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Struggling for Interdisciplinarity: Reflections of an Astrophysicist Working in Cultural Astronomy[1]

César Esteban

Abstract: I present a personal view `on the role of astrophysicists and astronomers doing research in cultural astronomy. First, I discuss the definition of archaeoastronomy or cultural astronomy and its controversial interdisciplinary nature. I comment about the actual curricular problem of astrophysicists working in this topic and the difficult communication between astrophysicists—as well as other natural scientists—and archaeologists or anthropologists. I highlight the importance of accuracy in determining the orientation when mapping archaeological sites. Finally, I insist on the necessity of considering the celestial sphere as a part of the context of the archaeological sites, and that archaeoastronomy should be considered as a part of landscape archaeology.

A Definition Problem

The systematic study of astronomical orientations in Neolithic megalithic monuments began just over 50 years ago in the British Isles with the work of Gerald S. Hawkins on Stonehenge and the detailed studies of stone circles by Alexander S. Thom.[2] Hawkins was an astronomer and Thom an engineer and therefore used a rather different methodology to that familiar to archaeologists. These early researchers interpreted the existence of astronomical alignments as a demonstration of the high degree of geometric and astronomical knowledge gained by Megalithic

[1] First published as César Esteban (2009) 'La astronomía cultural ¿es interdisciplinar? Reflexiones de un astrofísico', *Complutum* Vol. 20, no. 2, 69-77.

[2] Gerard S. Hawkins, 'Stonehenge decoded', *Nature* 200 (1963): pp. 306-308; Gerard S. Hawkins, 'Stonehenge: a Neolithic computer', *Nature* 202 (1964): pp. 1258-1261; Gerard S. Hawkins and John B. White, *Stonehenge decoded* (New York: Doubleday, 1963); Alexander Thom, *Megalithic sites in Britain* (Oxford: Clarendon Press, 1967); Alexander Thom, *Megalithic lunar observatories* (Oxford: Clarendon Press, 1971).

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man. In fact, for both, these sites functioned as true observatories.[3] Hawkins and White called the study of astronomical orientations astro-archaeology, defining it as an auxiliary discipline of archaeology, anthropology and history.[4]

Archaeologists harshly criticized early works on the orientation of megalithic monuments from both the conceptual and methodological points of view. In fact, a lively discussion was opened in *Antiquity*, one of the leading international archaeological journals.[5] According to S. Iwaniszewski, this disagreement between archaeologists and the first astro-archaeologists was mainly due to 'the lack of a theory for analysing the astronomical knowledge in prehistoric societies'.[6] That is, the lack of a cultural, social and anthropological framework with which to interpret the data provided by astronomical alignments. Euan MacKie proposed a first but controversial attempt to explore the social implications of the results of astro-archaeological research on megalithic monuments.[7]

The precise name one uses for our topic of interest is not a trivial issue for many researchers. The term astro-archaeology was soon no longer used, at least in scientific circles. MacKie introduced the term 'archaeoastronomy' and defined it as the study of astronomical practices in the past.[8] On the other hand, in the early 1980s Anthony Aveni defined astro-archaeology as a hard branch of archaeoastronomy only limited to fieldwork and the subsequent calculations, detached from any kind of social or cultural analysis of the data.[9] Today pseudo-scientists have appropriated the term astro-archaeology so, for many of us, the situation of astro-archaeology is rather analogous to that of astrology with respect

[3] Thom, *Megalithic lunar observatories*, p. 9; Fred Hoyle, 'Stonehenge – an eclipse predictor', *Nature* 211 (1966): pp. 454-456.

[4] Hawkins and White, *Stonehenge decoded*, p. 121.

[5] Richard J. C. Atkinson, 'Moonshine on Stonehenge', *Antiquity* 40 (1966): pp. 212-216; Jacquetta Hawkes, 'God in the Machine', *Antiquity* 41 (1967): pp. 174-180; Fred Hoyle, 'Speculations on Stonehenge', *Antiquity* 40 (1966): pp. 262-276.

[6] Stanislaw Iwaniszewski, 'De la astroarqueología a la astronomía cultural', *Trabajos de Prehistoria* 51, no. 2 (1994): pp. 5-20.

[7] Euan MacKie, *Science and Society in Prehistoric Britain* (London: Paul Elek, 1977).

[8] Euan MacKie, 'The last word on archaeoastronomy?', *Archaeoastronomy (BCA)* 4, no. 1 (1981): p. 6.

[9] Anthony F. Aveni, *Observadores del cielo en el México antiguo* (Mexico City: Fondo de Cultura Económica, 1991): p. 14.

to astronomy. I recommend the book by John Michell about the early years of the studies of astronomical alignments and the history of astro-archaeology.[10]

One of the most lucid—but somewhat lengthy—definitions of archaeoastronomy has been proposed by Ed C. Krupp:

> Archaeoastronomy is the interdisciplinary study of prehistoric, ancient, and traditional astronomies worldwide within their cultural context. It includes both written and archaeological records. It embraces calendrics; practical observation; sky lore and celestial myth; symbolic representation of celestial objects, concepts and events; astronomical orientation of tombs, temples, shrines, and urban centers; symbolic displays involving celestial phenomena in the natural environment; traditional cosmology; and ceremonial application of astronomical tradition.[11]

By including traditional astronomy and cosmology—those of living cultures—Krupp is implicitly considering ethnoastronomy as a part of archaeoastronomy, although many interpret them as separate disciplines.

According to Iwaniszewski the diverse views on the definition of archaeoastronomy can be divided into three groups:[12]

> a) Archaeoastronomy is an interdisciplinary field of research and, along with ethnoastronomy, represents a holistic approach to the study of astronomy in the past and in the present.
> b) Archaeoastronomy is a branch of the history of science.
> c) Archaeoastronomy is a part of anthropology.

Iwaniszewski also questions the consideration of archaeoastronomy as an interdisciplinary field of study. He argues that its methods of interpretation use concepts and models of anthropology and history, but

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[10] John Michell, *A Little History of Astro-Archaeology: Stages in the Transformation of a Heresy* (London: Thames & Hudson, 1989).

[11] Ed C. Krupp, 'Archaeoastronomy', in John Lankford, ed., *History of Astronomy. An Encyclopedia* (New York and London: Garland Publishing, Inc., 1997): pp. 21-30.

[12] Stanislaw Iwaniszewski, 'Archaeoastronomy and cultural astronomy: methodological issues', *Archaeologia e astronomia: esperienze e prospettive future*, Atti dei Convegni Lincei 121 (Rome: Accademia Nazionale dei Lincei, 1995): pp. 17-26.

not of modern astronomy.[13] Juan A. Belmonte seems to share this idea, as he says that archaeoastronomy 'is not a research topic of modern Astrophysics, and does not provide further information to advance in our knowledge of the physical universe'.[14] Iwaniszewski concludes that an archaeoastronomer is a researcher trained in anthropology—though not necessarily an anthropologist—and interested in the study of the role of the sky and celestial bodies in past and present cultures.[15]

For some scholars, the alleged interdisciplinary nature of archaeoastronomy is or may become a problem. For example, Krupp indicates that this can lead to the production of superficial studies.[16] M. Zeilik argues that it is precisely its interdisciplinary character that is responsible for the generally negative reception that archaeoastronomy has had among archaeologists.[17]

In 1990, Iwaniszewski proposed a new term: cultural astronomy, defining it as the study of the relationships between man and astronomical phenomena within a cultural context. Although considered as a separate discipline, it would be composed of four sub-disciplines: archaeoastronomy, ethnoastronomy, history of astronomy and social astronomy.[18] C. L. N. Ruggles and N. J. Saunders also endorsed this definition, indicating that cultural astronomy is closely related to the three anthropological disciplines—cultural anthropology, archaeology and ethnohistory—and one of its main objectives is the creation of a rigorous methodology with which to integrate data from such diverse sources.[19]

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[13] Iwaniszewski, 'Archaeoastronomy and cultural astronomy: methodological issues'.

[14] Juan A. Belmonte, 'La investigación arqueoastronómica', in José Lull, ed., *Trabajos de Arqueoastronomía. Ejemplos de África, América, Europa y Oceanía* (Gandía: Agrupación Astronómica de La Safor, 2006): pp. 41-79.

[15] Iwaniszewski, 'Archaeoastronomy and cultural astronomy: methodological issues'.

[16] Ed C. Krupp, 'A glance into the Smoking Mirror', in Ray A. Williamson, ed., *Archaeoastronomy in the Americas* (Los Altos: Ballena Press/Center for Archaeoastronomy, 1981): pp. 55-59.

[17] Michael Zeilik, 'One Approach to Archaeoastronomy: An Astronomer's View', *Archaeoastronomy (JCA)* 6, nos. 1-4 (1983): pp. 4-7.

[18] Stanislaw Iwaniszewski, 'Astronomy as a Cultural System', *Interdisciplinarni zsledvaniya* 18 (1991): pp. 282-288.

[19] Clive L. N. Ruggles and Nicholas J. Saunders, 'The Study of Cultural Astronomy', in Clive L. N. Ruggles and Nicholas J. Saunders, eds., *Astronomies and Cultures* (Niwot: University Press of Colorado, 1993): pp. 1-31.

The development of archaeoastronomy and cultural astronomy in Spain has been summarized in several works.[20] The first publications were the product of specific collaborations between archaeologists and astronomers to study particular archaeological sites and the series of studies published by Michael Hoskin on dolmens on the Iberian Peninsula.[21] Some of Hoskin's works were done in collaboration with Spanish researchers—mostly archaeologists—and have been published since 1994.[22] Since 1993, Juan A. Belmonte and I, both astrophysicists at the Instituto de Astrofísica de Canarias (IAC, in Tenerife, Canary Islands) have undertaken extensive work in cultural astronomy—working together and separately—and published numerous papers and books.[23] One important addition to our research group at the IAC was A. César González-García, who is now one of the leading Spanish researchers in the area. In the last 10 to 15 years, we have had several additions to the Spanish archaeoastronomical community: the interdisciplinary group at the Universidad Complutense de Madrid, led by M. L. Cerdeño and G. Rodriguez, who have carried out interesting studies on Celtiberian culture; the work of M. Pérez Gutiérrez on Spanish Iron Age sites; and

[20] César Esteban, 'La arqueoastronomía en España', *Anuario del Observatorio Astronómico de Madrid para 2003* (Madrid: Instituto Geográfico Nacional, 2003): pp. 309-322; María L. Cerdeño, Gracia Rodríguez-Caderot, Pedro R. Moya, Ana Ibarra and Silvia Herrero, 'Los estudios de arqueoastronomía en España: estado de la cuestión', *Trabajos de Prehistoria* 63, no. 2 (2006): pp. 13-34.

[21] María S. López Plaza, Fernando Alonso, Manuel Cornide and A. Alvarez, 'Aplicación de la astronomía a la orientación de los sepulcros megalíticos de corredor en la zona noroccidental de la Península Ibérica', *Zephyrus* XLIV-XLV (1991-1992): pp. 183-192; Martín Almagro-Gorbea and Jean Gran-Aymerich, 'El estanque monumental de Bibracte', *Complutum Extra*, 1. (Madrid: Universidad Complutense de Madrid, 1991).

[22] See a compilation in Michael Hoskin, *Tombs, Temples and their Orientations: A New Perspective on Mediterranean Prehistory* (Bognor Regis: Ocarina Books, 2001).

[23] Juan A. Belmonte, *Las leyes del cielo* (Madrid: Temas de Hoy, 1999); Juan A. Belmonte, *Pirámides, templos y estrellas* (Barcelona: Crítica, 2011); Juan A. Belmonte and Michael Hoskin, *Reflejo del cosmos. Atlas de arqueoastronomía en el Mediterráneo antiguo* (Madrid: Equipo Sirius, 2002); Antonio Aparicio and César Esteban, *Las pirámides de Güímar. Mito y realidad* (Santa Cruz de Tenerife: Centro de la Cultura Popular Canaria, 2005).

the studies carried out by Francisco Burillo Mozota and Maria P. Burillo on Celtiberian sites and ancient representations of constellations.[24]

A Curricular Problem

As discussed in the preceding section, for several scholars it would seem that astronomers have little role to play in cultural astronomy, at least in carrying out high-level studies. Honestly, I do not think this is the case. The historical development of our discipline has led to an evolution of its actors, as we have seen: first they were astronomers and engineers but gradually archaeologists and anthropologists have been taking a more important role. This is a reasonable and healthy evolution, because these professionals are precisely the ones most interested in the output of cultural astronomy studies. Moreover, archaeologists and anthropologists possess the training and methodologies with which archaeoastronomical results can be understood in their context. It is clear that astronomical alignments and other kinds of raw archaeoastronomical data are themselves not the important thing. They acquire full meaning when they help us to better understand the symbolism, religion and social and economical relations of human communities. Therefore, if an astronomer or astrophysicist wants to do a valuable job in archaeoastronomy and cultural astronomy, she or he should acquire some serious training in the methodologies of the humanities.

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[24] María L. Cerdeño, Gracia Rodríguez and Marta Folgueira, 'El paisaje funerario de la cultura celtibérica', *Anales de Prehistoria y Arqueología* 17-18 (2001-2002): pp. 177−185; María L. Cerdeño, María C. Hernández, Gracia Rodríguez and Marta Folgueira, 'Novedades culturales y metodológicas en la necrópolis de Herrería (Guadalajara)', *Novedades arqueológicas celtibéricas* (Madrid: Publicaciones del Museo Arqueológico Nacional, 2004), pp. 43-62; Gracia Rodríguez, María L. Cerdeño, Marta Folgueira and Teresa Sagardoy, 'Observaciones topoastronómicas en la Zona Arqueológica de El Ceremeño (Herrería, Guadalajara)', *Complutum* 17 (2006): pp. 133-143; Manuel Pérez Gutiérrez, 'Astronomía y Geometría en la Vettonia', *Complutum* 20, no. 2 (2009): pp. 141-164; Manuel Pérez Gutiérrez, Jordi Diloli Fons, David Bea Castaño and Samuel Sardà Seuma, 'Astronomy, culture and landscape in the Early Iron Age in the Ebro Basin', in Clive L. N. Ruggles, ed., *"Oxford IX" International Symposium on Archaeoastronomy*, Proceedings of the IAU Symposium No. 278 (Cambridge: Cambridge University Press, 2011): pp. 382-389; Francisco Burillo Mozota, María P. Burillo and Puy Segurado, 'De la investigación a la escuela: "Segedadenoche". Una reinterpretación teatralizada de la cosmogonía celtibérica', *Complutum* 20, no. 2 (2009): pp. 195-210.

From my professional experience and taking into account the current situation, the ideal researcher in cultural astronomy — to have higher possibilities to follow a consistent career — should be an archaeologist or anthropologist who acquires serious training in positional astronomy. A paradigmatic example of this would be the Mexican school of archaeoastronomy and cultural astronomy, such as the research groups organized around J. Broda (Instituto de Investigaciones Históricas, in the Universidad de Nacional Autonóma de México [UNAM]) and S. Iwaniszewski (Escuela Nacional de Antropología e Historia), both in Mexico City. These groups develop research projects and train new professionals in cultural astronomy from the fields of archaeology and anthropology. In Spain, we do not have a long tradition in interdisciplinary groups working in cultural astronomy, although those led by M. L. Cerdeño at the Universidad Complutense de Madrid and F. Criado-Boado and A. C. González-García at the Instituto de Ciencias del Patrimonio in Santiago de Compostela are seminal in this regard.

During my years of experience in teaching positional astronomy in the Degree on Physics at the Universidad de La Laguna, I have noticed that cultural astronomy arouses much interest among students. Every year, I had undergraduate students interested in carrying out works of introduction to research in this field. In fact, the level of interest on cultural astronomy is fairly similar to other topics I have taught at the University, the physics of interstellar matter or exobiology. When an undergraduate of astrophysics would ask me to work in cultural astronomy, I use to be frank and say that the experience gained with this kind of work can hardly have a place in the current design of the *curriculum vitae* of an astrophysicist. At any rate, they usually complete the work successfully and are happy to do it. In Spain, there is an extremely limited number of astrophysicists who have done or are doing a PhD in cultural astronomy and there are no contract offers for postdoctorals in this area, so that the academic and professional training in this topic is extremely difficult, at least until now, for astrophysicists. However, the National Plan for Astronomy and Astrophysics of the Spanish Government made a breakthrough in this direction by approving—in three consecutive occasions—three-year research projects devoted to cultural astronomy led by J. A. Belmonte. This was an official recognition of this branch of research by the rest of Spanish astronomers. Unfortunately, these research projects were never endowed with postdoctoral contracts but only with PhD studentships.

In my particular case, I dedicate most of my research to astrophysical issues. The work in cultural astronomy occupies a limited percentage of my time—a varying percentage depending on the circumstances and commitments of each moment. I started working on astronomical alignments shortly before finishing my PhD thesis, which was devoted to the determination and analysis of the chemical composition of nebulae associated with evolved massive stars. Some years later I got a permanent position as lecturer in the Department of Astrophysics at the Universidad de La Laguna, with a research and teaching profile in physics of the interstellar medium. To gain that position, I defended the merits of my curriculum vitae in a public exam before a panel of five astrophysicists. Of course, I mentioned the work I had done in cultural astronomy, but only as an additional merit. Honestly, I think this was the most reasonable strategy to get the position, taking into account its profile and the composition of the panel. Fortunately, getting a permanent position has allowed me to work in cultural astronomy without pressure, but the problems of astrophysicists who like to do other kinds of research does not stop here. In Spain, those who have permanent positions at universities or research centres have the possibility to obtain a complement to their salaries based on the evaluation of the quantity and quality of their research activities during six-years periods (the so-called *sexenios*). As I have to apply to the physics and astronomy panel, the merits presented for evaluation should be related to astrophysical research. The presentation of merits based on research in cultural astronomy may very probably be undervalued or even ignored by the panel, so one needs to do research on astrophysics to obtain such *sexenios*. Unfortunately, the situation of a researcher with a postdoctoral position or a temporary research contract—currently, the situation of most Spanish researchers under the age of 40—is far more difficult. The enormous competitiveness and the lack of positions and research contracts in cultural astronomy make it extremely difficult to build a career in this topic. Disseminating the results of our research among our colleagues is a key issue in getting any kind of official recognition by the astrophysical community. This is a true challenge for our still small group. The ideal situation would be to reach a certain critical mass of staff researchers with well-funded projects in cultural astronomy to ensure some representation and appreciation by the community.

Seeking Recognition by Archaeologists

The controversies that appeared with the early astro-archaeological works resulted in a rather general rejection of the discipline by the archaeological community. This has been—and still is—a handicap on the recognition of cultural astronomy as a valid field of research for many archaeologists. However, the main problem is the continuous development of a genuine pseudo-science under the heading of astro-archaeology, which confuses both the general public and the uninformed professionals.[25] An additional fact that does not contribute to the communication between astronomers and archaeologists is the important differences between the epistemology of the 'hard' or natural sciences and humanities, which may lead to mutual misunderstanding, prejudice and, in extreme cases, to a complete disregard. Cerdeño et al. discussed the lack of a common language between the communities, but fortunately noted some improvements: 'The scientism of the earlier authors (referring to the Spanish case), always astrophysicists, was completely exclusive, but that problem is becoming solved with the use of a more accessible language that allows easier access to technical data'.[26] The maturity that comes with experience, the dialogue—in some cases struggle—with journal referees, and above all, the contact and collaboration with archaeologists, have helped to improve the communication.

Sometimes, I feel that archaeoastronomical findings seem to have a rather limited impact on archaeological research, at least in the cultural areas more familiar to me. This makes me think that perhaps we are trying to answer questions that nobody has formulated or nobody is interested in.[27] While this may be true in some cases, I am convinced that this is a problem of the pioneering character of our research, because we are actually opening a new way of obtaining information about important cultural aspects of past societies. The main goal of cultural astronomy is to provide information about the ideological and religious systems of past cultures. For example, by studying the calendar we can infer aspects of

[25] César Esteban, 'Arqueoastronomía y pseudociencia', in Inés Rodríguez Hidalgo, Luis F. Díaz Vilela, Carlos J. Álvarez González and José M. Riol Cimas, eds., *Ciencia y pseudociencias: realidades y mitos* (Madrid: Equipo Sirius, 2004), pp. 249-259; Belmonte, 'La investigación arqueoastronómica': pp. 41-79.

[26] Cerdeño et al., 'Los estudios de arqueoastronomía en España: estado de la cuestión'.

[27] I think this thought arose in a conversation with my colleague and friend Ivan Šprajc.

the organization of the subsistence cycle and its relationship with the environment, which is often also intimately related to the social cycles. These cycles reflect the organization of the community at different levels and the power relationships. Fortunately, in Spain the number of archaeologists that are beginning to take into account these aspects is continuously increasing, and this is good news.[28] One example is the opinion of the renowned reputed archaeologist T. Chapa Brunet concerning archaeoastronomical works carried out on Iberian culture:

> Considering the data we have at hand, these kinds of proposals are for the moment rather speculative, but the knowledge of the annual rhythms of a society tells us a lot about its economic and ideological organization, and therefore more emphasis should be given to this type of documentation when studying the archaeological sites.[29]

The Celestial Sphere as a Context

One of the trends of modern archaeology is the study of sites in relation to their geographic and ecological contexts, which is now known as landscape archaeology. I. Grau Mira gives a lucid definition of this discipline: 'Landscape archaeology may be defined as a comprehensive and multidirectional analysis of the elements of the landscape that tries to

[28] López Plaza et al., 'Aplicación de la astronomía a la orientación de los sepulcros megalíticos de corredor en la zona noroccidental de la Península Ibérica'; Almagro-Gorbea and Gran-Aymerich, 'El estanque monumental de Bibracte'; Cerdeño et al., 'El paisaje funerario de la cultura celtibérica'; Cerdeño et al., 'Novedades culturales y metodológicas en la necrópolis de Herrería (Guadalajara)'; José L. Escacena Carrasco, 'Allas el estrellero, o Darwin en las sacristías', in José L. Escacena Carrasco and Eduardo Ferrer Albelda, eds., *Entre Dios y los hombres: el sacerdocio en la antigüedad*, Spal Monografías VII (Seville: Universidad de Sevilla, 2006), pp. 103-156; Felipe Criado and Marco García Quintela, 'Landscape, archaeology and ethno-astronomy: a union foretold', in Mauro P. Zedda and Juan A. Belmonte, eds., *Lights and Shadows in Cultural Astronomy* (Isili: Associazione Archeofila Sarda, 2007), pp. 87-99.

[29] Teresa Chapa Brunet, 'Sacrificio y sacerdocio entre los iberos', in José L. Escacena Carrasco and Eduardo Ferrer Albelda, eds., *Entre Dios y los hombres: el sacerdocio en la antigüedad*, Spal Monografías VII (Seville: Universidad de Sevilla, 2006), pp. 157-177.

understand the society that models the space and interacts with it'.[30] It seems obvious that the celestial sphere should be considered as part of the context for understanding the possible reasons for the location of any archaeological site. In fact, some archaeologists have begun to consider the study of the orientations of archaeological remains as a part of landscape archaeology.[31]

An example of an archaeological monument tied in context at different levels may be the Iberian temple of Tossal de Sant Miquel de Llíria, in the province of Valencia, Spain.[32] The building is embedded within the layout of an Iron Age Iberian settlement, but precisely in a place where its orientation is twisted to lie in an east-west direction and in a high place with an open view of the Eastern horizon. Curiously, the space in front of the temple entrance is clear of the remains of any other construction. The archaeologists that worked on the site confirmed that no other buildings were ever erected in that particular spot—at least during the existence of the Iberian settlement—leaving an empty space that allowed a view of the eastern horizon from the temple. This first fact indicates the importance of the location and arrangement of the temple within its nearest context, the settlement. As I have said, the building is oriented in the east-west direction and is facing very precisely the point of the horizon where the sun rises at the equinoxes. This second fact relates the temple with its celestial context. But the relations do not end here: seen from the temple, the sunrise at the equinoxes takes place on the top of a small mountain that breaks the monotony of flat southeast horizon. Therefore, the mountain could have a function as a marker or calendrical reference, providing a third fact that indicates the integration of the archaeological site within the geographical context.

Because of my training as astrophysics, the type of research I usually do in cultural astronomy is the determination and analysis of alignments defined in archaeological sites and the horizon that surrounds them. In most cases, I collaborate with archaeologists that have excavated the sites. This collaboration has proved extremely useful especially at two

[30] Ignasi Grau Mira, *La organización del territorio en el área central de la Contestania Ibérica* (San Vicente del Raspeig: Publicaciones de la Universidad de Alicante, 2002), p. 20.

[31] Criado and García Quintela, 'Landscape, archaeology and ethno-astronomy: a union foretold'.

[32] César Esteban and Soraya Moret, 'Ciclos de tiempo en la cultura ibérica: la orientación astronómica en el templo del Tossal de Sant Miquel de Llíria', *Trabajos de Prehistoria* 53, no. 1 (2006): pp. 167-178.

key moments of the research. Firstly during the fieldwork, where we try to combine our different but complementary points of view—the astronomical and archaeological— for better understanding the site and to consider subtle important aspects that otherwise could go unnoticed to one of us working alone. And secondly, in the discussion of the results where we try to integrate the archaeoastronomical findings into the wider ideological and archaeological context of the culture we are investigating.

The astronomical analysis of the alignments defined in a monument tells us if their spatial arrangement is related to the points of the horizon where the rising or setting of certain celestial bodies occur on the local horizon. The measurable elements we analyse are:

a) The orientation of different structures of the archaeological site.
b) The relation between elements of the horizon that surrounds the site and position of celestial bodies.

To carry out a valuable archaeoastronomical study, it is clear that one should measure the alignments defined in archaeological sites with the highest precision possible. In principle, one could do this kind of research simply working on published maps of them, but unfortunately this has been demonstrated to be a very risky task. My experience has shown that most of the published plans are not made with sufficient precision and therefore are misleading or even useless for our purposes. The general impression is that a significant amount of archaeologists are not particularly worried in accurately placing the sites in space, something that is essential for us. First, many published maps do not show the position of the north, and when it is indicated one does not know if it corresponds to magnetic or true north. This distinction is important because, in general, they do not coincide and the difference is usually several degrees. Magnetic north is the one that provides the compass point and its position relative to the true north changes with time and with the site coordinates. Using magnetic north in a map could be useful if the date of the planimetric measures is indicated in it, since the variation of the angular difference between magnetic and true north—what is called magnetic declination—over time can be estimated with some precision unless there are local magnetic anomalies.[33] However, the plans

[33] There are some web pages where the magnetic declination can be obtained, see for example at http://www.ngdc.noaa.gov/geomag/ [accessed 31 October 2014] or http://www.qibla.com.br [accessed 31 October 2014]. These variations may be

containing magnetic north never provide the date they were made. Using published maps of archaeological sites has provided me some surprises. There is a particular case of an Iberian temple in which the difference between the orientation of the north indicated in the plan and the true north I determined at the site was 42°, or nearly a half quadrant. An error of this magnitude clearly indicates that the layout of the building in space was of no particular concern to the archaeologists who published the map.

In recent years, the arrival of Google Earth has provided us with a tool that may be a powerful source of archaeoastronomical data. With this application we can determine alignments of architectural structures that are identified in the high-resolution images available. An advantage of Google Earth is that the images are orientated with respect to true north and, in principle, we can measure azimuths. Interesting examples of the use of this tool can be found in the study carried out by Belmonte on the orientation of temples of the Kingdom of Kush in Sudan, and also in the book by F. Herráiz Sánchez on the geometry and possible astronomical implications of the original layout of the city of San Cristóbal de La Laguna in Tenerife.[34] My experience with Google Earth is quite positive; for several sites, I have compared azimuth measurements of distant elements of the local horizon obtained with a precision compass or theodolite with those determined from the web application and the agreement is about one degree. Although Google Earth is a tool that can be very useful in many cases, it should never replace fieldwork at the site when it is feasible.[35] Obviously, satellite maps can never give the wealth of detail provided by fieldwork at the site. One extremely important drawback of using Google Earth is that it does not provide information on the precise shape and height of the different features of the local horizon—the visibility—which can be essential to correctly assign an astronomical relation to an alignment measured in an archaeological

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terrific in special geological areas. For example, in volcanic terrain as in the Canary Islands the determination of magnetic declination at the site is mandatory due to the large local variations.

[34] Juan A. Belmonte, 'Kingdom of Kush', in Clive L. N. Ruggles, ed., *Handbook of Archaeoastronomy and Ethnoastronomy* (Heidelberg: Springer, 2014), pp. 1541-1548; Fernando Herráiz Sanchez, *La Laguna oculta. El cielo y la piedra*. (Santa Cruz de Tenerife: Ediciones Idea, 2007).

[35] In some cases, Google Earth may be the only possibility to do archaeoastronomical work, as in the case of geographical areas where access is dangerous because of political situations or wars.

structure or to find an astronomical marker over the horizon. Another limitation of using Google Earth is that one can only measure relatively large structures that are distinguishable from the air at the spatial resolution of the images available. However, as almost everything can now be found in the web, one can get an idea of the local horizon from the armchair using the web application HeyWhatsThat.[36] It provides a scaled view of the horizon from a specified location, defined as a map point on Google Maps.[37] My own experience with HeyWhatsThat is rather limited, but the horizon views are of rather low resolution and its accuracy drops dramatically when the local horizon is close to the site and you do not have a precise determination of the height of the site above sea level.

Epilogue: Recreating the Ancient Skies

I want to end this article by discussing an experience that archaeoastronomy that may illustrate the discipline's use in archaeology. Sometimes, when working on astronomical orientations one finds that, from an archaeological site, a celestial object — generally the Sun or Moon — either transits or has its rising or setting at a conspicuous place and/or produces a striking phenomenon in a singular moment of its apparent orbital cycle around the Earth (solstices and equinoxes in the case of the Sun, lunastices in the case of the Moon). If the site has not too early a chronology, we may be lucky enough to observe the astronomical phenomenon practically in the same manner as did those who built the archaeological site. Among the places I have studied, the equinox sunrise at the Iberian shrine of El Amarejo or the equinox sunset at the cave–sanctuary of Castellar may be good examples of such a 'rendezvous with the past'.[38] The phenomena that occur on those two places are full of symbolism, should have a public dimension, and may be interpreted as

[36] http://www.heywhatsthat.com [accessed 31 October 2014].

[37] For an example of the use of this application, see Andrea Rodríguez-Antón, Juan A. Belmonte and A. César González-García, 'Orientation of Roman Camps and Forts in Britannia', in Fabio Silva, Kim Malville, Tore Lomsdalen and Frank Ventura, eds., *The Materiality of the Sky, SEAC 2014* (Ceredigion: Sophia Centre Press, 2015): in press.

[38] César Esteban, 'Elementos astronómicos en el mundo religioso y funerario ibérico', *Trabajos de Prehistoria* 59, no. 2 (2002): pp. 81-100; César Esteban, Carmen Rísquez and Carmen Rueda, 'An evanescent vision of the sacred? The equinoctial sun at the Iberian sanctuary of Castellar', *Mediterranean Archaeology and Archaeometry* (2014): in press.

true hierophanies. It is difficult to explain what one feels when discovering an astronomical phenomenon of this type: it is like receiving a message from the distant past, reliving an experience after centuries or millennia of being forgotten. I suppose that an archaeologist must feel something similar when opening a grave, but the difference is that the archaeologist discovers something that is definitely dead while the eyes of the archaeoastronomer may see a phenomenon that, although intangible, is still alive, returning with the perfect accuracy of the celestial cycles. It is the generosity of heavens; one can understand why it was so important in ancient culture.