

Archaeoastronomy and its educational potencial

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Introduction

Archaeoastronomy, astroarchaeology, cultural astronomy, ethnoastronomy, history of astronomy, ... In recent years, the scientific world, and by extension the academic audience in general, has begun to recognize a number of subdisciplines that in one way or another strive to relate the science of astronomy to the traditional humanities (archaeology, history, ethnography, anthropology, art history or philosophy, etc.) or, more properly, to the social sciences.

The Archaeoastronomy supplement to the *Journal for the History of Astronomy* created by Michael Hoskin -unfortunately no longer published- popularized the term "archaeoastronomy" in the mid-1980s. (To make matters confusing, however, an equally valid term "astroarchaeology", relating the astronomical orientation of archaeological remains, has wound up being applied to attempts to relate archaeological sites to visits of supposed extraterrestrial beings. The blurring of scientific terminology with pseudoscience is, unfortunately a long tradition. That's why astronomers call themselves by a prosaic term meaning "namers of stars" rather than the more appropriate "astrologers", as biologists, ecologists, anthropologists and a long list of other "treaters of" sciences do.)

What then is archaeoastronomy? In the **History of Astronomy: an Encyclopedia**, the "archaeoastronomer" Edwin Krupp, Director of the Griffith Observatory in Los Angeles, proposes the following definition of the term: *archaeoastronomy is the interdisciplinary study of the prehistoric astronomy, ancient and traditional all over the world, in the frame of its cultural context. In this study both written and archaeological sources are included, covering the following topics: calendars; practical observation; cults and celestial myths; symbolic representation of events, concepts and astronomical objects; astronomical orientation of graves, temples, sanctuaries and urban centres; traditional cosmology and the ceremonial application of astronomical traditions.*

Granted, this definition is broad enough to cover a wide variety of topics. However, "archaeoastronomy" defined in this way ignores two very important areas where astronomy fully relates to the social sciences, the history of astronomy and ethnoastronomy. The first area of study, which has already a long tradition, properly chronicles the advance of astronomy as a scientific discipline and the evolution of astronomical thought and practice starting around the time of classical Greece. Ethnoastronomy, complements this by tracing astronomy in the oral traditions of cultures that currently exist and, according to some researchers, the written sources (chronicles of conquest, ancient anthropological studies) of extinct cultures, covering a range of topics that largely coincide with the ones of archaeoastronomy proper. Actually, the boundaries between these three disciplines are

extremely ill-defined and studies that fall into two or all of these categories are more the rule than the exception.

For this reason, the general term "cultural astronomy" seems most appropriate to any study in which astronomy is related to the social sciences. This is why specialists in this field today call themselves the "European Society for Astronomy in Culture (SEAC)" www.archeoastronomy.org.

Where is archaeoastronomy located?

One of the most important distinctions between archaeoastronomy and the "hard" physical sciences is the replacement of "astronomical" language by language more compatible with the epistemological point of view of social sciences. Archaeoastronomy, one must keep in mind, is not another branch of modern astrophysics, nor is its fundamental purpose the advance of physical knowledge of the Universe. Rather, archaeoastronomy is a specialty more closely allied with anthropological studies, serving disciplines such as landscape archaeology (in the all-embracing sense of the term landscape), the history of religions or the archaeology of power. Therefore, an astronomer trained primarily in the quantitative sciences may find it difficult to know how to answer the questions that interest archaeologists---or even to pose the questions themselves. Yet it is important for people interested in astronomy to become familiar with their roots and to understand how different cultures have used the observation of the sky to shape their vision of the universe around them into a coherent and meaningful worldview.

It has been argued that close collaboration between archaeologists and astronomers is necessary to carry out substantial research in archaeoastronomy. This interdisciplinary symbiosis is a natural consequence of the need for archaeologists, anthropologists, and historians of astronomy to master astronomical techniques such as positional astronomy or celestial mechanics and mathematical tools such as spherical trigonometry, that go well beyond their customary training.

However, my current opinion, after more than two decades of experience in the field is that both the astronomer and the anthropologist need to transform themselves into a substantially different type of scholar, an archaeoastronomer, forgetting many of the epistemological habits of long years of disciplinary training and establishing quite new patterns of thought. Not everything which is studied in archaeoastronomy can necessarily be considered interdisciplinary, although a certain multidisciplinary approach may be necessary. It is, in short, a legitimate field in and of itself.

Archaeoastronomy has another important problem: it is a sort of no-man's-land in which astronomers and astrophysicists feel out of place (although this, fortunately is beginning to change), and archaeologists and historians often cannot see anything in it that is useful to their understanding of the past. This contrasts with other intersections of the humanities with the experimental sciences as, for example, the use of C14 in dating, which is widely accepted by scientists, historians, and archaeologists alike. The problem is compounded when the title "archaeoastronomer" is applied to scientists interested applying their knowledge to historical

subjects and who use (and abuse) the considerable physical and mathematical tools at their command to propose absolutely preposterous historical theories, to the horror of both archaeologists and anthropologists. Efforts by conscientious scientists to gain degree of recognition for astronomical approaches to archaeology can be frustrated by a few prominent members of what British scientists call the lunatic fringe.

The border between what is science and what is not should be based on the application of basic rules such as Ockham's Razor, the simplest formulation of the Principle of Economy (faced with two possible answers to a scientific problem, the simplest is often true). However we must recognize that these rules are not universally applicable.

Archaeoastronomy and NASE

The potential of archaeoastronomy in the teaching of astronomy is that it can inspire the hearts and consciousness of young apprentices to see their own culture reflected in the way of understanding the cosmos of their ancestors. In this sense, archaeoastronomy can provide a direct connection to their immediate environment as opposed to the apparent remoteness of the sky and the universe in general. If this is true, it would be interesting to conduct research on the pedagogical effects of either archaeoastronomy or ethnoastronomy or even a combination of both.

These approaches open up opportunities for students to stimulate dialogue with elders to learn traditional knowledge of the sky, particularly if they are located near or in agricultural or hunter-gatherer societies. In modern urban societies knowledge is transmitted more formally through schools and the media. For students interested in this approach, a typical interview outline that could serve as a guide is attached (see Appendix 1).

On the other hand, it is almost certain that in the immediate environment of the young astronomy apprentice, wherever he or she is located, there will be a series of buildings that could have a marked symbolic character and which already have a religious or secular function. Those buildings, or urban spatial planning, are potential objects of archaeoastronomical experimentation. We quote some examples:

- Churches in a Christian environment.
- Mosques in a Muslim environment.
- Temples in a Hindu environment, Buddhist or Shinto (pagodas or gopurams included)
- Urban plans, especially those with a clear organized orthogonal frame (very common around the world).
- Sanctuaries of indigenous societies (Polynesia or America)
- Other places of worship in tribal societies.
- Ancient monuments if there were any.

The existent astronomical iconography in these places can also be studied, for instance the analysis of rock carvings stations which often show elaborate astral representations. Therefore, cultural astronomy can become an effective and valuable approach that can bring astronomy to the general public, and especially to young people.

Appendix I (Adapted from “El Cielo de los Magos”)

INTERVIEW TYPE FOR FIELDWORK ETHNOASTRONOMY

The set of questions proposed is a general nature type and can be applied in most cases. However, experience shows that, in this type of research, once a conversation starts, countless more specific questions related more directly to the subject being treated will arise. Consequently, though this outline can serve as a guide, it is expected that most of the interviews will naturally take on a more open character.

1. First, have the interviewee explain what we know and why, starting with general questions such as:

- Here are you recently looked up in the sky for something?
- Do you use it as a guide, a sign, symbol, or guide for something?

2. Then ask specifically about each object that can be used for predictive purposes:

a) Questions focused on the Stars

- Are you guided by the stars at night?
- What stars do you know in the sky?
- Do you know "this or that" star (*)?
- Ask questions about the place and time of year you go out to observe and what stars you look at, in order to clarify which star or stars the interviewee is referring to.
- Do you remember the names of other groups of stars?
- Does it indicate you something about the stars?
- Is rain associated with any star?
- Are observations most commonly made at night or early in the morning?
- Do you use observations of stars to decide when and where to do agricultural work?
- On what basis do you make these decisions... whether a star is seen or not seen at a given time? Whether a star is in a particular position? etc. ...?
- How does the interviewee tell the time at night?
- Is there any importance to the rising of a particular star?
- Do cattle do something or does something happen that is associated with the stars?
- Do cattle get restless or nervous because of the position or behaviour of the stars?

(*) **Note:** Specific reference will be made to any star, known by the previous interviews or collected in the previous bibliography on the subject.

b) Questions related to the Moon:

- Have you looked at the Moon?
- Do you use the Moon as a guide for something?
- Have you looked at or noticed where the Moon sets?
- Have you notice the position, form, or phase of the Moon recently?

- Does the position of the Moon indicate something?
- Have you looked at the Moon to help you with farm work?
- Have you anything special you noticed about the Moon?
- Is any phase or seasonal Moon more important than the others?
- Does the moon have any influence on rain?
- Does the moon affect animals?

c) Questions related to the Sun:

- Have you looked at the Sun?
- Do you use the Sun as a guide for anything?
- Have you looked at or noticed where the Sun sets?
- Do you use the Sun to tell the time? ... How?
- Have you looked at the Moon to help you with farm work?
- Have you heard something about seeing the Sun dance?

d) Questions related to meteorological phenomena:

- How do you know if it will rain or not?
- Do you know of some sign of something, somewhere, that indicates that it will rain.?
- What other known signs relate to the winds, clouds or celestial events?
- Was there any sign for this or that mountain?
- Do you have any way of knowing what the weather will do in the sea (fishing)?
- If it's going to rain, can you tell by watching the sky what time it's going to happen, ... (*)?
- When, at that time do you watch (*)?

(*) Note: The intention of these last two questions is to find out if they know the Cabañuelas without expressly mentioning the name. Otherwise ...

e) Questions related to the Cabañuelas and the Aberruntos (traditional methods for meteorological predictions):

- Is there some special time to look for signs of the weather during the rest of the year?
- Do you know the Cabañuelas?
- What do you know about the Cabañuelas?
- On what date?
- What does the method consist of?
- Do you know any Aberrunto?
- What does that mean?
- Do these methods work or not?
- Is there any Cabañuela which is more accurate than other methods?
- Is there any Cabañuela associated with the Sun or the Moon?

f) Questions related with holidays and the saint's days:

- What fiestas do you have here?
- When are they?

- What are the most important?
- What is your Patron Saint?
- What does your Saint do?
- What do you do on the special day?
- Do you do anything related to the sky on that date?

3. Questions of a general nature to do so sandwiched along interview:

- Do you remember a song, singing or saying related to the things of heaven?
- Do you have someone who knows how to predict the weather?
- What's his or her name?
- Are the predictions very accurate?
- What other signs do you know?
- Do you trust all these signs?
- These days do you still follow these signs?
- These days, do people still look for those things?
- Do you think that the signs are trustworthy?
- Who taught you this lore?
- Where was he or she born? Where did he or she grow up? From where was his (father, grandfather, father, ...)?

Appendix II (Adapted from “La Orientación como seña de identidad cultural: Las Iglesias Históricas de Lanzarote”)

Abstract

The orientation of the Christian churches is a distinctive element of its architecture which repeats patterns from Christian times. There is a general trend to orient their apses in the solar range, with a predilection of geographical east (nearby astronomical Equinox), although alignments in opposite directions, with the apse to the West, even though they are exceptional because they do not follow the canonical pattern, are not unusual.

The case of the churches built in the Northwest of Africa before the arrival of Islam is paradigmatic in this respect and could reflect previous traditions. The Canary Islands represents the western end of the North African cultural koinè, so it has been considered relevant to address a study of a compact set of ancient churches in one of the Islands, choosing Lanzarote. The orientation of a total of 30 churches built prior to 1810, as well as some more examples of later periods, are measured. Sample indicates that a pattern of decisive orientation on the island followed, but unlike the standard found so far in the rest of the Christian world, this prototype is twofold. On the one hand, appears the standard East (or West) direction, but the sample is also a marking orientations towards North-Northeast, for now, exclusive of Lanzarote. The annex discusses why this strange rule, considering several possibilities mostly discarded. We found that the explanation may be very prosaic, in such a way that, sometimes, the earthly needs are most relevant than decision-making needs of the cult.

Introduction: Prolegomena

The study of the arrangement and orientation of Christian churches has interested since old times and has recently gained a new boom in the specialized literature. This is an important factor of their architecture. According to the texts of writers and early Christian apologists, the churches should be following a certain orientation, i.e. the priest had to stand facing the East during the cult. Recognized by Origenes, Clement of Alexandria and Tertullian, the Council of Nicaea (325) determined this as a priority fact. Atanasius of Alexandria, also in the fourth century, expressed that the priest and the participants should be directed towards the East, where Christ, the Sun of Justice, will shine at the end of time (*ecclesiarum situs plerumque talis erat, ut fideles altare facie versa orientem solem, symbolum Christi qui est Sun iustitia et lux mundi [...] interentur*; for an in-depth analysis of the early sources and methods of orientation you can follow Vogel (1962).

However, these commandments are not entirely clear making it possible to choose between different interpretations: is it oriented towards the rising Sun the day that begins the construction of the church? Or towards the Sun another day that is considered important, such as on the day of the patron saint of the church? Either the orientation towards the East, would be considered in the strict sense? Churches were orientated towards sunrise at the Equinox? in that case, towards which Equinox? Initially, the early Christian basilicas were not built with the apse, or the head of the Church, diverted to the East. In this regard, Delgado-Gomez (2006) indicates that of the 20 first Christian basilicas built during the time of Constantine and his successors in Rome, Jerusalem, Constantinople, and the North of Africa, 18 are located approximately on the East-West line, but the apses of 11 of them is directed towards the West. However, it is interesting to note that in these cases the Chair and the priests are positioned looking towards East, hence the altar is located between it and the mourners.

Between the 3rd and 7th centuries recommendations were imposed and thus the Apostolic constitutions indicate that churches should be built facing the East (const. Apost., II, 7). In the 5th century, Sidonius Apolinar and Paulinus of Nola indicated that the apse should look towards the East, i.e. to the Equinox, something later confirmed both by the Pope Virgilius and by Isidoro of Seville in his *Etymologiae* (XV, 4) (McCluskey 1998). This would be confirmed during the Middle Ages by Honorius Augustodunensis (11th-12th centuries: [...] *ecclesiae ad orientem vertuntur ubi sol oritur [...]*) and by other authors such as William Durando (12th-13th centuries: [...] *versus orientem, hoc est, versus solis ortum aequinoctialem, nec vero against aestivale solstitium [...]*), that clearly indicates the direction to follow: the Equinox, preventing the sue of the solstices. The orientation towards the East has a clear symbology, as we discussed earlier. It is in that direction where the sun rises and thus Christ, as Sun of Justice, will emerge from there in the Last Judgment (McCluskey 2004, 2010). On the other hand, the non-preference of the solstices could be linked to the importance of these dates in the previous periods and the numerous pagan temples targeted in these directions (see, for example, Belmonte, 2012).

However, in these prescriptions, ambiguity still persists. Which Equinox must be considered? As it is mentioned by McCluskey (2004), there are several possibilities: the Roman vernal equinox occurred on March 25, while the Greek happened on March 21 – as it was reflected in the Council of Nicea -; but you can use other definitions, such as the entrance of the Sun in the sign of Aries or the autumnal Equinox. Each of these definitions would offer various dates

and, therefore, slightly different orientations (Ruggles 1999, González-García & Belmonte 2006).

Another important point to consider is the use of the Julian Calendar during the Middle Ages and part of the Modern one. The nature of this would drive to the fact that, if we look at an Equinox calendar - i.e. in a specific date - such time would be displaced in time, something which would be reflected in a systematic change of orientation, if this was done by observation of sunrise on that day.

Along with the pyramids of Egypt and the European megaliths, the study of the orientation of European medieval churches is one of oldest trials that have been faced on Archaeoastronomy. González-García (2013) recently conducted a collection of works in this field. It shows that prescriptions for the orientation toward the East followed a quite systematic pattern throughout Europe during the Middle Ages, as can be seen in Figure 1. All areas studied by González-García (2013) follow this pattern of orientation with a clear maximum predominantly focused on the East, stressing that on numerous occasions, especially in Western Europe, such maximum is slightly moved northward of the astronomical east, perhaps indicating a use of specific dates for the equinox (March 25) that, with the passage of time, were moving as described above, although in each region there are particular characteristics.

Fig. 1: Azimuth Histogram of a sample of 1274 European medieval churches.

It is interesting to note that a constant in literature about the orientation of churches is that they are oriented towards the rising of the Sun in the ephemeris of the patron saint (which does not seem at all be the case of Lanzarote churches, as we shall see). However, in the early writings, and until well into the Middle Ages, does not exist an epigraphic endorsement for such an assertion. The works reviewed by González-García (2013) indicate that for areas of Germany and perhaps England and France there might be an interest by some Saints in some monuments, even though these buildings are generally Romanesque monastic churches or Gothic cathedrals and therefore late. An interesting and well documented case is given in Slovenia where Čaval (2009) has found evidence of a special predilection for the so-called feast of the Chair of Saint Peter, tilt that is reflected in the orientation of a significant number of churches in the direction of the sunrise on that day. McCluskey (2004) indicates that something similar happens in England in the Romanesque churches where, perhaps, the

churches with Marian dedications and some few more saints can follow this standard, complementing the orientation toward the East.

In this context, and given the object of the present study, it is interesting to note that, except for a small number of works dedicated to particular churches, especially in England and Central Europe, there are no systematic studies on the orientation of temples in periods after the Middle Ages, as the present one. As we shall see, the vast majority of the churches and chapels of Lanzarote began to be erected decades after the conquest and colonization of the island by the Normans at the service of the Crown of Castile in the 15th century.

Interestingly, an exception to the rule of orientation is North Africa, where churches are built in opposite directions. The data shown in figure 2 were obtained by Esteban et al. (2001) and Belmonte et al. (2007), as well as others not published previously (González-García 2013) and includes a total of 23 churches, in particular in Africa Proconsularis and Tripolitania, possible places of origin of the aboriginal population of the Canary Islands (Belmonte et al.2010). It is interesting to observe that these churches show a good number with orientation towards the West, usual in the early times of Christianity, as noted above. It also highlights that most of the churches are located within the solar range, with concentrations on the equinoxes and solstices, which could give clues about the process of Christianisation in this region.

Fig. 2: Orientation diagram of 23 early Christian churches in the north of Africa.

In Spain, both in the Iberian Peninsula and in the two archipelagos, while there are reports of particular events of light and shadow within Romanesque temples at special times such as the Equinox (as in Santa Marta de Tera or in San Juan de Ortega, in the respective provinces of Zamora and Burgos), the question of the orientation of the churches has been little investigated in general from a statistical point of view, which has led to claims pilgrim explanations on the possible cause of deviations from some churches with respect to the canonical orientation (see for example Godoy-Fernández, 2004). Perez-Valcárcel (1998) has investigated the orientation of 187 Romanesque churches of the Camino de Santiago. Although his data do not include the measurement of the angular height of the horizon, something unfortunately very common in other European studies, what does seem clear is that

he is does not establish a general relationship between the orientation of these churches and sunrise on the date of the patron saint of worship of the Church.

Our team has decided to start a project on a large scale both in the Iberian Peninsula and the Canaries. In the latter, what it is shown here is the first systematic study developed so far. However, within a wider program to measure the orientations of the pre-Romanesque churches of the peninsular territory in a systematic way, González-García et al. (2013) have devoted special attention to the churches of the Asturian period and its interaction with the dominant Muslim power in the South of the Peninsula. In particular, there are 13 churches from the period still existing in Asturias which possess a canonical orientation, with the apse to the East, although generally deflected several degrees north of East. In addition, the authors found that the mosques of Al Andalus, although they could have been oriented towards Mecca, with qiblahs which could have been consistent with the canonical alignments of the churches. However it would seem that the mosques "avoid" possible orientations that may confound their temples with churches, while the Asturian churches, and perhaps the immediately subsequent Mozarabs also tend to avoid those positions that confuse these temples with mosques in an example of the interaction of religion, power and astronomy. Therefore, we see that in exceptional circumstances, the canonical patterns may be altered.

Lastly, García-Quintela et al. (2013) have investigated the introduction of Christianity in the Northwest of the Peninsula and the possible replacement of Indo-European (Celtic) elements by Christian factors, through the introduction of what it called a "martyr landscape": through the orientation of the churches and the Christianization of their environments, as well as the creation of myths and stories that channeled, modified or replaced the possible pagan cults. Thus, it would be interesting to analyze this same phenomenology in the Canary Islands and, in particular, on the island of Lanzarote, a particularly striking case since it was the first to be colonized by Europe and its size and number of population nuclei would allow a survey of a statistically significant sample in a very compact and small space.

Example: The churches and chapels of Lanzarote. Conclusions

After the conquest and colonization of the Canary Island of Lanzarote by European populations at the beginning of the 15th century, colonization in a large scale began in the centuries immediately following with the establishment of small farms and hamlets, alongside some older sites such as Femés or Teguisse, where the construction of a significant number of Christian temples was accomplished that illustrated the new social and religious situation.

In some few places, it is possible that buildings were orientated imitating aboriginal worship patterns. In others, tradition canonical alignment of the temples to the East (with some exceptions to the West) was respected but with a degree of freedom larger than usual. In this regard, it should be mentioned that only the church of Mala appears to present an orientation that is compatible with the sun rising on the day of the (Marian) invocation of the temple (figure 3).

Fig. 3: Church of Ntra. Señora de las Mercedes in Mala.

Finally, in Lanzarote, there is a statistically significant number of churches oriented North-North-East, which is a notable exception to the rule. Various possibilities have been analyzed to explain this anomaly, reaching the conclusion that the most plausible answer is in turn the most prosaic. This pattern of orientation seems to obey a desire to avoid the strong prevailing winds on the island, precisely from that direction, and, in particular, to avoid the inconvenience caused by the sand displaced by wind in those buildings near or bordering El Jable, a sandy region in the north of the island.

This is only the first experiment of a project that we hope to be able to undertake in the coming years, by measuring the orientation of the oldest Christian temples in other islands of the Canary Archipelago. In this respect, we assume that study of the island of Fuerteventura, subjected to the same flow of wind, blowing even more intense, will be a very interesting case study to compare with the neighbouring island of Lanzarote.

Will Fuerteventura churches also have a double standard? Its builders dared to breach the canonical precept to impose the human needs of the cult? Time will say!.

Bibliography

- Belmonte J.A., *Pirámides, templos y estrellas: astronomía y arqueología en el Egipto antiguo*, Crítica, Barcelona, 2012
- Belmonte, J.A. y Sanz de Lara M., *El Cielo de los Magos*, La Marea, La Laguna, 2001.
- Belmonte J.A., Tejera A., Perera M.A. y Marrero R., “On the orientation of pre-Islamic temples of North-west Africa: a reappraisal. New data in Africa Proconsularis”, *Mediterranean Archaeology and Archaeometry*6, 3: 77-85. 13, 2007
- Belmonte J.A., Perera Betancort M.A. y González García A.C., “Análisis estadístico y estudio genético de la escritura líbico-bereber de Canarias y el norte de África”, en VII Congreso de patrimonio histórico: inscripciones rupestres y poblamiento del Archipiélago Canario, Cabildo de Lanzarote, Arrecife, (2010)

- Čaval, S. (2009). “Astronomical orientations of Sacred Architecture during the Medieval period in Slovenia”, en J.A. Rubiño-Martín, J.A. Belmonte, F. Prada and A. Alberdi (eds.), *Cosmology Across Cultures*, 209-19. San Francisco. Astronomical Society of the Pacific.
- Estéban, C., Belmonte, J.A., Perera Betancort, M.A., Marrero, R. y Jiménez González, J.J., “Orientations of pre-Islamic temples in North-West Africa”, *Archaeoastronomy* 26, S65-84, (2001).
- Gangui A.; González García A.C.; Perera Betancort M.A. y Belmonte, J.A., *La orientación como una seña de identidad cultural: las iglesias históricas de Lanzarote*, Tabona en prensa, 2015
- García Quintela, M.V., González-García, A.C. y Seoane-Veiga, Y. , “De los solsticios en los castros a los santos cristianos: la creación de un paisaje mártir en Galicia”, *Madridler Mittelungen*, 2013
- González-García, A.C., “A voyage of christian medieval astronomy: symbolic, ritual and political orientation of churches”, en F. Pimenta, N. Ribeiro, F. Silva, N. Champion, A. Joaquineto, L. Tirapicos (eds.): *Stars and stones. British Archaeology reports*, 2013
- González-García, A.C. y Belmonte, J.A., “Which Equinox?” *Archaeo-astronomy, The Journal of Astronomy in Culture* 20. 97-107, 2006.
- González-García, A.C., Belmonte J.A. y Costa-Ferrer, L., “The orientation of pre-Romanesque churches in Spain: Asturias, a case of power re-affirmation”, en M.A. Rappenglueck, B. Rappenglueck and N. Champion (eds.), *Astronomy and Power. British Archaeology Reports*, 2013.
- Godoy Fernández, C. , “A los pies del templo. Espacios litúrgicos en contraposición al altar: una revisión”, *Antigüedad Cristiana* 21, 473-89, 2004
- Krupp E.C., *Echoes of the Ancient Skies*, Harper & Row, Nueva York, 1983
- Krupp E.C., *En busca de las antiguas astronomías*, Pirámide, Barcelona, 1989.
- Krupp E.C., *Beyond the Blue Horizon*, Oxford University Press, Oxford, 1991
- McCluskey, S.C., *Astronomies and cultures in early Medieval Europe*. Cambridge University Press. Cambridge, 1998.
- McCluskey, S.C. , “Astronomy, Time, and Churches in the Early Middle Ages”, in M.-T. Zenner, Villard’s legacy: *Studies in Medieval Technology, Science and Art in Memory of Jean Gimpel*. Ashgate, Aldeshot: 197-210, 2004
- McCluskey, S.C. , “Calendric cycles, the eighth day of the World and the orientation of English Churches”, en C. Ruggles and G. Urton (eds.), *Skywatching in the Ancient World, New Perspectives in Cultural Astronomy*, 331-353. University Press of Colorado. Bolder, 2010.
- Pérez-Valcárcel, J., “La orientación de las iglesias románicas del Camino de Santiago”, en F. Bores, J. Fernández, S. Huerta, E.Rabasa, *Actas del Segundo Congreso Nacional de Historia de la Construcción*. La Coruña, Servicio de Publicaciones Universidad de La Coruña: 391-396, 1998.
- Ruggles, C.L.N., “Whose equinox?” *Archaeoastronomy* 22:S45-50, 1999.
- Vogel, C., “Sol aequinoctialis. Problemes et technique de l’orientation dans le 15 culture chretien”. *Revue Sciences Religieuses* 36, 175-211, 1962.