 27 BCE (δ ≈ -22.66°)	1711901.88
8 December 27 BCE (δ ≈ -22.79°)	1711902.88

FIGURE 1. Example of the ArchaeoSky results table, showing the target δ, user-defined tolerance, solar range, and the corresponding matching dates.

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CULTURAL ASTRONOMY IN *CANDOMBLÉ* AND ITS POTENTIAL FOR SCIENCE EDUCATION

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Cultural Astronomy, Science Education, Afro-Brazilian Culture

Brazil is a country of continental dimensions and profound ethnic diversity. Yet, its formal science curriculum remains heavily anchored in a Eurocentric perspective. This disconnect is particularly evident in Astronomy Education, which systematically ignores the rich cosmological systems of Afro-Brazilian populations (ALVES-BRITO 2021), despite the legal requirement to teach Afro-Brazilian history and culture in the country's basic education system (according to Federal Law 10.639/03, BRASIL 2003). To address this gap, where specific data on Afro-Brazilian celestial phenomena remains largely undocumented, this research investigates the astronomical knowledge preserved in Candomblé, an Afro-Brazilian religious tradition rooted in African heritage. Nevertheless, this work aims at developing a didactic transposition for formal education in alignment with the Brazilian National Common Curricular Base (BNCC).

The theoretical framework draws upon Decolonial Studies, aiming to combat epistemicide. CARNEIRO (2005) defines "epistemicide" beyond the mere erasure of knowledge: this concept here describes a persistent mechanism of intellectual inferiorization that disqualifies and delegitimizes Black people as valid holders and creators of knowledge. Consequently, "*(...) epistemicide mortally wounds or sequesters the rationality of the subjugated, mutilates the capacity to learn, etc*" (CARNEIRO 2005: 97). Therefore, integrating knowledge systems developed by Afro-Brazilian cultural groups into the classroom serves as a direct countermeasure to this process. This practice validates these communities as legitimate holders and creators of knowledge, acting as a foundational strategy for an effective anti-racist education.

Within this scope, the *Candomblé* is defined not only as a religion, but as a complex civilizational system created by enslaved Africans in Brazil during the colonial period, that until today deeply preserves the knowledge systems brought by those trafficked during the Atlantic trade (DOS SANTOS LEITE 2017). Rooted in several African traditions (such as Yoruba, Ewe-Fon, and Bantu), it possesses an intrinsic relationship with nature, preserving a complex knowledge system despite centuries of colonial violence and attempted erasure. By ignoring this knowledge, the Brazilian educational system perpetuates a colonial logic that separates students from their own cultural heritage, failing to comply effectively with Brazilian Federal Law 10.639/03.

This research adopts a qualitative approach rooted in Ethnoastronomy and Science Education. The primary methodology involves Oral History, recognizing the oral tradition as the central vehicle for knowledge transmission in Candomblé communities. The study aims to engage with community elders (*mais velhos*) from traditional *Terreiros* (Candomblé temples). Data will be collected through semi-structured interviews, a format chosen to grant interviewees 'epistemic freedom' to narrate their cosmological understandings without being confined by rigid Western academic categories. Currently, the methodological design is under review by the Research Ethics Committee (CEP), adhering to strict protocols to ensure participant safety.

FIGURE 1. Ritual of 'Águas de Oxalá' (Waters of Oxalá).
Photo: Úrsula Freire, courtesy Wikimedia Commons.

Finally, based on the knowledge shared in these dialogues, the researcher will develop an educational resource (Didactic Sequence). This material aims to connect the oral traditions of the *Terreiros* with topics of the formal science curriculum, providing teachers with concrete pedagogical tools to implement Law 10.639/03 and foster an intercultural dialogue in the classroom.

By engaging with the oral tradition of the *Terreiros*, this research seeks to identify and systematize astronomical concepts that are currently absent from academic literature. The central hypothesis is that these communities possess a structured knowledge of celestial phenomena, closely linked to environmental cycles, that acts as a tool for the cultural system preserved by them.

Ultimately, this study underscores the urgency of decolonizing and bringing Afro-Brazilian perspectives into Astronomy Education in Brazil. By bridging the gap between academic science and the ancestral knowledge of *Terreiros*, the research contributes to a more inclusive curriculum. It demonstrates that complying with Law 10.639/03 is not merely a legal duty, but an opportunity to enrich scientific literacy with diverse cultural perspectives, ensuring that Afro-Brazilian history is recognized as a legitimate producer of knowledge.

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AN AMAZING SOLAR EPIPHANY (*HĒLIASMOS*) IN TWO COPTIC CHURCHES OF THE DELTA (ṢAHRAGT ʾAL-KUBRA AND KAFR ʾAD-DAIR)

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Archaeoastronomy, Astronomy, Solar Phenomena, Solar Symbolism, Coptic Architecture, Ancient Egyptian Orientation Methods, Solar Cult, Amarna Period, Akhenaten

Many ancient cultures related their sacred sites with firmamental periodicities, between which those of the stars and the Sun were the most important. This was particularly interpreted by orienting a sacred space in a way that could put it in direct relation to the divine; especially with symbolic undertones of certain astronomical bodies, like the Sun, whose blazing light could be considered as a quasi-divine and sacred symbol of (theological and metaphysical) virtue.

A fascinating archaeoastronomical aspect of Coptic Sacred Architecture is related to illumination effects, when the solar light marks some significant points at specific times, concerned with the celebration of the Holy Mass. During these instances an amazing phenomenon of *Hēliasmos* is being observed, when the solar rays hit the Altar at the exact time of the ritual, which also takes into account the specific calendric (*i.e.*: synaxaric) details for each Saint. The entrance of sunlight is taking place from small windows constructed on the dome (cupola) over the Altar, which seem to be not randomly, but properly, chosen in order to permit the solar rays to illuminate the Altar in a very specific time related to the concomitant ritual. To the best of the authors' knowledge, there are (at least) two Coptic Churches in Egypt, both of them in the Delta Area, which consist of unique paradigms of a perfect archaeoastronomical solar orientation; all of them fulfill the aforementioned criteria and *Hēliasmos* is happening at precisely calculated moments concerned with the celebration of the Holy Mass.

These Churches are situated in the Lower Egypt, namely Ṣahragt ʾal-Kubra and Kafr ʾad-Dair. Each one has three separate altars for the celebration of certain feasts dedicated to three different Saints. In Ṣahragt ʾal-Kubra the Eastern (Central) Altar is for Saint George, the Northern Altar is dedicated to Virgin Mary and the Southern Altar is for Archangel Michael. In Kafr ʾad-Dair the Eastern (Central) Altar is for Archangel Michael, the Northern Altar is (again) for Virgin Mary and the Southern Altar is for Saint George. In all six instances, the Altars are properly and amply illuminated during specific feasts of the honoured Saints during specific hours of the synaxaric celebration of the Holy Mass. The precise architectural contruction of the small windows of the domes over each altar permits the solar light to enter and hit all six of them with a phenomenal accuracy and perfect timing.

The present study examines in scrutiny with archaeoastronomical methods and software the background of Practical Astronomy and the special architectural whereabouts of these Churches that permit such breathtaking phenomena of *Hēliasmos* to happen, excluding any accidental origin of the lighting effects. Not only solar charts and characteristic pictures featuring the observed phenomena are presented, but useful archaeoastronomical diagrams too, which clarify and explain everything properly. This special and interesting orientation is thoroughly discussed in terms of astronomical, archaeoastronomical, architectural and theological perspectives.

Finally, the continuity of astronomical orientation practices from Pharaonic Religion into Christianity is examined. Emphasis is given on paralleled to ancient solar worship of Amarna depictions of Akhenaten adoring his (sole solar) god under the blazing sunlight, and the seasonal orientation of the Small Temple of Akhet-Aten (*Ḥwt-Ỉtn*); the similar orientation of the Great Temple of Ramses II at Abū Simbel; the solsticial orientation of significant temples in the broader area of Luxor towards the Winter Solstice sunrise —Great Temple of Amūn-Rē‘ at Karnak (*Ỉpt-Swt*), Mortuary Temples of Hāt-shepsūt (*Ḏsr-Ḏsrw*) and Monthū-hotep II (*Ꜣḫ-swt* (*Nb-ḥpt-Rꜥ*)) at Deir ’el-Bahri.

FIGURE 1. Hēliasmos during the celebration of the Holy Mass at the Altar of Saint George, in the Church of Ṣahragt ’al-Kubra (Left), and at the Altar of Archangel Michael, in the Church of Kafr ’ad-Dair (Right).

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WHEEL-CROSSES IN SOUTHERN GALICIA: ARCHAEOASTRONOMICAL PATTERNS AND INTERPRETATIONS

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Archaeoastronomy, Rock art, Wheel crosses, Bronze Age cosmology

Archaeoastronomy has proved fundamental to the study of rock art, allowing researchers to move beyond merely descriptive and contextual analyses by identifying non-random orientations that link prehistoric engravings to celestial cycles, seasonal rituals and ancestral cosmologies. In Northwest Iberia, rock outcrops engraved with wheel crosses emerge as paradigmatic cases of this interdisciplinary approach, in which the landscape acts as an interface between human communities, topography and the celestial sphere (MARINHO *&al*. 2025).

FIGURE 1. Engraved outcrop of Chan da Lagoa 1, in Campo Lameiro, Galicia: wheel crosses (segmented circles) and their relationship with other motifs. Photo courtesy of Megaliticia.

The main objective of this study is to undertake a comparative assessment of the archaeo-astronomical data obtained from two datasets: around twenty-nine outcrops in Northwest Portugal and more than ninety inventoried sites in southern and south-western Galicia. In Portugal, precise measurements of azimuth and horizon elevation, calculated declinations and celestial reconstructions (Stellarium / PeakFinder / Horizon) document peaks along N-S axes (±45°), solstices (±23°), equinoxes (0°) and a possible lunar standstill (–30°), with case studies demonstrating structured local concentrations.

The analysis brings these results together with the Galician corpus, testing the existence of cross-border continuity or significant variations that may reflect cultural, topographic or chronological differences. This substantial increase in cases provides a statistically robust basis, clarifying the role of wheel crosses within the cosmological grammar of the Bronze Age in Northwest Iberia.

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BEYOND SALT: A NEOLITHIC FUNERARY VESSEL AS A POSSIBLE ASTRONOMICAL TOOL?

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Neolithic, funerary vessel, liquid mirror, astronomy, Lunar cycles, meridian, altitude

This study examines a remarkable Neolithic-era ceramic found beneath the *Lannec er Gadouer* mound in Brittany (France), within a funerary vault dated to 4400 BCE. Initially believed to have been used as a vessel for heating saltwater (CASSEN 2012), this study suggests an alternative hypothesis. While there is no definitive evidence that liquid reflection was employed to measure the altitude of stars in ancient times, it remains a plausible possibility. The ceramic may have functioned as a liquid mirror, designed specifically for celestial observation, particularly for determining the altitude of celestial bodies as they crossed the meridian.

FIGURE 1. Flat-based ceramic with sub-vertical walls and incised external decoration

This hypothesis is supported by an experimental approach in which the reflection of the Moon—observed at the centre of a liquid-filled container— is measured in relation to the observer's position (the ground projection of the observer's eye). Further evidence comes from incised decoration on the outside of the ceramic base, organized into two distinct levels interpreted as a chthonic/aerial complementarity. The upper level features an "arboriform" motif, consisting of a central axis, 27 "branches" bearing 12 "spheres", and two half-circles positioned at the ends of the median ground line. The lower level presents three serpentine waves.

Interpreting these motifs as representations of the lunar year necessitates an examination of several astronomical factors, including the number of months in a year, the sidereal duration of a lunar month, the meridian altitudes of full moons, and the rising or setting positions of the full moon on the horizon. Additionally, the motifs may symbolically reflect the cyclical progression of day and night. Furthermore, a comparative analysis of 44 predominantly oral traditions across Europe reveals a consistent association between trees and the concept of the year. In these traditions, the year is depicted as a tree, with the number of branches and leaves corresponding to the number of seasons, months, and days. This lends further support to the proposed interpretation.

If confirmed, the Lannec er Gadouer ceramic would represent the earliest known depiction of this significant symbolic motif, suggesting that it held deep cosmological and practical meaning (in particular for tide prediction) for the Neolithic societies that created it.

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CHAN U'BIH: AN ONLINE ARCHAEOASTRONOMICAL RESEARCH ENGINE FOR HORIZON-BASED ALIGNMENT STUDIES

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ChanUbih, archaeoastronomy, software

The quantitative assessment of astronomical alignments in archaeological monuments demands high-precision tools capable of integrating celestial mechanics, topographic data, and atmospheric modelling within a coherent uncertainty framework. Existing software solutions address these domains in isolation, making researchers to combine multiple packages and propagate errors manually. This fragmentation introduces inconsistencies and limits the reproducibility of archaeoastronomical arguments, particularly when declination errors of fractions of a degree may determine whether an alignment is considered intentional.

FIGURE 1. Screenshot of the main dashboard.

Chan U'bih ("Four are the paths of the Sun" in Maya Ch'orti' language) is a browser-based archaeoastronomical research engine that integrates all computationally relevant modules into a single, reproducible pipeline. The system supports two interchangeable ephemeris back-ends: NASA JPL DE441 (via the Skyfield library) for maximum precision in the range −3000 to +3000, and the PyEphem Python library based on the VSOP87 planetary motion theory for rapid exploratory calculation. All coordinates are computed as topocentric apparent positions referred to the True Equator and Equinox of Date (EoD), the reference frame for azimuth comparisons at a specific terrestrial location. On the other hand, topocentric horizon altitudes are derived from high-resolution DEMs (COP30/AW3D30/SRTMGL1 priority cascade) with integrated Earth-curvature correction. Atmospheric refraction follows the standard model (P = 1013.25 mbar, T = 10 °C) augmented by a geodetic correction gradient. The resulting topocentric azimuth carries a combined uncertainty of ±0.15° (refraction + astrometry), propagated analytically through the declination formula and reported explicitly in all outputs.

The engine computes a comprehensive suite of astronomical events, including most of the archaeoastronomical research-related variables in any cultural regions and historical time frame: solstices, equinoxes, and zenith passages with precision ±2 s; major lunar standstills and the longitude of the ascending node Ω (uncertainty < 0.0001°); the full synodic cycle of Venus including morning and evening phenomena with time resolution to the second; and heliacal rising dates for catalogue stars using the B. Schaefer dynamic arc-of-vision model (SCHAEFER 1987), adjusted by apparent magnitude and atmospheric extinction coefficient k. Stellar proper motions are taken from the Hipparcos/Gaia J2000.0 catalogue. The ΔT correction follows the Morrison & Stephenson polynomial series, incorporating tidal braking and post-glacial rebound residuals, with accumulated uncertainty ±1 s at the epoch of the telescopic record.

Results are presented in a dual-panel interface (FIGURE 1): an interactive azimuth-altitude diagram overlaying the DEM-based horizon profile with the computed solar, lunar, and stellar arcs for any given epoch; and a tabular panel with time-stamped ephemerides. A multi-page technical PDF report is generated on demand, embedding the diagram rendered for print (CMYK-optimised palette), full ephemeris tables with date and time separated to the second in Universal Time, and a structured "Reference System and Uncertainty Propagation" section that documents all models and their uncertainty budgets, enabling peer review of every parameter entering the alignment analysis.

Chan U'bih is a brand-new browser-based architecture which can deliver research-grade archaeo-astronomical computation without requiring local software installation, lowering the barrier to reproducible alignment studies including high resolution horizon profiles. The explicit, end-to-end uncertainty budget —from ephemeris to printed report— offers a methodological template for the discipline, focusing in reproducibility of quantitative arguments.

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CATCHING THE EQUINOX, SANTIAGO DE COMPOSTELA

John David MOONEY

John David Mooney Foundation, Chicago, USA

Art installation, Spain, Constellation, Hercules, Sundial

Catching the Equinox is a large-scale, site-specific drawing and light installation by sculptor John David Mooney created for the historic courtyard of the Faculty of Geography, Art History, and History at the University of Santiago de Compostela, Spain. Conceived for the interdisciplinary dialogue between astronomy, culture, and art, the project explores the relationship between celestial events, architectural space, and cultural memory.

FIGURE 1. Catching the equinox. © John David Mooney.

Occupying approximately 1,600 m^2 of the neoclassical courtyard, the installation is structured around a solar alignment revealed during the autumnal equinox. At solar noon on the equinox, the shadow cast by the courtyard's 6.7 m high central monument aligns precisely with the geometry of the courtyard. Research conducted in Chicago during the development of the project revealed that the courtyard and the building itself, which is an Enlightenment structure, are oriented to "true North". Mooney transforms this phenomenon into a monumental ground drawing that traces the movement of shadow across the site as a sundial, effectively turning the monument into a giant gnomon and the courtyard into a solar observatory. To accurately understand and plan this alignment, architectural models of the courtyard and the position of the sun throughout the year were created in the studio, calculating the solar position on the equinox, along with shadow paths and geometry.

The installation operates in two complementary phases. A daytime piece in which shadow geometry is articulated with line and shape, becoming a major piece of land art. This drawing emphasizes the astronomical alignment embedded within the architecture. By night, the space is transformed through an array of more than 1,100 solar-powered blue and white lanterns, invented in 2017 in Chicago by Anna Stork and Andrea Sreshta, which form a luminous field that references the colors of the Galician flag. This first use of LuminAID solar lanterns within an artwork is a unique demonstration of the technology's ability to provide light in disaster recovery environments. The curvilinear blue light forms evoke ocean waves and the shell shape associated with Santiago de Compostela, linking the site symbolically to the Atlantic coast and the nearby Tower of Hercules, of which Mooney believes the central monument refers.

Astronomical references of the autumnal equinox continue in the night installation, through the overhead constellation Hercules and the star Vega, whose outline and position is marked on the ground plane. Additional motifs, including Celtic spiral forms and a boat-like outline created from seashells, connect the work to regional myth, the pilgrimage traditions associated with Santiago de Compostela, and the broader historical relationship between navigation, the night sky, and cultural identity.

Through the integration of solar observation, constellation mapping, and symbolic landscape references, *Catching the Equinox* situates astronomical phenomena within a broader historical framework, demonstrating how contemporary art can reveal ancient relationships between sky, place, and human culture.

The artist will present visual process history of the project, from studio model making, to on site execution, the community involvement, and its afterlife. This presentation will be the first time that the project (created in 2017) has been documented and shown to an audience of scholars and the public.

TIWANAKU (BOLIVIA): AN ARCHAEOASTRONOMICAL STUDY ON THE ROLE OF THE STARS IN THE DATING OF THE SITE

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Tiahuanaku, Archaeoastronomy, Orion

In a previously presented work we analyzed the role of possible astronomical targets in the orientation of the site. In this paper we present new evidences of the archaeoastronomical analysis of Tiwanaku, which is located near the southern shores of Lake Titicaca on the Altiplano, at an altitude of 3,850 m., Department of La Paz, Bolivia.

It was a public-religious space of this city and it is shaped by a series of architectural structures. The Centre of the Tiwanaku Culture (200 BCE – 900 CE), contains traces of more than 1200 years of human occupation. It is the most important pre-Inca site of the Andean region of South America and the archaeological remains have maintained to a certain extent their physical integrity.

The Temple of the Sun, or Kalasasaya, perhaps is the best preserved of the ruins. Here is an immense rectangular terrace nearly 46 m^2 with its edges outlined by rows of cut stone columns from 4.5 to 6 m in height.

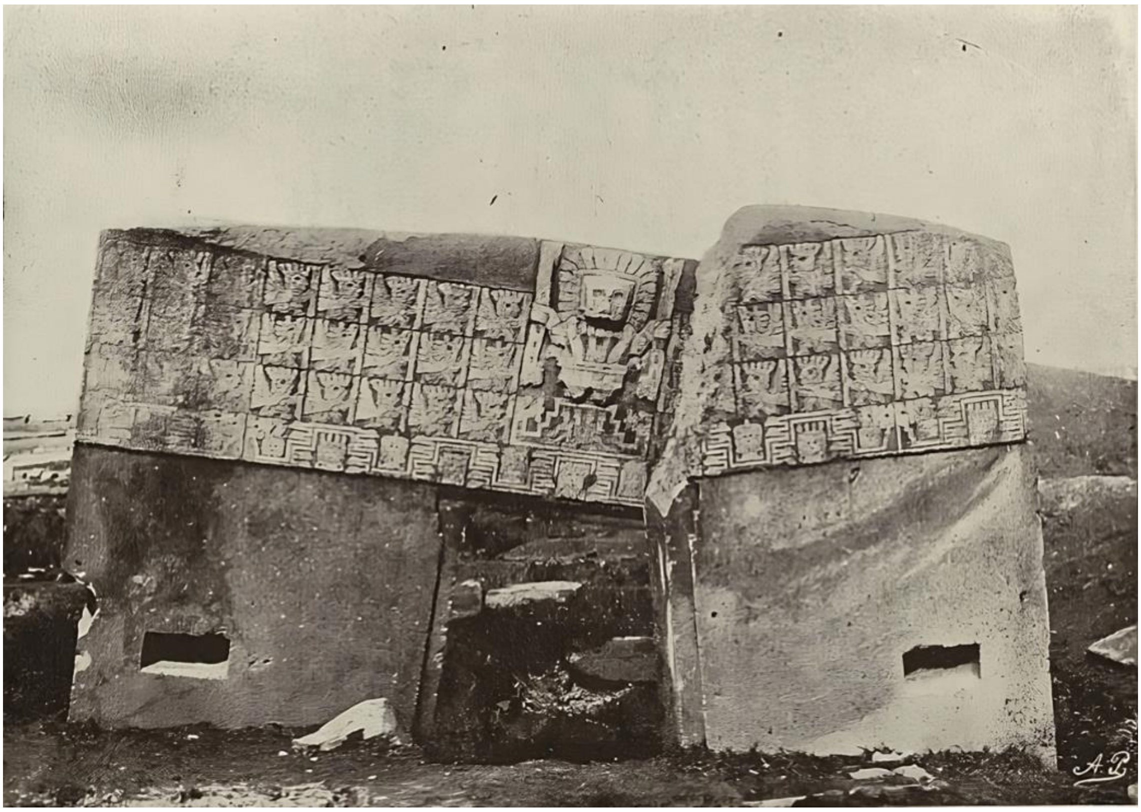

FIGURE 1. The Gate of the Sun in 1903. Photo: Arthur Posnansky, courtesy Wikimedia Commons.

The data have been collected *in situ*, by the authors in 2007–2008, 2014, 2019, 2022 in the area of Tiwanaku. It is a project carried out by AKAKOR to do research in collaboration with UNAR, that will continue over the next few years until the end of the investigations, for a geological, archaeological, astronomical and cartographic study.

The purpose of this new work is to highlight the close correlation between the alignments of the Kalasasaya temple towards stars belonging to the Orion constellation and then to apply a correct and scientific method to date the site, using the collimation between a structure and a star.

In 1943, Posnansky reckoned, with the method of varying the obliquity of the ecliptic over time, the date of the site, but he failed to realize that the high propagation of errors led to incorrect results.

In this analysis we suggest —by obtaining the alignment azimuth value from the GPS data detected *in situ* and knowing the star that is the target— that it is possible to define the dating period.

An aerial survey was carried out using a drone Phantom Gx and the data have been processed with the software Pix4D. The magnetic measurements have been corrected by the magnetic declination. We analyzed all the records, obtaining notable results. Subsequently an appropriate statistical study was carried out in order to check their astronomical consistency.

The statistical analysis was performed using the most recent techniques belonging to the theory of the Circular Data that is one of the most suitable ways in the archaeoastronomical data processing. Statistical test has been applied to verify the confidence level of the results obtained.

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From Logos to Algorithm: The Antikythera Mechanism Between Nomos, Physical Law, and Proto-Artificial Intelligence

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Antikythera mechanism, mechanical computation, algorithmic thinking, proto-artificial intelligence, determinism, astronomical cycles (Metonic, Callippic, Saros, Exeligmos), epistemic instruments, scientific instrumentation (antiquity), logos (λόγος), nomos (νόμος), laws of physics, ancient Greek cosmology, embedded knowledge systems, ancient automata, materialization of knowledge

This study proposes an integrated interpretation of the Antikythera Mechanism as a material synthesis of Greek philosophical concepts of *logos* and *nomos* with the operationalization of physical law in a mechanical system. Within classical Greek thought, logos denotes rational structure and intelligibility, while nomos —beyond its juridical sense— can be understood as the regular, law-like ordering of nature. The Antikythera Mechanism (*ca.* 150–100 BCE) represents a unique convergence of these abstractions into a fully realized analog computational device encoding astronomical periodicities.

Figure 1. Inscription from the Antikythera Mechanism.

Through its gear trains, differential rotations, and inscriptional program, the Mechanism transforms celestial phenomena —lunar phases, eclipses, planetary cycles— into deterministic, reproducible outputs. This transformation constitutes a shift from philosophical articulation to mechanical instantiation: natural law becomes algorithmic process. The device thus embodies what may be termed the “apotheosis of nomos”, where the regularities of the cosmos are not merely described but physically enacted.

The paper further argues that the Mechanism can be meaningfully interpreted as a proto-artificial intelligence system, not in the modern sense of adaptive or learning systems, but as a rule-based, predictive machine implementing encoded knowledge. Its operation corresponds to a fixed algorithmic architecture: input (manual rotation) produces output (astronomical prediction) via a structured sequence of transformations governed by gear ratios equivalent to mathematical relations.

By situating the Antikythera Mechanism at the intersection of philosophy, physics, and computation, this work reframes it as an epistemic instrument that materializes Greek conceptions of cosmic order. It demonstrates that the roots of algorithmic thinking —and, by extension, artificial intelligence— can be traced to Hellenistic scientific practice, where the laws of nature were first rendered into autonomous mechanical processes.

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ASTRONOMICAL ORIENTATION OF ORTHOGONAL BUILDINGS IN NEOLITHIC THESSALY

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Sesklo, Dimini, archaeoastronomy, history of astronomy, ancient calendars, Greek astronomy, architecture and astronomy, astronomy in society, astronomy and agriculture

The Early Neolithic settlement of Sesklo (*ca.* 6500–6000 BCE) provides compelling evidence for systematic astronomical orientation embedded in early architectural planning. This study synthesizes two building phases to demonstrate a coherent solar-stellar calendrical system encoded in Megaron-like structures. The earliest phase (*ca.* 6500 BCE) is characterized by a dominant axis near azimuth ~142°, formed by a dual-door configuration functioning as a horizon "viewfinder". Using spherical horizon geometry at latitude ~39.5° N and heliacal visibility constraints ($m \leq 1.5$), this axis is shown to track a structured sequence of heliacal settings in November and heliacal risings in December-January of bright southern stars (declinations ~−25° to −42°, precessed). Key markers include the late-autumn sowing cluster —Fomalhaut, Alpha Centauri, Beta Centauri, and Achernar— and the winter solstice renewal signaled by Antares and Shaula. In the subsequent phase (*ca.* 6000 BCE), architectural reorientation introduces two complementary axes at ~100° (ESE) and ~200° (SSW). The ~100° axis aligns with late-October sunrise (≈25–27 October, modern equivalent), corresponding to the onset of autumn rains and cereal sowing, while the ~200° axis captures a bidirectional stellar sequence of heliacal settings (May-June) and risings (November-December) of prominent northern stars, including Castor, Pollux, Arcturus, Capella, Vega, and Deneb.

The transition between phases is consistent with the gradual effects of axial precession, necessitating recalibration of stellar sightlines. The combined evidence indicates that Sesklo's inhabitants employed geometry, day-counting, and long-term observation to construct a resilient calendrical framework integrating solar seasonality and stellar proxies. These findings support the interpretation of Sesklo as an early center of applied astronomical knowledge, where architecture functioned as a durable instrument for synchronizing agricultural practice, ritual timing, and environmental cycles.

The Early Neolithic settlement of Sesklo (*ca.* 6500 BCE) represents one of the earliest sedentary agricultural communities in Europe. This study investigates whether its architectural orientations encode systematic astronomical knowledge. The principal finding concerns a dominant alignment near azimuth ~142°, expressed most clearly in the earliest Megaron-like structure, whose axial doorway configuration functions as a horizon "viewfinder". Using spherical horizon geometry at latitude ~39.5° N and heliacal visibility criteria ($m \leq 1.5$), we demonstrate that this axis corresponds to a coherent sequence of heliacal settings (November) and heliacal risings (December-January) of bright southern stars with declinations approximately −25° to −42° (precessed to 6500 BCE).

The resulting annual sequence provides two robust calendrical markers: (1) a late-autumn cluster (≈10–22 November) —including Fomalhaut rising (~137°), and paired settings of Alpha Centauri and Beta Centauri (~142°), followed by Achernar (~141°)— coinciding with peak cereal sowing; and (2) a winter-solstice cluster (≈22 December-early January) led by the heliacal rising of Antares (~140°) and Shaula, marking the inception of the new year. These data indicate a solar-based agricultural calendar encoded along a single architectural axis, integrating stellar events as seasonally precise proxies for solar phase. The persistence of late-autumn sowing markers in later traditions (e.g., Polysporia and Eleusinian rites) supports long-term continuity between Neolithic practice and historical ritual calendars. Overall, the Sesklo evidence implies organized climatic knowledge, day-counting (arithmetic), and practical geometry, manifested in architectural orientation for calendrical regulation of agrarian life.

At Sesklo (*ca.* 6000 BCE), a second-generation Megaron exhibits a reconfigured astronomical design, plausibly reflecting the cumulative effects of axial precession on stellar coordinates and the need to recalibrate earlier sightlines. The building defines two principal axes: an ESE-WNW line near ~100° and a SSW-NNE line near ~200°, forming a complementary observational system for seasonal tracking. The ~100° axis aligns with sunrise in late October (≈25–27 October, modern equivalent) at Thessalian latitude (~39.5° N), coinciding with the onset of autumn rains and the cereal sowing window. This orientation is functionally analogous to later and geographically distant installations, including Abu Simbel (solar penetration events in October/February), the Minoan site of Papoura, and Mycenaean Eleusis, indicating a durable solar-agricultural alignment tradition across the eastern Mediterranean. The ~200° axis operates as a stellar "corridor," capturing heliacal settings (May-June) and risings (November-December) of bright northern stars ($m \leq 1.5$). A spring sequence —Castor (~3 May), Pollux (~5 May), Arcturus (~10 May), Capella (~20 May), Vega (~1 June), and Deneb (~10 June)— marks the closure of spring approaching the summer solstice. The reciprocal autumn-winter sequence begins with Castor and Pollux rising (~20–22 November), followed by Arcturus (~30 November), Capella (~5 December), and Vega (~15 December), structuring the sowing period and onset of winter.

Together, these axes encode a solar-stellar calendar that integrates agrarian timing, ritual sequencing, and architectural geometry, evidencing advanced observational practice and intergenerational calibration in Early Neolithic Thessaly.

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GREEKS, GNOMONICS, MATHEMATICS: SUNDIALS AND THEIR INVENTORS IN ANCIENT GREEK CULTURE

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Ancient Greek sundials, gnomonics, mathematics

Sundials from ancient Greece bear eloquent witness to an interest in projecting optical effects caused by the daily, apparent movement of the sun onto a surface. First theoretical foundations of gnomonics are associated with 6th c. BCE philosophers, such as Thales of Miletus (*ca.* 624–546 BCE) and his successor Anaximander (*ca.* 610−647 BCE). However, archaeological evidence for sundials in ancient Greek culture appears no earlier than the fourth and third centuries BCE. Accordingly, the Late Classical and Hellenistic periods form the chronological framework of the present study (*ca.* 400–330/20 BCE). The area of Greece and significant parts of the west coast of Asia Minor (modern-day Turkey/Türkiye), where numerous Greek cities were located, form the geographical framework of research.

The evidence of ancient Greek sundials has expanded considerably in recent years, see more recently SCHALDACH (2021, vols. 1 & 2). Nevertheless, studies on the ongoing, parallel development of both sundials and sciences in ancient Greek culture have been neglected by research, resulting in artefacts being divorced from their context and their scientific value being underestimated. However, the inventors of ancient Greek sundials in particular —insofar as their names are known— made significant contributions to the field of mathematics (geometry), which also included reflections on cosmology. This mutual influence can be best exemplified by a Hellenistic (*i.e.*, 3rd c. BCE) sundial made of marble found in Heraclea at Latmus, southwestern Asia Minor, in 1872 (HERMANN *&al.* 2017, 62, pl. 22; SCHALDACH 2021, 1, 128−129, Pl. 46; SCHALDACH 2021, 2, 323, 635). The sundial is the form of a partial sphere or *scaphe* (*cf.* ancient Greek: σκάφη; "bowl") and an additional *conarachne* (*cf.* ancient Greek: ἀράχνη; "spider") or a sundial's network of lines that resembles a spider's web. In addition, the dedicatory inscription has remained preserved and reads as follows:

> "βασιλεῖ Πτολεμαίωι Ἀπολλ[ώ]νιος Ἀπολλοδότου. / Θεμισταγόρας Μενίσκου Ἀλεξανδρεὺς ἐποίει." In English translation by the author: "[Dedicated to] King Ptolemy by Apollonios, son of Apollodotos. Themistagoras of Alexandria, son of Meniskos, made it [*i.e.*, the sundial]."

FIGURE 1. A (scaphe including inscription [bottom]), 1b (side view), and 1c (conarachne) © 2024 GrandPalaisRmn (musée du Louvre) / Gabriel de Carvalho. (https://collections.louvre.fr/en/ark:/53355/cl010276635 , accessed: 20 March 2026).

Interestingly, we know about Apollonios of Perga, a renowned mathematician who was born during the reign of one of the Ptolemaic kings; thus, his date of birth has often been assigned to *ca.* 240 BCE. He is best known for his outstanding achievements and treatises in the fields of conics and advanced geometric constructions (for detailed information, see FRIED & UNGURU 2001). The unusual, partially hollow cone-shaped design of the sundial from Heraclea at Latmus could therefore have originated from him or his scientific findings.

Seeking to advance with this and related issues, the present paper focuses on a set of relationships —of an archaeological, science historical, and philosophical nature— between the evidence from Classical or Hellenistic Greece, western Asia Minor and, though to a minor degree, their Eastern neighboring countries. This interdisciplinary approach has been inspired from research ideas gathered from the author's online archival research and review of relevant studies in these fields. In particular, this combined approach has revealed certain gaps and contradictions, making the case for a fresh, more detailed look at the evidence of sundials, gnomonics and mathematics in ancient Greek culture. Finally, yet importantly, addressing gaps and contradictions in research also offers a perspective for future research in the fields of archaeoastronomy and history of science.

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ASTRO-ARCHITECTURAL DESIGN PRINCIPLES IN GREEK AND ROMAN THEATRES: SOLAR-GNOMONIC CONSTRUCTION RULES

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Theatre, Greek theatres, Roman theatres, archeoastronomy, solar geometry, gnomon, orchestra radius, theater slope, astro-architecture, Pythagorean geometry, ancient metrology, unit of foot, right-triangle construction, equinox, solstice, architectural orientation

This study investigates the possibility that Greek and Roman theatres (500–100 BCE) were designed according to a consistent astro-geometric principle linking architectural design to solar observations at particular times of the year. The analysis is restricted to theatres across Greece, Italy, and Asia Minor with reliable knowledge of architectural parameters including their sizes and shapes of the theatre and the orchestra, the orientation (azimuths of all relevant lines, radii, inclination of the cavea, inclination of the seats, etc).

FIGURE 1. Ancient theatre of Demitrias, Volos. © Diazoma.

We investigate the possibility that the radius of the orchestra is determined by the shadow cast by a gnomon placed at the center of the orchestra during key solar events, particularly the equinoxes and winter solstice. This implies a direct dependence on solar altitude and azimuth. We investigate the possibility that the inclination (slope) of the theatre is similarly derived from gnomonic shadow geometry at the orchestra boundary, relating seating inclination to solar position. Both hypotheses assume the Pythagorean framework in which measurements are expressed as integer multiples of a fundamental unit of length, as in ancient constructions.

The methodology combines archaeological plans, satellite imagery, and digital elevation models with astronomical simulation tools (Stellarium), geometric modelling (GeoGebra), and horizon reconstruction (Chan U'bih). Results suggest a structured correspondence between solar geometry and theatre architecture.

A dependence of theatre geometry on latitude has been found, consistent with solar-driven design constraints. Theater inclinations (slopes) and geometric relations exhibit consistent right-triangle (level-cathet) behaviour, supporting a Pythagorean construction model. A temporal variation in the unit of foot over the centuries.

A structured distribution of theatres between 36.1° and 40.7° latitude, covering modern Greece, Italy (Magna Graecia) and Asia Minor. A strong correlation is found between gnomon size (Gz) and the derived unit of length (Ut), with a mean value of $Ut \approx 0.318$ m, suggesting metrological coherence across sites.

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CELESTIAL GARDENS: PLANT AND CONSTELLATION LORE IN THE SKY OF CENTAURUS

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Constellation lore, Plant symbolism, Centaurus sky-region

North of the constellation of Centaurus, along the celestial band that rises through Hydra and Virgo toward the faint star cluster today known as Coma Berenices, ancient star lore preserves traces of vegetal and agricultural symbolism that later reinterpretations overshadowed. This paper reconsiders the plant-based traditions in this region of the sky and explores its conceptualization as a celestial "garden" associated with the experiential and healing knowledge attributed to the centaur.

In the Hellenistic period, the faint star cluster north of Centaurus was named by the court astronomer Conon of Samos "Lock of Berenice" after Queen Berenice II, narrating that her vowed lock of hair was placed among the stars in recognition of her devotion. Callimachus' poem canonised this dynastic interpretation, and Catullus' Latin translation established the name "Coma Berenices", which remains in use today. However, earlier and parallel traditions tell a different story.

Situated between Leo, Virgo, and Boötes, the asterism Coma Berenices has been described since ancient times as a nebulous convolution of weak stars. Ptolemy included Coma Berenices among the nebulous stars listed in the *Almagest*, objects whose indistinct visibility later acquired significance in iatromathematical and astrological medicine. Because only exceptionally sharp eyesight can perceive such clusters under optimal conditions, they became associated in later traditions with visual impairment or chronic conditions. The ambiguous perceptual status of the cluster may therefore have reinforced its openness to multiple metaphorical interpretations. The principal stars of Coma Berenices —Diadem (α-Com), β-Com, and Al Dafirah (γ-Com)— belong to solar or orange spectral types, yet their faint magnitudes make colour perception uncertain to the naked eye. The indistinct visual appearance of this stellar cluster may have encouraged multiple symbolic readings, which encompass a sheaf of grain, a tuft at Leo's tail, or a more general vegetal element —a bundle of herbs, a lotus, or even a small arboreal form (FIGURE 1).

Ancient textual traditions occasionally refer to the nebulous stars above Virgo as a *kēpos* "garden". Scholia to Aratus report that earlier astronomers described this region as an interwoven mass of foliage, while passages attributed to Pseudo-Eratosthenes associate it with the Garden of the Hesperides. Such vegetal imagery gains further resonance through the proximity of Spica, an agricultural marker linked to harvest cycles (ANTONELLO 2013; NAVA 2023), to the anciently more extended figure of Centaurus. Mythographic accounts connect Chiron with the discovery and transmission of medicinal plants, and Latin sources drawing on Greek material preserve echoes of these associations, for instance in references to *centaurium* as a healing herb.

Hermetic and astrological traditions reinforce this perception of the zone as a celestial herbarium. Manilius, drawing on Greek astronomical thought, attributes to Virgo and nearby stars agricultural significance and knowledge of both sacred botany and hidden natural properties. Symbolic convergence may also have been encouraged by overlaps with other catasterisms: Eratosthenes reports confusion between Coma Berenices and Corona Borealis, the crown of Ariadne (NAGY

2013), while literary traditions emphasise the golden-blond quality of Berenice's hair, an imagery that resonates with the tawny colour of grain or leonine fur.

FIGURE 1. Manuscript Schoenberg LJS 57 (Catalonia, 1361), Northern hemisphere, fol. 112 (detail). Coma Berenices represented as a vegetal cluster (quadrifolium motif), illustrating the long-term persistence of plant-based interpretations of the asterism.

By moving beyond the later dynastic and celebratory reading of Coma Berenices, this paper focuses on the earlier traditions identifying the celestial region north of Centaurus as a zone of vegetal, agricultural, and medicinal symbolism. Considered together, Centaurus, Virgo with Spica and Vindemiatrix, and the faint stellar cluster later formalised as Coma Berenices may be understood as elements of a single conceptual landscape, a possible celestial "garden" rooted in traditions of experiential knowledge and seasonal observation.

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FACING WEST: A NEW ARCHAEOASTRONOMICAL ANALYSIS OF WEDGE TOMBS

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Wedge tomb, Ireland, Chalcolithic-Early Bronze Age, solar cosmology

Beginning in Volume 1 of the Survey of the Megalithic Tombs of Ireland (1961), archaeologists Ruaidhrí DE VALERA and Seán Ó NUALLÁIN noted how all wedge tomb entrances in Co. Clare face between south and west-northwest. They found such constancy in orientation to be repeated throughout the whole monumental tradition, related “to a general alignment towards the side of the heavens in which the sun sets”. The pattern recurs to such an extent throughout Ireland that by the publication of Volume 6 in the same series in 2002, the authors concluded this adherence was a “rule” observed by the builders. Gabriel COONEY (2023, 182) confirms this “almost obsessive persistence” of constructing tombs to face south-west, noting a possible “prescriptive world view” but with “considerable local variation”. This paper investigates these claims by presenting a new transdisciplinary analysis of the 581 extant wedge tomb orientations considered at an island scale. Supported by statistical modelling, relevant cosmological questions are asked and answered linking the role of the sky-horizon interface and solar symbolism with perceived journeys of the dead in the Late Neolithic to Early Chalcolithic/Bronze Age. Azimuthal rose plots, and significance tests of axial orientations and astronomical declinations, reveal evidence of a probable solar cosmology linking the funerary role of the tombs across the island with the descending-setting Sun. Broader ideological parallels with chronologically similar cultures in northwest Europe are considered.

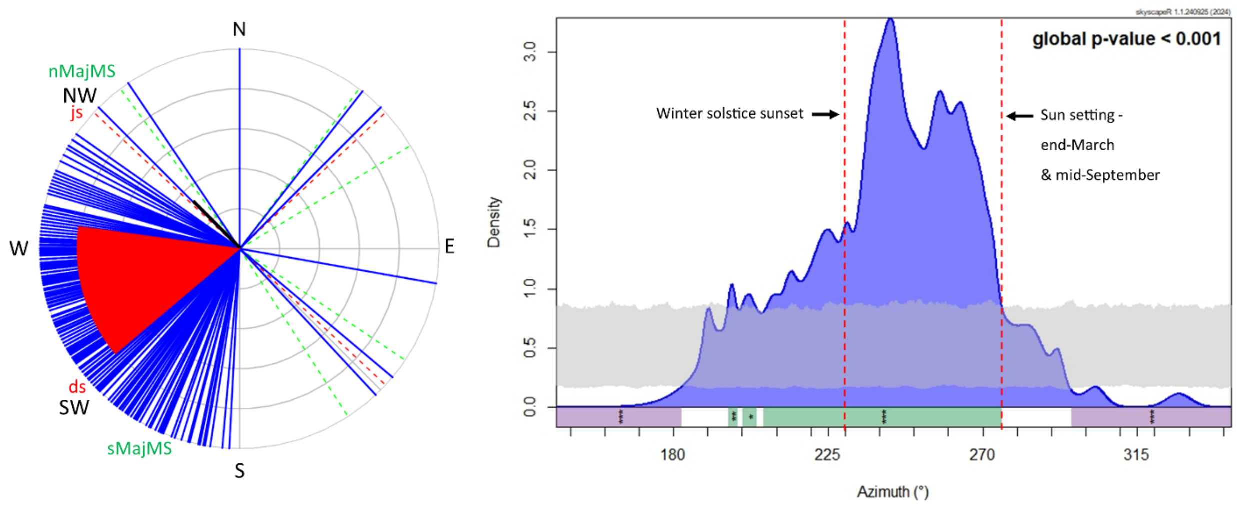

FIGURE 1. Rose plot and statistical significance test of wedge tomb azimuths.

FIGURE 2. A wedge tomb in southwest Ireland (credit: Dan O'MEARA).

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FROM EMBODIED MEASUREMENT TO CELESTIAL ORDER: THE TECHNOLOGICAL FOUNDATIONS OF EARLY CULTURAL ASTRONOMY

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Palaeolithic measurement, proto-mathematics, embodied metrology, artificial memory systems, proto-astronomy

This paper argues that systematic measurement practices in the Palaeolithic formed the operational precondition for early cultural astronomy. Rather than emerging from abstract speculation, celestial ordering is here interpreted as the extension of embodied and materially scaffolded metrology into the sky.

Proto-arithmetic is defined as counting, grouping, iteration, interval structuring, and proportional reasoning; proto-geometry as directionality, axiality, modular spacing, circular construction, and symmetry. These capacities were grounded in body-based units (handspan, cubit, pace) and stabilised through external supports such as cords, notched artefacts, tallies, and structured surfaces. Body-based units are now empirically recognised as stable and transmissible metrological systems (KAARONEN, MANNINEN & ERONEN 2023).

Building on RAPPENGLÜCK (2018), repeated incisions and grouped markings are evaluated as potential artificial memory systems enabling external storage and manipulation of quantities. Recent spatial-statistical approaches refine diagnostic criteria and strengthen methodological control in identifying such systems (COURTENAY, D'ERRICO, NÚÑEZ & BLASI 2025).

FIGURE 1. Upper Palaeolithic artefacts and architectural reconstruction illustrating embodied metrology and proto-mathematical structuring within transferable measurement frameworks relevant to early cultural astronomy: incised reindeer-antler bâton, Abri Laugerie-Basse (France), 11.0–10.2 ka cal BP; mammoth-bone dwelling (replica), Mezhirich (Ukraine), ca. 18–17 ka cal BP; square-section bone rods, La Garenne, Saint-Marcel (France), 22.6–16.7 ka cal BP; reconstructed plumb bob, Kostenki I (Russia), 24.5–23.5 ka cal BP. Reconstruction and collage: Michael A. RAPPENGLÜCK.

Metric planning demonstrably extended beyond portable objects. Middle Palaeolithic cave constructions demonstrate modular organisation and reproducible spatial calibration, implying transferable reference frameworks (JAUBERT *&al.* 2016). Fibre technologies plausibly enabled distance transfer, circular layout, and angular referencing —procedures directly applicable to horizon observation.

Recent evidence for Upper Palaeolithic topographic modelling further demonstrates scaled spatial abstraction (THIRY & MILNES 2024). While not directly astronomical, such modelling confirms that calibrated spatial reasoning and representational transfer were technically feasible.

Astronomical cycles (solar motion, lunar phases, recurrent horizon events) offered stable periodicities compatible with embodied interval structuring. The hypothesis advanced here is graded and non-teleological: it does not posit formal astronomy in the Palaeolithic but identifies the measurable conditions under which systematic celestial ordering becomes possible.

The broader implication is historiographic and technological. Cultural astronomy in deep time can be reinterpreted as part of a longue durée trajectory of transferable measurement practices that precede theoretical formalisation. Everyday metrology provided the operational grammar through which spatial and temporal regularities of the sky could be stabilised, modelled, and culturally encoded, opening a new perspective on the early history of scientific reasoning.

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ASTRONOMY AND RELIGION IN THE ROMAN TEMPLES OF NEAR EAST

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Roman religion, Roman Eastern Empire, Temples

The annexation of the province of Syria to the Roman Republic in the 64 BCE by Pompey involved the establishment of new political and economic structures that affected different aspects of the existing cultures in the region, such as religion. During a relatively narrow time span, from the 1st c. BCE to the 3rd c. CE, several Roman temples of exceptional monumentality were constructed in the area of present-day Lebanon. This building phenomenon created a hybrid sacred landscape that integrated local Levantine traditions in the new architectural framework, representations and in the cults performed (ALIQUOT 2008). Previous works have identified astronomical elements in the design and the iconography of Roman temples in Lebanon, such as decorations with sun disks and orientations; for example, in Qsar Naous and Chimm temples (WALISZEWSKI & WICENCIAK 2015).

FIGURE 1. Roman temple near Chhim, at 13 km northeast of Sidon.
The temple was bult in the 2nd c. BCE over the ruins of a Phoenician temple. © Authors.

FIGURE 2. Roman temples of Qsar Naous (Ain Akrine, Lebanon). In particular, East temple (left) and entrance to the West temple (right). Sun disk, probably from the tympanum of the West temple in Qsar Nous. © Authors and Sun disk from TAYLOR (1967, Fig. 112).

FIGURE 3. Temple of Iupiter Heliopolitanus in Baalbek (Lebanon). © Authors.

In contrast to other regions, the results in the Near East reveal a diversity of orientations, suggesting an absence of a single guiding criterion possibly due to the persistence of previous and diverse traditions (MAGLI 2021; RODRÍGUEZ-ANTÓN 2024). This work offers an updated archaeoastronomical study of Roman temples in different areas of present-day Lebanon, Syria and Jordan with the aim to have a more nuanced understanding of the role of astronomy in the religious life and in the creation of sacred landscapes in the Roman Levant.

Although diverse, the orientations of these monuments often coincide with celestial events, especially connected to relevant moments of the solar and productive cycle in the context of study that could have coincided with the celebration of fertility cults related to productive activities such as the harvest, as well as moments of renewal and transition.

Beyond the religious dimension, the results highlight the interplay between Roman imperial power and local identities. The temples functioned not only as places of worship but also as instruments of cultural negotiation, where Roman authority was expressed while local traditions were preserved and reinterpreted. By examining the astronomical orientations and symbolic elements of these monuments, this study contributes to a deeper understanding of how celestial phenomena were integrated into the religious and political fabric of one of the most dynamic regions of the Empire.

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THE CELESTIAL DOG: A PRE-REGISTERED NEOLITHIC STELLAR ALIGNMENT SYSTEM IN SOUTHEASTERN SICILY (5000–4300 BCE)

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archaeoastronomy, Sicily, Neolithic, Pantalica, Sirius, Orion, stellar alignments, Monte Carlo, landscape archaeology, precessional drift

This study documents a pre-registered stellar alignment system connecting the Nymphaeum Terrace (Siracusa, 37.077° N, 15.275° E) and the Anaktoron of Pantalica (37.134° N, 15.026° E) with the coastal landmark Scoglio dei Cani in southeastern Sicily. The investigation follows the myth-seeker framework (BOUTSIKAS & RUGGLES 2011): the toponym 'Scoglio dei Cani' (Rock of the Dogs), attested since the 16th c. (CAMILLIANI 1584), lacks any known morphological or ecological explanation, generating the hypothesis that Sirius (the "dog star") is its astronomical referent.

Two terrestrial axes (A: Nymphaeum→T1, 125.85°; C: Anaktoron→T1, 108.33°) were pre-registered in technical document v5.0 (7 January 2026, OSF DOI: 10.17605/OSF.IO/3C8Y4) before any astronomical calculation. Stellar rising azimuths were computed with Stellarium 24.3 (IAU 2006 precession) and independently validated with Astropy 6.0 (mean deviation ±0.013° across 8 star-epoch combinations).

FIGURE 1: Scoglio dei Cani, courtecy Google Earth.

An exploratory scan across six chronologically constrained epochs (5500–3500 BCE) and nine candidate stars identified residuals $\Delta \leq 0.25°$ at only two epochs: 5000 BCE (Mintaka rising at 126.009°, $\Delta = 0.159°$ from Axis A) and 4300 BCE (Sirius on Axis A, $\Delta = 0.154°$; Betelgeuse on Axis C, $\Delta = 0.145°$). These two epochs are linked by precessional drift: at 5000 BCE, Orion's belt marks the direction of Scoglio dei Cani; 700 years later, Sirius —the Celestial Dog— rises along the same line, while Betelgeuse simultaneously aligns with the second axis.

A confirmatory Monte Carlo test ($n = 10^6$, uniform null model [0°, 360°), Bonferroni ×54) returns $P = 1.62 \times 10^{-4}$ (3.6σ). A sensitivity analysis under a restricted null model [60°, 130°) —the empirical stellar rise window at 37°N— yields $P = 4.05 \times 10^{-3}$ (2.6σ), confirming significance below $\alpha = 0.01$ under the most conservative assumption. Temporal negative controls at 5500 and 3500 BCE produce no match $\Delta \leq 0.25°$. The archaeological negative control at the Thapsos necropolis (20 sightlines) yields 0/20 stellar matches.

The chronological coherence with the Stentinello culture (5800–4000 BCE; BERNABÒ BREA 1990) and the documented presence of canine symbolism in the Neolithic material record of the Syracusan region (a zoomorphic canine sculpture from Punta Arenella and a canine protome from the Stentinello horizon) support the hypothesis that the documented alignment system is consistent with an intentional observational practice oriented toward the rising of Orion and Sirius.

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THE CELESTIAL BODY: THE INTERSECTION OF ASTRONOMY, HISTORY, AND ARCHITECTURAL SYMBOLISM IN NIZAMI'S *HAFT PEYKAR*

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Nizami Ganjavi, Archaeoastronomy, Persian Architecture, Sasanian History, Cosmic Order

Nizami Ganjavi's 12th c. epic, *Haft Peykar* (The Seven Beauties), represents a sophisticated synthesis of astronomical science, Sasanian history, and philosophical wisdom. This study employs a descriptive-analytical approach to investigate how Nizami utilizes the symbolism of the number seven (the definitive signifier of cosmic order) to construct a semantic framework that explains the universe and man's place within it. By systematically linking seven domes to the wandering planets, specific colors, and the days of the week (from Keyvan-Sheed to Nahid-Sheed), the poem transforms physical architecture into a microcosm of the celestial spheres. This analysis is grounded in classical astronomical texts such as Biruni's *Al-Tafhim* and Al-Sufi's *Suwar al-Kawakib* (The Book of Fixed Stars), which provide the technical basis for Nizami's celestial mapping.

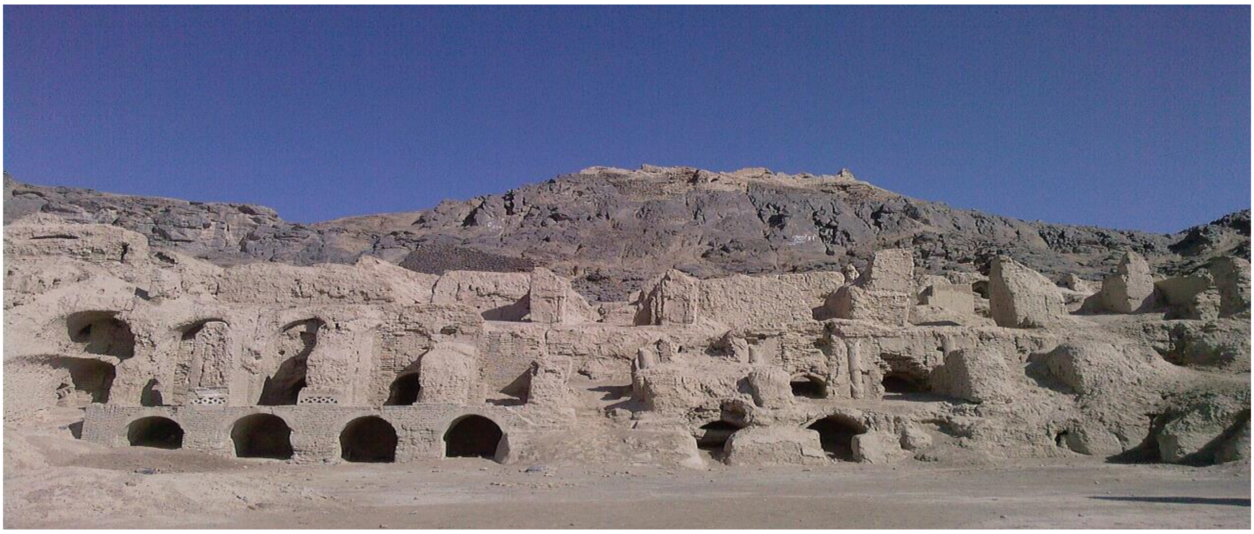

FIGURE 1. The Kakha Castle inside mount khaje.

A primary objective of this research is to examine how Nizami utilizes these astronomical and mythological concepts to define cosmic order while simultaneously distancing his narrative from the fatalistic attitudes of his era. Drawing on YAHAGHI's (2007) documentation of mythological allusions and ZANJANI's (1994) comprehensive commentary, the study argues that Nizami's "astronomical architecture" emphasizes the triumph of human reason and free will over astral determinism. Furthermore, the specific color symbolism associated with the planets is analyzed through the framework provided by VELAYATI (2010), bridging the gap between artistic signifiers and Sasanian historical precedents.

By analyzing the poem alongside historical sites such as the Sarvestan Palace and the solar-aligned Chahar Taqi structures (AKBARI & KHAREGHANI 2021), the research suggests that the poem's technical and geographic details (specifically the hilltop observatory layout) align most accurately with the complex sacred geography and archaeological remains of Mount Khajeh in Sistan (GHANIMATI 2000; ALAEI MOGHADDAM *&al*. 2024). Ultimately, the findings reveal that the *Haft Peykar* is not merely a romantic tale but a vital cultural record of the Persian architectural tradition, which served as a bridge between technical geometry and a spiritual journey, tracing King Bahram's evolution from the material "bewilderment" of Saturn to the absolute light of Venus.

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THE VEDIC NAKSHATRAS AND THE BABYLONIAN ZODIAC

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Constellations, Nakshatras, coordinate systems, Babylonian astral science

The nakshatra form a system of 27 or 28 lunar stations which are named after constellations (WEBER 1860, DIKSHIT 1981). The asterisms are of unequal size, sometimes being groups of two to dozens of stars, sometimes only consisting of a single bright star, but the sections of the division of the ecliptic are now formed in a uniform way. They have been considered canonical for ~2000 years. For Stellarium (ZOTTI *&al*. 2020), we created an introductory text because we contributed a new version of the "Indian Vedic" sky culture, with nakshatra constellation depictions from a temple, roughly 1000 years old. This is the earliest known historical depiction of accurate star patterns, although the patterns do not form a map, and the individual nakshatra drawings are not to the same scale.

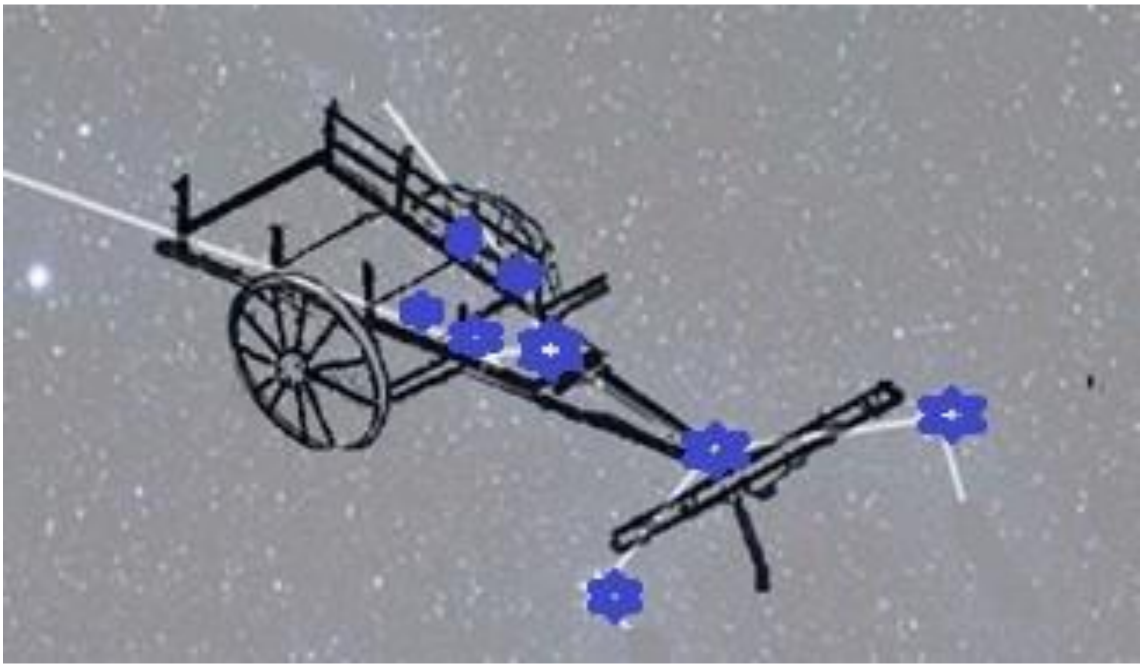

FIGURE 1. Hyades as the "Rohini shakata" (cart of Rohini). Drawing by the B. S. Shylaja.

It is commonly known that ancient cultures across Eurasia exchanged. In this contribution, we attempt to explore possible connections between early Indian and Mesopotamian astral science. We evaluate the mathematical data in both cultures, consider their coordinate systems and compare them. The results are astonishing regarding the long process and precursors of the discovery of the precession of the equinoxes.

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SKY ON STONE: EVOLUTION OF THE DEPICTION OF CELESTIAL OBJECTS ON ROCK SURFACES IN PREHISTORY

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Celestial object, Symbols and signs, Monochrome painting

The evolution of the depiction of celestial objects (Sun, Moon, Planets, Bright Stars) on rock surfaces in prehistory shows a transition from a symbolic-mythological perception to a more systematic, functional astral observation. This process spans tens of thousands of years, beginning in the Paleolithic and extending to the end of the Bronze Age. Space and time, objects and phenomena not only exist objectively, but are also experienced and understood subjectively by people. The thinking of ancient people is characterized as a stream of images, and symbols are at the center of this imaginative life (CHEVALIER & GEERBRANT 1995). The report traces the evolution of the depiction of celestial objects (the Sun, the Moon, planets, and bright stars) on rock surfaces at prehistoric sites within the territory of the Republic of Bulgaria. It discusses the image of the celestial object in the context of the spiritual counterpart of humans and deities. An attempt is made to interpret the rock image not as a whim of the era, but as an urgent necessity for the spiritual existence of prehistoric humans. The evolution moves from an abstract, intuitive representation of stars in caves (Paleolithic) to a symbolic, calendrical, and ritual reflection of solar and lunar cycles, necessary for agriculture and animal husbandry (Neolithic, Eneolithic). Prehistoric humans used rock depictions of celestial objects as a celestial map to mark time in relation to cosmic events. Worldview of the ancient humans consisted of several interdependent and interrelated aspects at different levels: cosmic (astronomical), geographical, religious-mythological, and personal perceptions. Conventional goals are also defined in this sense, established. However, objectively existing (physical, including the celestial sphere) space has often not coincided with subjective (human) space. Consequently, rock depictions of celestial objects —in addition to their practical significance (as a calendar)— usually also held sacred meaning. Ancient humans sought to recreate spatio-temporal structures from the surrounding microcosm that would mimic macrocosmic relationships, not least so that, by acting within this model, they could influence the macrocosmic forces governing their existence. Celestial objects on a stone base were made in accordance with the laws of the cosmic order, projected onto the earth; the religious rites surrounding them arose from the desire and the possibility of interacting with (influencing!) cosmic processes through sacred rituals.

A comparative analysis was conducted of star images from the Topchika Cave near the village of Dobrostan, Asenovgrad Municipality; a rock star map from the village of Osikovo, Devin Municipality (VALCHANOVA *&al*. 2024); rock star configurations from the Belogradchik area; and monochrome cave paintings from the Magura Cave, the village of Rabisha, Belogradchik Municipality (MAGLOVA, STOEV & SPASOVA 2020), and a cave complex near the village of Baylovo, Sofia Province. The results of the analysis show that for prehistoric humans, the sky and celestial bodies were among the incomprehensible, inaccessible, yet necessary objects to explain. This required a different, non-visual form of expression, driven by the genuine human need to explain the incomprehensible. This led to the birth of the second, figurative and symbolic stage of

human cognition, which provides a figurative and symbolic representation of the observed phenomenon(s) or object(s) and replaces its object-sensory perception.

FIGURE 1. Rock altar near the village of Osikovo, Devin Municipality. The constellations Cygnus, Lyra and Eagle, the brightest stars of which form the so-called Summer Triangle, have been identified. The stars in the circumpolar zone are also shown symbolically.

A comparative statistical analysis was also conducted of pitted depressions, solar and lunar incisions, and indentations on the rock surface to determine whether they are of natural origin or the result of human intervention. The role of the rock's petrographic surface is emphasized, revealing the additional mica particles it contains when illuminated by natural or artificial light. The precise craftsmanship of the rock carvings is demonstrated as representations of actual stars from constellations, showing all the bright stars in it. Reproducing each group of stars with precision requires specific astronomical knowledge, including the practical determination of angular distances with sufficient accuracy, mastery of numerical skills, spatial and temporal orientation, and more. The report also discusses the issue of depicting the Sun, the Moon, and bright stars using the technique of monochrome cave painting to create a "database" in prehistoric astronomy and the calendar. It highlights the role of celestial symbolism in the structure of the calendar and the need to develop solar and astral symbolism over time as the volume of observational data collected by the sky-watchers of that era increased.

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HOROSCOPY IN BABYLONIAN SOCIETY

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Babylonian astronomy, Babylonian astrology, Horoscopes

The history of Babylonian astronomy and astrology has been thoroughly investigated over the past 150 years or so. As a result, we now have a good, although still incomplete, understanding of the technical aspects of the various forms of astronomy and astrology in Babylonia during the 1st millennium BCE. Recent work has also explored the scribal and archival context of astronomical cuneiform texts. Several studies of the role of astronomy in Babylonian society have also been published, although much more research remains to be done in this area. This paper is a contribution to the study of the place of astronomy and astrology in wider Babylonian society through an analysis of Babylonian horoscopes.

FIGURE 1. Fragment of a tablet from MUL.APIN astrological series. AO 7540 © Musée du Louvre.

Horoscopy, the practice of predicting aspects of the life and character or an individual from the positions and phenomena of the sun, moon, and planets at or near the time of birth, is first attested in Babylonia towards the end of the 5th c. BCE. Roughly thirty tablets containing horoscopes are currently known. Although most of these horoscopes do not identify the individual for whom it is cast, a few name the child. These names include both male and female names. Both Akkadian and Greek names are attested. It has been suggested by HUNGER (2011) and BROWN (2018) that the practice of horoscopy represents a "democratization" of astrology, which has previously been restricted in focus to the king and the country as a whole. However, ROCHBERG (2019), cautions against this conclusion.

In this paper I will explore the social setting of horoscopy through a detailed archival, contextual, and content-based analysis of the preserved horoscopes and the related texts containing information used in interpreting a horoscope.

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RESEARCH ON ENEOLITHIC PROJECTIVE SYSTEMS FOR DETERMINING SOLAR CULMINATIONS WITH DRONE TECHNOLOGIES

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3D modeling, Cave projective systems, Solar culminations

Throughout human history, man-made caves have been used not only as dwellings, places of worship or religious temples, but also as tools for astronomical observations, time measurement and tracking the movements of the Sun. Projective systems for calendar projections of the noon Sun in prehistory were the most ancient astronomical instruments, using light and shadows to record key time markers of the year (mainly solstices and equinoxes). These systems were based on observations of changes in the height of the Sun and the length of shadows or light projections cast by gnomons and/or vertical openings (which are often natural landscape features) and were projected onto artificial markers (petroglyphs, rock circles, altars, pits, rock "thrones", etc.). These systems allowed prehistoric pre-literate cultures to effectively plan agricultural work, religious ceremonies, and social life.

FIGURE 1. Tangardak Kaya cave and the projection of the entrance during the summer solstice.

The report proposes a concept for drone technology capable of operating in confined cave spaces. It can precisely map caves (refined and oriented by humans) and used for the purposes of archaeoastronomical projections on sacred days. Using RGB-D data collected by a drone, we can create an accurate 3D model and semantic maps with appropriate lighting, controlling the flight of the drone in the cave volume. It is shown that such a practice in archaeoastronomy can accelerate archaeoastronomical studies by expanding their scope and accuracy. This allows for 3D analyses to be performed in accordance with the new requirements for accuracy regarding the morphometric characteristics of the cave. It is noted that archaeoastronomers can visualize the data collected by the drone, as well as program the drone for its next mission in real time (OGNYANOV, MAGLOVA & STOEV 2022). These data are also important for obtaining precise data about the site, data sharing and visualization. Human/drone interaction becomes important not only for operating the equipment, but also for guiding the drone to interesting locations on the site to be mapped in detail. This human interaction is vital in visualizing and understanding the cave space as a site for astronomical projections. Drone technology creates long-term impacts on archaeoastronomy and digital heritage and potentially creates a transformative way to further improve the productivity of 3D mapping of indoor spaces (BIRCHER 2016).

The report presents the Tangardak Kaya cave (a rock-cut structure with a length of 22 m, a height of the entrance opening 5 m, a width of 3 m) whose main axis is oriented in the plane of the meridian of the observation site. The artificial cave is located in the Eastern Rhodopes near the village of Ilinitsa, Kardzhali District, Republic of Bulgaria.

The analysis of the rock carvings, made using traceological methods, shows the use of tools that are characteristic of the beginning of the Eneolithic in the Bulgarian lands (5^{th}–4^{th} millennium BCE). At the bottom of the cave, a peculiar carving is formed, which creates a small platform with obvious altar functions. In the middle of the gallery there are two adjacent zones with an almost elliptical cross-section, the ceiling of which has a clearly pronounced dome-shaped shape. In the foci of the domes, sound amplification and prolonged reverberation are recorded. The maximum sound amplification and reverberation time are in the low sound frequency range.

The projective system formed in the artificial cave by its opening and the main gallery is oriented in the plane of the main meridian (north-south) and allows determining the meridian culminations of the Sun. The exact moments of the winter and summer solstices were critically important for determining the agricultural cycles and religious rites. A ray of light passing through the phallic entrance hole and the crack shows the deepest penetration into the cave for several days during the winter solstice with the illumination of the altar table. This phenomenon has been interpreted as a kind of divine fertilization (chthonic marriage), personifying the sacred marriage between the Great Mother Goddess and the Sun and the revival of life. The study of this structure shows that the ancient Eneolithic civilization that lived in these lands had practical skills for astronomical observations of the Sun and the ability to accumulate astronomical data. The report also presents the results of the use of modern drone technologies to obtain a 3D model of a rock-cut monument of speleological type and with astronomical purpose, as well as the integration of the 3D model into modern astronomical software for searching for observational correlations with extreme positions of the Sun in prehistory (MAGLOVA *&al*. 2025).

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FROM ARITHMOGEOMETRY TO STELLAR ALIGNMENTS: EXPLORING A POLYHEDRAL MODEL UNDERLYING THE CLASSICAL CONSTELLATIONS

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Platonic geometry, ancient cosmology, archaeoastronomy, constellation design

This presentation introduces delegates to a recently published polyhedral model postulated to underpin design of the classical constellations (SUTTON 2019). According to Plato (*Timaeus* 53–57), the bodies Fire (tetrahedron), Air (octahedron), Water (icosahedron) and Earth (cube) were composed from primary scalene triangles (sides 1, √3, 2) or isosceles triangles (sides 1, 1, √2), where these triangles represent the fundamental "elements". Conversely, at a macroscale, Plato noted that a fifth geometric body was used to decorate the universe (*Timaeus* 55c), where the dodecahedron is inferred but not named.

Methodology and Data: Recognizing that Plato included the language of ancient alchemy for breaking down (*kratei*, *nika*) and remixing these bodies (*Timaeus* 56e), and that the concept of aether (the material of the heavens) links both perspectives, this led to two hypotheses:

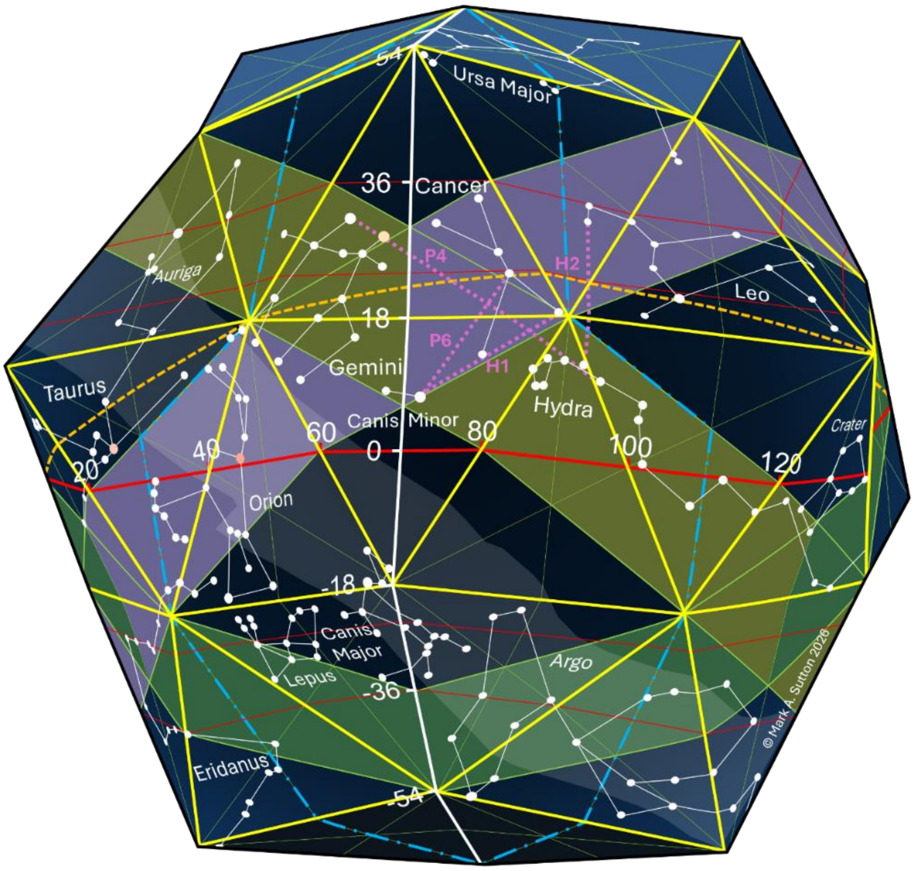

FIGURE 1. Dodecahedral model of the universe for 1200 BCE, with 0° RA set in the middle of the 20° sector of Aries. The bold white and blue dot-dashed lines illustrate the 12-fold division of zodiac sectors. The gold dashed line is the ecliptic. Red lines are the equator and ±24° and ±36° δ. The purple, green and brown bands indicate three rings with five-fold symmetry. Example star lines (dashed pink lines) are also shown as recorded by Hipparchus (H1, H2) and Ptolemy (P4, P6; Almagest 7). Modified from SUTTON (2019).

Hypothesis 1: that there was also a role for the elevated dodecahedron composed of sixty equilateral triangles, since this can be made by remixing the primary scalene triangles (based on analogy with the alchemical marriages to produce aether).

Hypothesis 2: that the elevated dodecahedron made from 360 of the fundamental scalene triangles was used as an actual model of the universe by ancient astronomers (noting how the model divides twelve ways at opposite primary vertices of the inherent dodecahedron).

In addition to exploring number relationships, I tested the hypotheses by assessing lengths and positioning of the zodiacal and other constellations. The approach led to a new dodecahedral projection of the globe (in emulation of the ancients), plotted using Stellarium star data for Right Ascension (*RA*) and declination (δ), and evaluated with ten assessment criteria (SUTTON 2019).

Results & Discussion: The dodecahedral model fits well for 1200–1100 BCE, best viewed from an "ideal latitude" of 36° North, consistent with the independent findings of SCHAEFER (2004, 194–205). Nevertheless, several Platonists and astronomers have raised objections to the model. Most modern Platonists tend to emphasize innovation by Plato rather than his dependence on antecedent traditions, so they find it hard to accept evidence of Platonic geometry centuries earlier. Certain astronomers have declared the model to be implausible, as other evidence has suggested that geometrical approaches were only introduced by later Greeks (after 500 BCE), while prior Chaldean and Egyptian astronomy supposedly only used arithmetical approaches. Such contentions should not prevent the consideration of new evidence, recognizing that there is much that we do not know. For example, the dodecahedral model can be constructed without complex geometry, while its simplicity may have been part of its attractiveness. I draw on ideas of PETRUCCI (2024) showing how the dodecahedral model would have been of interest from an arithmogeometry perspective (*i.e.*, arithmetical relationships in spatial context), as also indicated by Plutarch (*Plat. Quaest.* 5) and Alcinous (*Didaskalikos* 13), e.g., 12×30 triangles and the zodiac.

The strongest support for the dodecahedral model comes from mapping the classical constellations. Firstly, the model explains why the zodiac constellations are unequal in length, resulting from the intersection of the twelve north-south sectors of the elevated dodecahedron (when made from 360 primary scalene triangles) with a dodecahedral approximation to the ecliptic (following the dodecahedral boundary lines from +18° to −18° declination; SUTTON 2019). Secondly, multiple alignments of the classical constellations follow the dodecahedral mapping framework, as illustrated by FIGURE 1 (e.g., five alignments for Eridanus, while Taurus, Cancer and Leo follow the purple band). Several of the star lines of Hipparchus and Ptolemy (*Almagast* 7) fit to FIGURE 1, suggesting vestiges of an inheritance from the polyhedral model.

The presentation finishes by considering model performance in relation to the ten assessment criteria, noting especially how the stellar alignments deteriorate for other dates or other assumptions for setting 0° *RA*. Based on the first reactions, it is hoped that the presentation will stimulate lively debate.

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THE RAVEN, THE CROW, AND THE SUN: A QUANTITATIVE ANALYSIS OF CULTURAL TRANSMISSION

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Computational comparative mythology, Sun, skylore

This study asks whether a simple stochastic propagation model can reproduce the geographic spread of competing sub-motif structures in starlores, such as the Raven-and-Sun and the Man-or-Animal-on-the-Moon.

Dan SPERBER's theory of cultural propagation (1996) offers an alternative to the population genetics approach (BOYD & RICHERSON 1985; ACERBI 2024). Sperber suggests that ideas propagate like viruses. While population genetics primarily models competition among distinct traits within a population, the epidemiological perspective focuses on the inherent tendency of a story or cultural trait to spread to other traditions. Although Sperber's approach provides essential conceptual insights, it lacks mathematical modelling to test it against real data. This gap was addressed at the SEAC 2025 conference (THUILLARD 2025a,b) through a new model utilizing a contact process (birth-and-death) to quantitatively map the spread of myth and folktale motifs across space and time.

The model characterizes the emergence, propagation, and disappearance of motifs by assigning a likelihood to each event. It showed that propagation is the dominant factor compared to independent convergence. A mixture of two parameter sets accurately describes the real data. One set captures the most common regime of motif propagation, while the other describes motifs that are especially widespread, particularly some star and sky motifs, like the "Pleiades are persons". These findings show that sky motifs are disproportionately represented among the most widespread motifs. It is important to note that the model treats all traditions identically.

Further, we developed a method to estimate the age distribution of motifs. It uses an approach that can be described as a kind of "mythological clock" calibrated against ancient records. By anchoring the model in historical data, it becomes possible to estimate how long motifs tend to last. This method helps measure how long oral traditions persist by comparing model predictions to the actual distribution of motifs found today.

In this study, we analyze motifs embedded within layered, interdependent structures, such as the "Man or animal on the Moon" and "Raven and the Sun" motifs, which divide into sub-motifs.

The analysis of real data identifies "root motifs" that are found nearly everywhere and are closely tied to natural phenomena, such as the Moon's surface or the widespread presence of ravens. For the raven, these motifs reflect basic oppositions, such as white versus black and life versus death. Root motifs seem to move freely across languages, cultures, and regions. For example, the life-and-death motif associated with the raven appears in various forms across regions, such as the immortal raven or the raven that tries to kill people. The white-and-black raven root motif (KOROTAYEV *&al*. 2006) is also widely distributed. Both root motifs cover most of the natural range of ravens and crows. Along the Pacific Coast in both Eurasia and North America, the black raven is associated with the sun. Motifs involving the raven (or crow) and the sun are recorded in contiguous regions. Some of these motifs may be attested on ancient artifacts from the Han period and earlier, suggesting they are very old. This analysis shows that not all motifs are independent, and that the model must account for layered, overlapping structures. It is a challenge that the original model did not address.

These layered structures could disrupt a simple model. In the database (BEREZKIN 2015), about one-third of the motifs accommodate two competing, non-overlapping sub-motifs. The extended model integrates this layered structure.

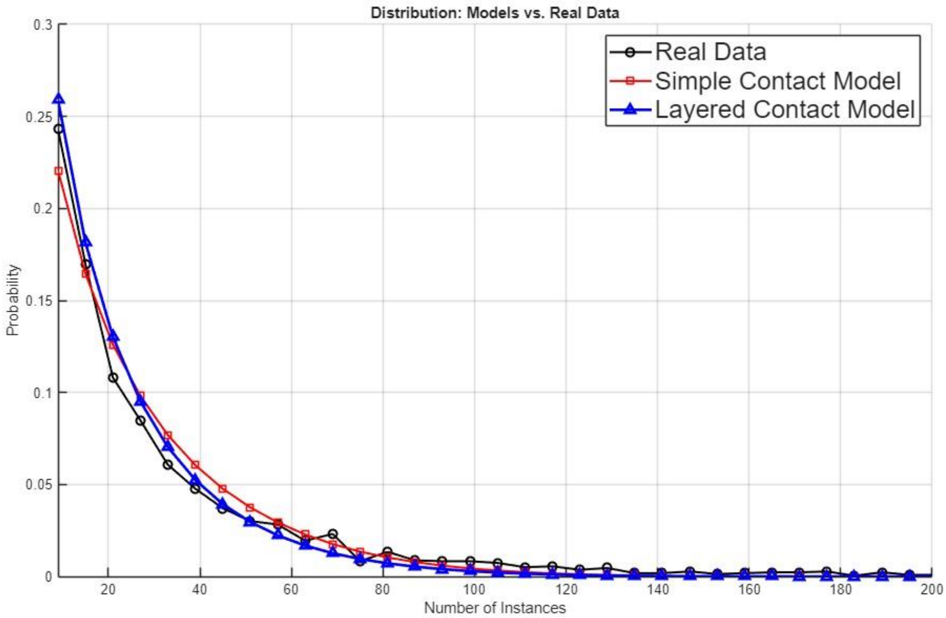

FIGURE 1. Probability distribution of the number of instances of myth and folktale motifs: real data (black circles); simple contact model (red squares); and extended model to include layered structures of interdependent motifs (blue triangles). An "instance" corresponds to one recorded motif occurrence in a distinct tradition.

Results show that competing, non-overlapping sub-motifs only slightly change the overall distribution. Accordingly, the simple model remains a reliable tool for predicting the spread of both independent motifs and layered interdependent motifs.

We also consider potential bias arising from private or secret stories excluded from the motif database. The absence of these motifs does not substantially affect the distribution; as such knowledge is structurally resistant to transmission between traditions. This analysis shows that public motifs constitute the predominant component of large-scale cultural propagation.

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THE "MINOAN GATE TO THE SKY" AND THE RHYTHMS OF NATURE

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astro-architecture, architectural orientation, Papoura, Minoan astronomy, agricultural calendar, cereal sowing, astronomical observatory

Papoura, the so-called "Minoan Gate to the Sky", is a circular Minoan monument (initial phase built ~2800 BCE, based on pottery) with seven concentric cylindrical towers and two crossed radial corridors aligned to key solar events. It functioned as an astronomical observatory and calendar, linking sunrise positions to agricultural seasons and ritual timekeeping within a structured, geometrically organized horizon-based observational system.

Its radial corridors align with sunrise near 26 October (onset of cereal sowing) and the winter solstice, marking the annual cycle. The concentric design and central cross suggest a structured observational system, effectively functioning as a horizon instrument. A bronze device – the so-called Minoan astronomical computer – mirrors this geometry, implying a portable counterpart to the monument.

FIGURE1. Top view of the circular tower on Pappoura hill, Crete. © Ministry of Culture.

This study investigates possible orientation of Papoura. The recurrence of an orientation near azimuth ~100° across multiple sites and periods (Papoura in Crete (~2800 BCE), Eleusis (14th–13th c. BCE), and the temple complex of Abu Simbel) strongly suggests the persistence of a functionally meaningful solar alignment embedded in agricultural and ritual calendars.

At the latitude of Greece, this azimuth corresponds to sunrise in the interval late October to mid-November (modern calendar equivalent). At Eleusis, the alignment toward ~100° at the Ploutonion hilltop church (≈26 October) and the slightly more southerly orientation of the Mycenaean

Telesterion (≈21 November) define a seasonal window rather than a single day. This interval coincides with the critical sowing phase for cereals, marking the transition from post-harvest to renewal, an axis entirely consistent with the chthonic symbolism of Demeter and Kore.

Taken together, these examples point to a shared archaeoastronomical tradition in which the cereal sowing dates (sunrise at ~100° azimuth) encodes a seasonally decisive solar event, integrating subsistence, ritual timing, and cosmological symbolism across regions and centuries.

Note, there is no academic article published yet by any author. It is a new discovery.

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THE DESCENT OF GAṄGĀ: GALACTIC AXIS INTERPRETATION OF INDIAN COSMOLOGY

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Independent Researcher, India

Archaeoastronomy, Nakshatras, Milky Way, Galactic Axis, Indian Cosmology, Stellarium

The descent of the celestial river Gaṅgā (Gangāvataraṇa) is one of the most important cosmological narratives preserved in Indian textual and iconographic traditions. Descriptions in the Mahabharata, the Vishnu Purana, and related Purāṇic literature describe Gaṅgā as originating in the celestial realm, descending through the mediation of Śiva, and flowing as a terrestrial river on Earth for the benefit of living beings. This study investigates whether the structural elements of this narrative correspond to stable astronomical features observable in the night sky, particularly the Milky Way, the galactic axis, and the nakshatra framework. Astronomical simulations were conducted using Stellarium (v25.3), configured for the latitude range of northern India (25°–32° N), where the Ganga cultural tradition is geographically centered. The simulations examined the spatial relationships between the Milky Way, the ecliptic, and prominent stellar markers identified with nakshatras.

The Milky Way forms a continuous luminous band across the celestial sphere, intersecting the ecliptic at two principal regions: near Orion and near Sagittarius. These intersections represent visually and structurally distinct transition points within the observable sky. The northern segment of the Milky Way passes near the bright star Vega, identified in Indian astronomical tradition as Abhijit. Abhijit occupies a special status in traditional cosmology and is explicitly associated with Viṣṇu in the Bhagavata Purana. This region lies within the celestial configuration described in Purāṇic cosmography as the Śiśumāra, a celestial structure encircling the pole and representing cosmic stability and continuity. From this northern origin, the Milky Way extends southward across Cygnus (associated with Haṃsa), Aquila (associated with Garuḍa), and toward Orion. The Orion region lies near the galactic anticentre, where the Milky Way becomes faint and diffuse, marking the region where the line-of-sight points outward from the galactic centre before the Milky Way band curves toward the southern sky. The gradual increase in stellar density and visual structure of the Milky Way after this region create the appearance of a luminous stream emerging around the Betelgeuse/Sirius region. Southward from Orion, the Milky Way continues through Crux, Hadar, Rigil Kentaurus toward Sagittarius, where the galactic centre is located. Sagittarius region represents the densest visible concentration of stars in the Milky Way and produces a visually striking luminous concentration. This region corresponds closely with the Makara sector of the Indian zodiacal framework, traditionally associated with the vāhana of Gaṅgā. It represents the point at which the celestial river manifests in the terrestrial realm. The intersection of the Milky Way and the ecliptic near this region creates a clearly identifiable astronomical transition zone. The high stellar density and brightness of the galactic centre reinforce its visual significance as a natural endpoint for the descending luminous path.

This cosmographic structure is also reflected in traditional iconographic representations, particularly those depicting Naṭarāja. The circular aureole surrounding the deity corresponds structurally to the ecliptic and contains symbolic representations of the 27 nakshatras. The spatial arrangement of symbolic elements within such representations corresponds closely to identifiable stellar regions along the Milky Way's trajectory, reinforcing the correspondence between celestial observation and cosmological symbolism. The analysis demonstrates that the Gangāvataraṇa narrative corresponds structurally to a continuous astronomical axis formed by the Milky Way extending from the northern celestial regions near Abhijit, across Orion near the galactic

anticentre, and toward Sagittarius at the galactic centre. This galactic axis represents a stable astronomical structure observable across millennia due to the long-term stability of galactic geometry. The correspondence between textual descriptions, nakshatra frameworks, and observable celestial structures suggests that Indian cosmological traditions preserved systematic observational knowledge of large-scale celestial organization within symbolic narrative frameworks. These findings demonstrate that the Gangāvataraṇa narrative preserves a coherent cosmographic structure aligned with the Milky Way and nakshatra framework. The stability of this galactic geometry across millennia makes it a reliable observational reference, suggesting that traditional Indian cosmology encoded large-scale celestial structure in narrative and iconographic form. This interpretation contributes to cultural astronomy by identifying a consistent astronomical framework underlying one of the most enduring cosmological narratives of South Asia.

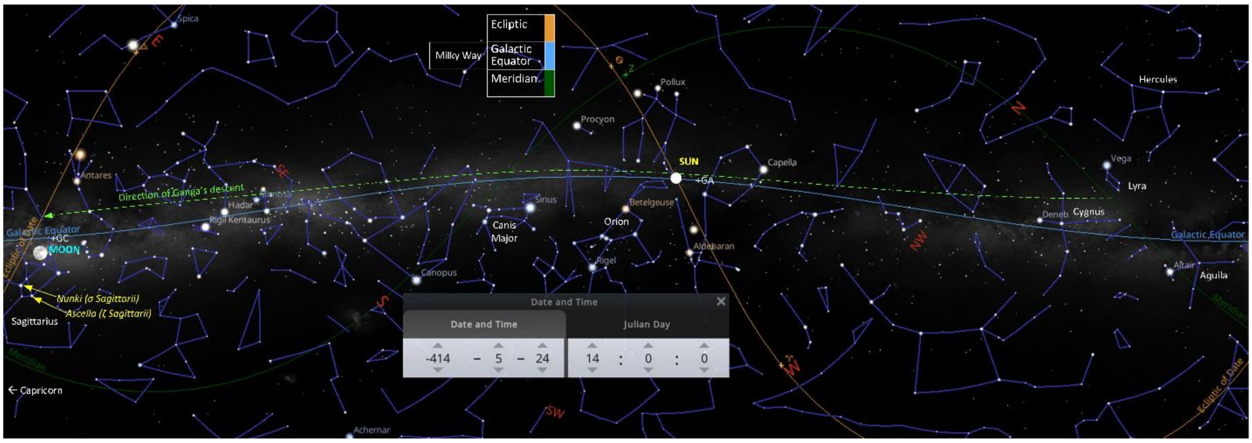

FIGURE 1. The Galactic Axis and the Descent Structure of Gaṅgā in the Nakshatra Framework.
This Stellarium simulation, configured for the latitude of northern India (28° N), shows the Milky Way forming a continuous axis across the celestial sphere. The Milky Way is anchored in traditional cosmography at Abhijit (Vega), from which it extends across the sky through Cygnus and Aquila, and Orion near the galactic anticentre, toward Sagittarius, where its densest and most luminous region marks the galactic centre. This region corresponds to Makara, the vāhana of Gaṅgā, marking the symbolic point of terrestrial manifestation. The ecliptic, containing the 27 nakshatras, intersects this galactic axis at these transition regions, forming a stable cosmographic structure reflected in traditional Gangāvatarana narratives.

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PREHISTORIC FUNERARY LANDSCAPES OF WESTERN SAHARA: FURTHER INSIGHTS FROM CULTURAL ASTRONOMY

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Western Sahara, Tumuli, Archaeoastronomy

Prehistoric dry-stone monuments are widespread across Western Sahara, forming extensive funerary and ritual landscapes that preserve the memory of millennia of human occupation in the Sahara Desert (see example in FIGURE 1). Previous research in North Africa and the Mediterranean has highlighted the importance of the sky in the lives of early communities, suggesting that the location and orientation of funerary structures reflect astronomical observations probably linked to religious beliefs, funerary practices, and systems of time reckoning (BELMONTE *&al*., 1999; GONZÁLEZ-GARCÍA & BELMONTE 2014; GAUTHIER 2009; 2015).

FIGURE 1. One of the documented tumuli in the 2025 campaign in Western Sahara.
© Maria Antonia PERERA BETANCOR.

Building on this background, RODRÍGUEZ-ANTÓN *&al*. (2023) analyzed the orientations of more than 200 prehistoric dry-stone monuments in Western Sahara. Statistical analysis revealed a clear preference for the eastern and south-eastern horizon, a pattern that lies slightly south of the typical lunisolar rising arc and led to the hypothesis that these monuments were oriented toward the waning moon around the winter solstice. This likely reflects symbolic ideas of transition associated with funerary contexts within a broader lunisolar time-reckoning tradition documented across the Sahara and neighboring regions (GAUTHIER 2009, 2015; PERERA BETANCOR & BELMONTE 2021).

To continue these studies, a new fieldwork campaign was conducted in 2025 in the Western Sahara in an area south of Dakhla, focusing on undocumented clusters near ridges. Several engraved stones were also documented, including a spiral, podomorph, and cup-marks. In this work, a preliminary analysis of the patterns of location and orientation of the different archaeological structures studied is presented. The results suggest a connection between the studied sites with significant landmarks in the local topography and, possibly, to some astronomical events, pointing to a close relationship between landscape and skyscape.

Beyond their scientific value, these monuments form part of a fragile heritage currently threatened by the ongoing political situation in the region, occupied by Morocco.

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GILGAMESH AND THE CENTAUR

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Mythology, History, Astronomy

Centering on the conference theme, "Star Lore in the Land of the Centaurs", I propose that the centaur archetype finds its earliest roots in the Epic of Gilgamesh. My research demonstrates that this epic was mapped not only onto the terrestrial landscape but across the celestial one as well, suggesting that the constellation Sagittarius originated within this foundational myth.

The Duality of the Hero: The narrative begins with the introduction of Gilgamesh, the formidable King of Uruk, and Enkidu, the "wild man". Initially, Enkidu lives among gazelles as if he himself possessed hooves; indeed, ancient reliefs frequently depict him with the lower body of an ungulate (see picture below). After being seduced by a priestess and "civilised" Enkidu is brought to Uruk to temper Gilgamesh's tyrannical nature. Following a fierce confrontation at a wedding, the two become inseparable, symbolising a potent union between the wild and the civilised.

From Myth to the Stars: After a series of legendary adventures and the slaying of divine monsters, the gods decree that Enkidu must die. His passing sends a devastated Gilgamesh on a failed quest for immortality. Ultimately, the epic concludes with their reunion in the "House of Dust" —the underworld.

FIGURE 1. Enkidu, Gilgamesh's friend. From Ur, Iraq. 2027–1763 BCE. Iraq Museum.

I argue that this “House of Dust” corresponds to the bulge of the Milky Way in Scorpio, the celestial domain of the goddess Ereshkigal. By the journey’s end, Gilgamesh has gained “wisdom from the deep”, a trait deeply synonymous with the centaur figure. Together, the wise king and his hoofed companion form a composite image that likely evolved into the figure of Sagittarius.

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HOLDING THE BEAST: THE PRESERVATION OF STAR LORE IN THE CAROLINGIAN *DE ORDINE AC POSITIONE STELLARUM IN SIGNIS*

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De Ordine ac Positione Stellarum in Signis, Star Lore, Centaurus, Carolingian Astronomy, Classical Mythology

In the early 9th c. the scriptoria of the Carolingian Empire became the stage for a massive rescue operation of ancient sky knowledge. This paper explores *De Ordine ac Positione Stellarum in Signis*, a star catalogue compiled around the Synod of Aachen (*ca.* 809 CE), which served as a critical vessel for transmitting classical star lore into the medieval Latin West.

While *De Ordine* functions as a technical catalogue listing 715 stars, it explicitly frames its scientific data within the realm of human culture and myth. The text's introduction famously asserts that constellation names are not "established by nature" but "invented by human custom" derived from "fables".

FIGURE 1. Folio 120v of Munich Clm 210, showing the constellations Cetus, Eridanus, Piscis Austrinus, Ara and Centaurus.

This paper will focus on the specific "star lore" preserved within the text, with particular attention to the Centaur. In *De Ordine*, the constellation Centaurus is accorded significant weight, described as containing 43 stars, one of the highest counts in the entire catalogue. The text preserves specific iconographic details crucial to the lore, describing the Centaur not merely as a hybrid creature, but as one holding a "thyrsus" (a staff of giant fennel associated with Dionysus) and gripping a "beast" (bestia, the constellation Lupus) in his hand.

By examining the textual descriptions alongside the manuscript illustrations (such as those in the Madrid 3307 and Munich 210 codices), this paper demonstrates how Carolingian scholars did not merely copy data; they actively curated a "museum" of classical mythology. In *De Ordine*, the Centaur is not just a pattern of stars, but a persistent narrative survivor. A mythological artifact carefully maintained in the new "land" of medieval European science.

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STAGING THE DIVINE: COSMOLOGY, EPIPHANY AND HYDRAULIC DISPLAY AT EFLATUNPINAR

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Hittite cosmology, Eflatun Pınar, ritual landscape, skyscape archaeology

The Hittite spring sanctuary of Eflatun Pınar (37°49′32.38″ N, 31°40′28.68″ E) was constructed in the late 13th c. BCE at a natural spring near the present-day village of Sadıkhacı, about 6.5 km northeast of Lake Beyşehir in Konya Province, central Türkiye. Situated at the empire's southwestern frontier, on the border with Arzawa and the small states of western Anatolia, it represents the most technically sophisticated structure known from the Hittite period. This study approaches the sanctuary as an integrated ritual installation in which architecture, water management, and cosmological imagery were deliberately combined to create a controlled epiphanic experience.

Unlike many Hittite sanctuaries carved into bedrock, Eflatun Pınar was built entirely from carefully dressed blocks of dacite. Fieldwork conducted in 2025 identified the associated quarries at Kara Tepe, near Selki Köy, approximately 6 km north of the site, which supplied more than 1,000 tons of stone. The sanctuary itself remained unfinished. The present analysis combines these new findings with architectural and spatial observations of the monument and its surrounding landscape.

FIGURE 1. The Hittite spring sanctuary of Eflatun Pınar in 2025 (Luwian Studies #1505).

The complex is remarkable for the way it integrates several constructed elements into a coherent cultic setting. Its principal features include a nearly square basin (31 × 34 m) with a flat gravel bed, where water from nearby springs was retained by a dam to a depth of about 50 cm. Along the northern edge rises the façade, composed of 26 monolithic blocks (6.18 m high, 7.06 m wide), decorated with 20 figures arranged across five registers.

As early as 1941, Kurt Bittel interpreted the relief program as a schematic representation of the cosmos. Excavations between 1996 and 2002 confirmed this interpretation by revealing a previously unknown lowest register of five mountain deities, representing the terrestrial realm.

Above this, a two-tiered sky is indicated by paired winged solar discs, surmounted by a larger winged sun. The water contained within the basin likely symbolized the underworld.

What distinguishes Eflatun Pınar is the integration of a water feature designed to induce an epiphanic experience during ritual performance. The façade was hollow and contained an interior chamber capable of accommodating two individuals. From within, a narrow slit allowed a controlled view of the visitors' platform across the basin. At a given signal, internal barriers could be removed, releasing stored water through outlets associated with the mountain deities and effectively animating the monument. As Martin BACHMANN (2006, 262) observed, "the impression on contemporary observers must have been enormous." The ceremony may have been timed to coincide with the spring equinox, when the discharge of the springs reached a seasonal maximum. These observations point to a deliberate orchestration of hydraulic control and visual staging.

Comparable performative effects have been proposed for the Hittite rock sanctuary of Yazılıkaya near Ḫattuša, where natural sunlight may have played a role in solstitial rituals. Evidence from Eflatun Pınar suggests that such multimedia performances formed an integral part of Hittite religious practice, reinforcing the connection between cosmic order and royal authority. The sanctuary thus emerges as a performative environment in which cosmology was not only represented but actively enacted.

At the same time, these effects were technically orchestrated rather than spontaneous manifestations of divine presence. Their authority rested, at least in part, on constructed illusion. The rapid collapse of central power in the Hittite kingdom around 1192 BCE suggests that such mechanisms, however effective in the short term, did not ensure lasting stability.

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NURAGHE SANTU ANTINE (SARDINIA) AS A COSMOLOGICALLY STRUCTURED PLACE: ARCHITECTURE, LANDSCAPE, CRUX AND THE MILKY WAY

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Nuraghe Santu Antine, cultural cosmology, Milky Way (Centaurus-Crux)

Nuraghe Santu Antine (Torralba, Province of Sassari, northern Sardinia; *ca.* 40°29′12″ N, 8°46′11″ E, ~361 m_{ASL}) is one of the largest and most complex monuments of Nuragic architecture (Early-Middle Bronze Age, *ca.* 19th–13th centuries BCE). Interpretations have variously emphasised monumentality, strategic function, socio-political display, and astronomical orientation.

We propose a different but testable framework: Santu Antine is understood as a ritually activated microcosm, whose primary logic is religious-cosmographic, while astronomical references are secondary and embedded within a broader symbolic program.

The architectural grammar forms a coherent cosmological structure: (1) a dominant central keep with three superposed tholos chambers (originally perhaps *ca.* 22–25 m high); (2) a trilobate bastion creating an almost equilateral triangular enclosure with three corner towers; and (3) an inner courtyard connected through seven symmetrically arranged entrances and long internal corridors. This configuration lends itself to a tripartite cosmology—underworld / middle world / upper world (or experientially: below / within / above).

Of particular importance is the presence of cultic water installations integrated into the monument. Subterranean water appears materially enacted as a liminal medium associated with chthonic and Otherworld semantics, while the central tower functions as axis mundi or world mountain mediating vertically between cosmic domains.

Orientation studies show that the entrance axis and upper window openings are directed toward an azimuth of *ca.* 152° ($h \approx 2°$ horizon altitude; $\delta \approx –40.5°$), interpreted as targeting the Centaurus-Crux region (ZEDDA & BELMONTE 2004). At the latitude of Sardinia, the exceptionally bright Centaurus-Crux stretch of the Milky Way forms one of the most visually prominent sectors of the southern sky and may have been perceived as a region of particular cosmological significance. It is plausible that such orientations relate not simply to stellar observation but to the Milky Way conceived as a celestial “dwelling of souls” or cosmic passage (GRIGSBY 2019; RAPPENGLÜCK 2017).

Landscape context is central. The nearby drainage system (Riu Mannu / Valle dei Nuraghi) follows a gently curved SE→NW axis (~140°→320°). Using GIS-based landscape analysis together with horizon-based simulations in Stellarium, tested across multiple epochs and seasonal windows relevant to the Nuragic period, we examine whether Milky Way configurations can appear visually parallel to this terrestrial river corridor.

Methodologically, the study integrates archaeology, architectural and landscape analysis, GIS spatial modelling, cultural cosmology, horizon astronomy, symbolic analysis, comparative mythology, and the history and sciences of religions. The approach is hypothesis-driven and falsifiable through comparative testing of other river-adjacent major nuraghi. Santu Antine is presented as a pilot case outlining a replicable protocol.

FIGURE 1. Nuraghe Santu Antine, Torralba, Sardinia (upper left: M. A. RAPPENGLÜCK; centre: Google Earth Pro, 2022; rising of Gacrux, 1600 BCE, near the spring equinox, ca. 1 h after sunset (Stellarium 25.4; magnitude reduced to 4.59 by atmospheric extinction).

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STELLARIUM SKYCULTURES 2.0: A SIGNIFICANT IMPROVEMENT

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Stellarium, sky cultures, star names

One of the original features of the free and open-source desktop planetarium program "Stellarium" (ZOTTI *&al*. 2021) has been the option of showing figure patterns not only of the standardized constellations, but also for constellations linked to other mythologies available in many cultures worldwide. However, the original implementation implemented only features necessary for the traditional European figures: Constellations as stick figures, figure artwork, and a nametag. At a later time, "asterisms" as established in the understanding of 20th c. were created, *i.e.*, inofficial auxiliary figures, sometimes part of the existing constellations, sometimes spanning parts of several constellations, or even those only visible with telescopes. However, as Stellarium gained popularity also among ethnoastronomers and educators as (probably) only free desktop planetarium showing more than one set of constellation figures, some deficiencies became apparent when contributors tried to add constellation figures which did not fall into the existing conceptual patterns (ZOTTI & WOLF 2021).

The software name "Stellarium" applies to several projects. Fabien CHÉREAU started the classical open-source multiplatform desktop planetarium in summer of 2000 (ZOTTI *&al*. 2021), and already around 2012 a first smartphone version was forked from this. In 2018, CHÉREAU created Stellarium-Web (https://stellarium-web.org), another open-source program that looks superficially similar but does not share program code with the desktop version. It runs in the web browser, necessarily online unless running on a web server hosted on the local computer. After this, he started Stellarium Mobile, a program with similar appearance best used outside, running on iOS and Android devices.

When IAU canonized the segmentation of the sky into 88 constellations (DELPORTE 1930), neither any constellation stick figures nor the traditional star names were of concern. In recent years however, the discovery of exoplanets triggered public naming campaigns which assigned a mingle-mangle of names from all over the world to stars invisible to the unaided eye. When exoplanets around brighter stars became known, IAU had to react and formed a Working Group on Star Names (WGSN), meanwhile headed by one of us (SMH). Its main task is to assign unique names to stars, often selecting authoritative name or spelling variants to well-known stars, but also introducing cultural names from other cultures into the figures of European scientific tradition. The best way to publicize the new names is certainly "by use". The wide acceptance of Stellarium makes it an almost natural candidate to involve this program.

Around 2022 a problem became apparent between the teams developing the various versions of Stellarium. Stellarium-web had introduced a more modern JSON-based file format which is also used by the mobile version. Coordinating additions into all program lines became increasingly problematic. In late 2023, a coordinative meeting between developers and experts in star naming took place in Jena which launched development of a new common file format which should eventually be used by all program versions, providing the chance to add missing features already identified (ZOTTI & WOLF 2021) and a few more desired by the present experts. Version 25.1 of Stellarium has introduced the new file format to be used by all flavours of Stellarium in the future (ZOTTI *&al*. submitted). Over the next few editions, several new skycultures were added which utilize the new cultural elements like dark constellations, single-star constellations, multilingual names and labels, and Zodiac and Lunar stations/mansions where applicable in a sky culture. The OnlineQueries plugin (ZOTTI *&al*. 2023) now can lookup cultural information in the All Sky Encyclopedia (https://ase.exopla.net/) (HOFFMANN *&al*. 2025). Another new plugin (program extension), the Sky Culture Maker, provides a wizard-like interface for adding a new sky culture, even including a geolocation editor to mark the origin of a skyculture on a map, and also interacts with the ASE.

We hope the new Stellarium skyculture format is ready for your contributions!

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SEAC XXXIII Annual Meeting

Programme

FRIDAY, 4 SEPTEMBER 2026

- **14:30** Registration
- **15:30** Welcoming speeches
- **16:00** Session 1: **Centaurs** (chair: John Steele)
  - S. Hoffmann: *Constellation Centaurus as case study*
  - W. Horowitz: *Mixed Beings: From Centaurus to the Sumerian Pig-Fish*
  - A. E. Kechagias: *Hercules and the Centaurs: Myth and astronomy between Ancient Greece and India*
  - M. Georgiadou: *Ritual procession on Pelion at the heliacal rising of Sirius*
  - D. Vickers: *Holding the Beast: The preservation of star lore in the Carolingian "De Ordine ac Positione Stellarum in Signis"*

- **18:00** Session 2: **Near East and Egypt** (chair: Rita Gautschy)
  - E. Zangger, A. Aşınmaz & N. Atila: *Staging the divine: Cosmology, epiphany and hydraulic display at Eflatunpınar*
  - J. Steele: *Horoscopy in Babylonian society*
  - B. P. Carpenter: *Using a least squares ΔT model to refine the chronology of the Amarna period*
  - A. Maravelia: *An amazing solar epiphany (hēliasmos) in two Coptic churches of the Delta*
  - A. Rodrígues-Antón & A. C. González-García: *Astronomy and religion in the Roman temples of Near East*

- **21:00** Conference dinner

SATURDAY, 5 SEPTEMBER 2026

- **09:30** Session 3: **European Prehistory I** (chair: Gail Higginbottom)
  - M. Incerti & F. Rossi: *Light phenomena and archaeoastronomy at Ponte d'Ercole (Italy): a 3D survey and diachronic simulation approach*
  - M. A. Rappenglück: *From embodied measurement to celestial order*
  - S. D. Kiotsekoglou: *Solstices and Equinoxes: Monitoring the positions and movements of the Sun through the eyes of the Ancestors*
  - M. Spasova, H. Valchanova, P. Maglova & A. Stoev: *Sky on Stone: evolution of the depiction of celestial objects on rock surfaces in Prehistory*
  - A. Stoev, P. Maglova & O. Ognyanov: *Research on Eneolithic projective systems for determining solar culminations with drone technologies*

- **11:30** Session 4: **European Prehistory II** (chair: Maitane Urrutia-Aparicio)
  - F. Prendergast: *Facing west—a new archaeoastronomical analysis of wedge tombs*
  - M. P. Zedda & M. A. Rappenglück: *Nuraghe Santu Antine (Sardinia) as a cosmologically structured place: Architecture, landscape, Crux and the Milky Way*
  - G. Higginbottom: *Interpreting local cosmological schemes through dolmen construction*
  - A. C. González-García: *Towards a comprehensive study of megalithic astronomy in Galicia (Spain)*
  - G. Russo: *The Celestial Dog: A pre-registered Neolithic stellar alignment system in southeastern Sicily (5000–4300 BCE)*

- **16:00** Session 5: **Africa & Asia** (chair: Marc Thuillard)
  - M. Urrutia-Aparicio, A. Rodríguez-Antón, M. A. Perera Betancor & A. C. González-García: *Prehistoric funerary landscapes of Western Sahara: further insights from cultural astronomy*
  - B. S. Shylaja & S. M. Hoffmann: *The Vedic Nakshatras and the Babylonian zodiac*
  - C. B. Ugranarasimhaiah: *The Descent of Gaṅgā: Galactic axis interpretation of Indian cosmology*

- H. Attaolahi: *The concept of time in Ancient Persia*
- S. Sheiki, N. Andalib & A. C. González-García: *The Celestial Body: The intersection of astronomy, history and architectural symbolism in Nizami's "Haft Peykar"*

- **18:00** Session 5: **America** (chair: Nicolas Balbi)
  - S. Gullberg: *Cosmic worldview of the Inkas*
  - S. Motta, S. Ayub, L. Epis & C. Paolo: *Tiwanaku (Bolivia), an archaeoastronomical study on the role of the stars in the dating of the site*
  - R. Kanazawa: *Afterimage Archaeoastronomy: A physiological framework for ancient sky perception and monumental alignments*
  - S. Iwaniszewski: *The origins and spread of Lunar Series in the Early Classic Period (ca. 250/357-600 CE), Maya Lowlands*
  - M. C. H. Lourenço & S. Valentim: *Cultural astronomy in Candomblé and its potential for science education*

- **21:00** Film screening (Kordatos Amphitheatre)
  - *Cielo* by Alison McAlpine
    Cielo is a love poem for the night sky, set in the Atacama Desert, Chile. Planet Hunters in the Atacama's astronomical observatories and the desert dwellers who work the land and sea share their evocative visions of the stars and planets, their mythic stories and existential queries with remarkable openness and a contagious sense of wonder.
    Language: Spanish / English / French
    Subtitles: English

SUNDAY, 6 SEPTEMBER 2026

- **09:30** Session 7: **Methodology** (chair: César González-García)
  - G. Zotti, S. M. Hoffmann & A. Wolf: *Stellarium Skycultures 2.0: A significant improvement*
  - R. Gautschy: *Reproducible Archaeoastronomy: Structured workflows for astronomical chronology in the digital humanities*
  - J. Mejuto & E. Rodas-Quito: *"Chan U'bih": An online archaeoastronomical research engine for horizon-based alignment studies*
  - M. Frincu, M. Urrutia-Aparicio, A. Ancuta & H. Hochbauer: *New tools for standard and GIS based archaeoastronomical analysis*
  - V. Lianou, M. Frincu & M. Urrutia-Aparicio: *Estimating orientation in Roman towns: An AI-based approach*

- **11:30** Session 8: **Science & Myth** (chair: Alicia Maravelia)
  - X. Moussas: *From Logos to Algorithm: The Antikythera Mechanism between nomos, physical law, and proto-artificial Intelligence*
  - S. Draxler & M. E. Lippitsch: *Description and illustration of solar and lunar eclipses in Medieval and Renaissance times*
  - J. N. Balbi: *The first stratospheric ascension project of the southern hemisphere (1938) and the scientists' questions*
  - M. Thuillard: *The Raven, the Crow, and the Sun: A quantitative analysis of cultural transmission*
  - N. Bekbassar: *The theory of celestial imbalance: On the question of the relationship between the Pleiades and the Big Dipper in the mythology of Eurasian steppe*

- **16:00 Workshop** (Computer Room)
  - Z. Kovačić: *Circular statistics in archaeoastronomy Using R*

- **20:30 Outreach lecture** in Greek (Kordatos Amphitheatre)
  - X. Moussas: *Ο Μηχανισμός των Αντικυθήρων πρόδρομος της Τεχνητής Νοημοσύνης*

- **21:30 Star gazing** with Volos Astronomy and Space Society

MONDAY, 7 SEPTEMBER 2026

- **09:30** Session 9: **Greece** (chair: Xenophon Moussas)
  - M. V. Garcia-Quintela & A. C. González-García: *Helios in Athens: from the city of Theseus to the city of Plato*
  - M. A. Sutton: *From arithmogeometry to stellar alignments: Exploring a polyhedral model underlying the classical constellations*
  - A. Paule: *Greeks, gnomonics, mathematics: Sundials and their inventors in Ancient Greek culture*
  - T. G. Dallas, C. Apostolou & L. Zacheilas: *The orientation of the tholos tombs in Dimini*
  - I. Cristofaro: *Conceptual developments in skyscape archaeology in sacrificial festival contexts: the seasonality–test*

- **11:30** Session 10: **Varia & Posters** (chair: Themis Dallas)
  - D. Hamacher & J. Holbrook: *Indigenous astronomy in the space age: a report on the 2025 IAU Symposium 399 / Oxford XIII Meeting*
  - J. D. Mooney: *"Catching the Equinox", Santiago de Compostela*
  - G. van Aarsen: *Gilgamesh and the Centaur*
  - V. Lianou: *"Archaeosky": A computational platform for archaeoastronomical analysis of the Roman world*
  - G. Henrikkson: *Caesar's comet identified as comet Encke II, a part of comet Encke*
  - K. N. Kokkolis: *Tiresias and the well-made oar: Cosmic orientation in Bronze Age sacred architecture*
  - A. Bajic & M. S. Dimitrijević: *"Shield of Heracles": A poem, a temple and a celestial battle*
  - X. Moussas: *Astronomical orientation of orthogonal buildings in Neolithic Thessaly*
  - M. Tsikritsis & X. Moussas: *The Minoan Gate to the Sky and the rhythms of nature*
  - R. Perez-Enriquez, E. Rodas-Quito, X. Moussas: *Astro-architectural design principles in Greek and Roman theatres: Solar-gnomonic construction rules*
  - D. Marinho, A. C. González-García & A. M. S. Bettencourt: *Wheel-crosses in Southern Galicia: Archaeoastronomical patterns and interpretations*
  - C. Maumené: *Beyond salt: a neolithic funerary vessel as a possible astronomical tool?*
  - R. Pierini & P. Nava: *Celestial Gardens: Plant and constellation lore in the sky of Centaurus*
  - A. Gangui & C. Rivera: *Archaeoastronomy in the Bolivian highlands: a preliminary analysis of the orientation of the funerary towers of Tama Chullpa, Culli Culli*

- Conference synopsis
- Light lunch
- **14:30** SEAC General Assembly
- *Carlos Jaschek Award* ceremony
- **21:00** Space-inspired concert (Kordatos Amphitheatre)
  - Performed by *Synola* the University of Thessaly Music Ensembles

TUESDAY, 8 SEPTEMBER 2026

- **09:30** Conference excursion to Milies.
  - Visit the historical library to browse through old astronomy books and see the famous zodiac fresco in the village church. Lunch included.

SEAC XXXIII Annual Meeting

Contributors’ biographical notes
in alphabetical order

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Chrisostomos K. APOSTOLOU is a Surveying Engineer with specialization in topography and geodesy. He is engaged in three-dimensional documentation of projects and monuments in both terrestrial and underwater environments. He is also a member of the Hellenic Institute of Maritime Archaeology.

Alper AŞINMAZ is a digital archaeologist specializing in geospatial analysis, remote sensing, and GIS-based approaches to archaeological research. He received his PhD in Geospatial Analysis in Archaeology from Dokuz Eylül University and was a postdoctoral fellow at ANAMED, Koç University, where he worked on geospatial and data science applications in archaeology. His research focuses on spatial data integration, landscape analysis, and remote sensing.

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Bentolhoda ATOLLAHI is a PhD student in the History of Astronomy at the University of Barcelona. Her research focuses on the concept of time in ancient history, with a special emphasis on Persian history and its astronomical traditions. hoda.ataollahi@gmail.com

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