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Supplementi ai Convegni

On the relationship between archaeoastronomy and “exact” sciences

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1. Introduction

Archaeoastronomy is a “new” science. Actually, it was born two times, because it was “invented from scratch” by Norman Lockyer at the end of the 19th century, but it was forgotten again, up to the sixties of the last century. Indeed, times were not ready for the newborn, perhaps because Lockyer’s approach was too enthusiastic to be accepted by archaeology (sometimes I doubt, if times are ready even now).

A famous example of how Lockyer’s studies were actually “modern”, and of the way they have been considered, is given by the orientation of the Karnak temple in Luxor, Egypt. Lockyer discovered that the straight axis of the temple is very precisely oriented to the summer solstice sunset. He published his discovery, together with other tens of data on orientation of Egyptian temples (Lockyer, 1894). He insisted that the study of the astronomical alignments in Egypt was a new way of *getting new insights* in the knowledge of the ancient Egyptian religion and lore.

Unfortunately, Lockyer was “wrong”, since the sunlight does not enter precisely into the temple at sunset, due to the presence of hills at the horizon. Today, we do know that the axis of the temple was rather oriented to the winter solstice sunrise; astronomical observations were likely made from a chapel located at the opposite end and endowed with a window constructed with this aim (Krupp, 1983). Thus, Lockyer was not really “wrong” since the astronomical orientation of the temple was a true fact, and of course the ancient Egyptians knew that the summer solstice sun was setting in a direction opposite to winter solstice sunrise. However, no doubt Lockyer was “in hurry” in drawing his conclusions. Consequences were very bad, because the possible contribution of the study of temple's alignments to Egyptology was dismissed for many years since then. Archaeoastronomy had to wait for another free-mind person: Alexander Thom. It is with Thom that Archaeoastronomy became a science; although some of the enormous amount of his fieldwork has been disputed, and some of his ideas about “megalithic science” discarded, it is certain that it was Thom to set up the theoretical basis on which Archaeoastronomy relies today (Ruggles, 1988).

In any science, the interaction between theory and experiments is obviously fundamental: from experimental results, a scientist confirms and extracts theories, from his mind, a scientist extracts theories as well, which have to be controlled experimentally. Thus, of course, (correct) theories predict *new* experimental facts.

It seems, however, that Archaeoastronomy is considered (when it is considered at all) by many archaeologists at the level of a technical complement to archaeological research; in some sense, it has not the status of a science by its own, so that Lockyer's dream appears to be still essentially unrealised (in part, this can be the result of the omnipresent "fringe" theories which go around without any possibility of control; however, it is also true that *all* sciences have their fringe load, without being particularly afraid of it). With the aim of stressing the potentialities of this discipline, I will discuss here a few examples in which Archaeoastronomy has *already* proven his potentialities in "predicting" new historical facts, i.e. new "experimental results" in archaeology. In addition, I present very briefly an attempt of "predictive archaeoastronomy" to which I contributed in recent years and it is still awaiting for a proof – or, of course, a disproof.

2. Predictive archaeoastronomy: examples

The first example regards the age of one of the so called "Medicine Wheels". These are large circles of small stones, which are present especially in Alberta and Saskatchewan, although the most famous one is the Big Horn Medicine Wheel in Wyoming. The circles are usually composed by a central stone cairn and one or more concentric stone circles. Many such wheels have a simple explanation in terms of remains of Indian camps, however some of them, such as the Big Horn one, exhibit a typical feature: some "radial" stone lines emanating from the centre and pointing to peripheral stone cairns. In 1974 the solar physicist John Eddy proposed the idea that this wheel was used for astronomical observations; he found indeed astronomical alignments, both solar (to the summer solstice sunrise) and stellar (towards bright stars such as Aldebaran, Rigel and Sirius, having heliacal rising days not far from the summer solstice) (Eddy, 1974). The alignments are far from being precise, and consequently their astronomical function has been disputed (Shaefer 2006). However, it remains the unique feasible explanation for such a curious artefact.

Of course, stellar alignments depend on precession, and therefore Eddy had to control that his astronomical interpretation was in agreement with archaeological dating. Actually it was, since the Big Horn wheel has been carbon-dated (trough remains of burns in the central cairn) to some 300 years ago, a date which is in good agreement with the alignments.

To double-check the validity of the astronomical hypothesis, Eddy, together with the archaeologists Alice and Thomas Kehoe, moved to another wheel, located on Moose Mountain, in south-eastern Saskatchewan. In this monument, Eddy was able to recognize the same stellar alignments observed at Big Horn (the solstice alignment is probably non-functional here however). Again, due to precession, the alignments at Moose Mountain were valid only in a specific period of time, around the last centuries BC – first centuries AC. Thus, either Archaeoastronomy was *predicting* the age of the monument or the astronomical hypothesis was simply a nonsense. Actually, carbon-dating of the wheel carried out by the Kehoes turned out to be compatible with Eddy's alignments.

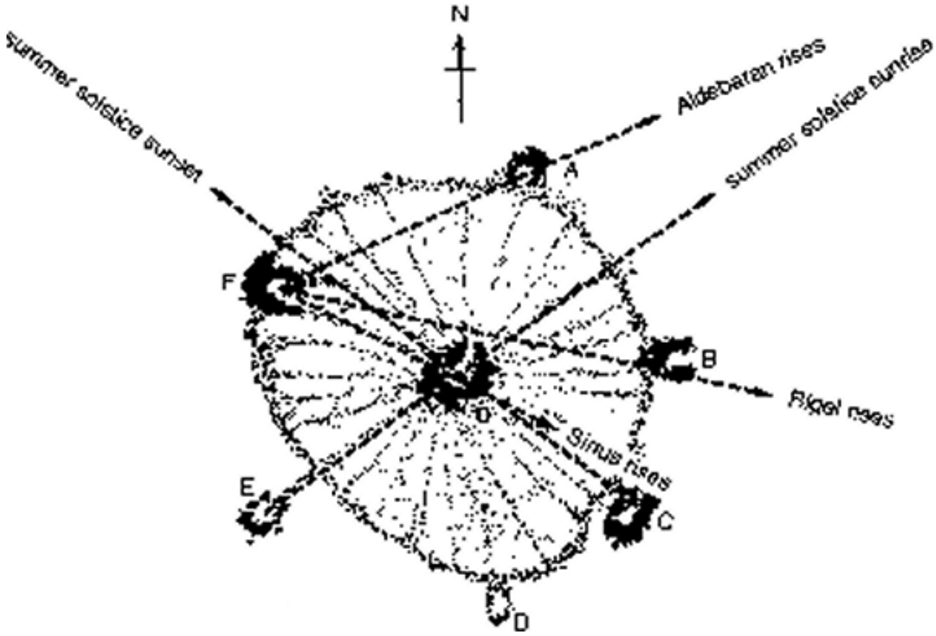

Fig. 1. The alignments of the Big Horn Medicine Wheel according to Eddy.

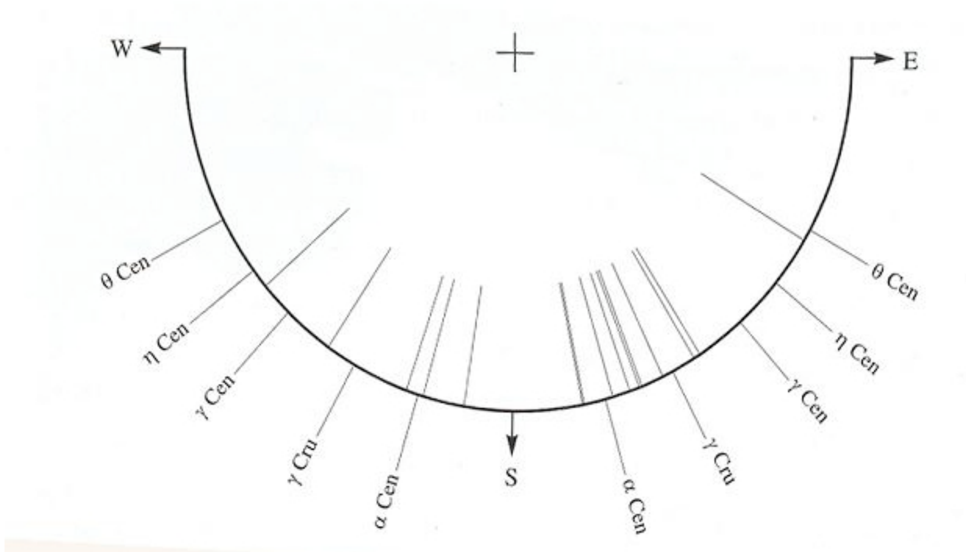

Fig. 2. Alignments of the sanctuaries of Mallorca, from Hoskin (2001).

Another interesting case of predictive Archaeoastronomy comes from the field work of Michel Hoskin at the *Son Mas* Sanctuary, one of eight known sanctuaries on the Balearic island of Mallorca. These sanctuaries are oval-shaped megalithic buildings in which unknown rites - probably including animal sacrifices - were carried out. Son Mas in particular was probably first constructed around the year 2050 BC and frequented up to 200 BC, but when carbon-dating of materials found in the site was carried out, the analysis showed a clear gap of some centuries starting from 1700 BC. Archaeologists were unable to find the reason of this abandonment. In the meanwhile, Michael Hoskin was independently studying the astronomical orientations of the sanctuaries, discovering that they were all oriented to the sector of the sky in which rising/setting of the stars of the Crux-Centaurus asterism was visible (Figure 2).

In the last two millennia BC, this asterism was an important group of bright stars, including α and β Centauri and α Crux, visible in the southern Mediterranean sky (today precession has brought it under the horizon). At Son Mas, Hoskin - who was unaware of the carbon-dating results - discovered that, due to the particular conformation of the hills at the horizon, the lowest star of Crux became invisible at a certain time around 1700 BC. When the two groups – Archaeologists and Archaeoastronomers - met at a conference, they realized that the archaeoastronomical research was providing a satisfactory explanation for the abandonment (Hoskin, 2001).

3. Predictive archaeoastronomy: a proposal

Several other interesting cases of successful predictive Archaeoastronomy exist, for instance the rediscovery of an ancient Maya site near the city of Uxmal, carried out by Antony Aveni on the basis of the astronomical alignment of a building in the city to the southernmost rise of Venus (Aveni 2001). I am going to conclude this discussion by presenting, very briefly, an example of theoretical "predictive archaeoastronomy" which is yet awaiting for a experimental proof (or disproof).

It is very well known that the Egyptian pyramids of the fourth dynasty (the Meidum pyramid, the two Snefru pyramids at Dahshur and the main three pyramids at Giza) were oriented to the cardinal points with very high precision; the deviation from true north is indeed the following (see figure 3): 1) Meidum -20' ± 1.0' , 2) Bent Pyramid -17.3' ± 0.2' ; 3) Red Pyramid -8.7' ± 0.2' ; 4) Khufu -3.4' ± 0.2' ; 5) Khafre -6.0' ± 0.2' ; 6) Menkaure +12.4' ± 1.0'.

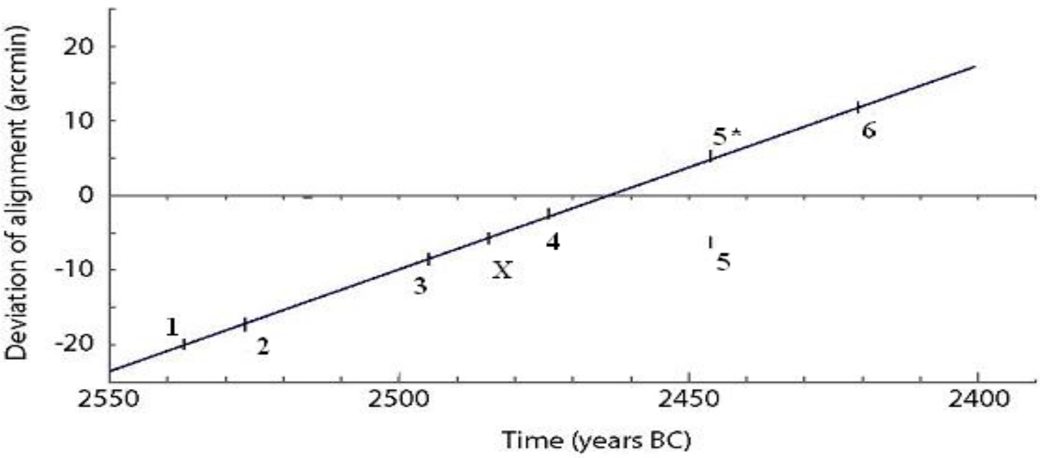

Fig. 3. Deviation from true north of the IV dynasty pyramids.

From the above data it is obvious to deduce that, if the ability of the builders remained constant in time during the fourth dynasty, a time-dependent font of systematic error was affecting the measures. The unique available physical phenomenon capable to introduce such an error is, obviously, precession. Up to recent years, the methods proposed for pyramid alignments (like e.g. bisection of the rising and setting positions of a star on a levelled horizon) were precession-independent and thus inadequate to explain the data. Finally, Kate Spence (2000) and Juan Belmonte (2001) proposed a new method of orientation, based on the observations of the ideal cord connecting two circumpolar stars, chosen in such a way to culminate one over the other. Due to precession, it is an easy exercise to check that this cord has a slow movement which brings it from the "left" to the "right" of the pole. Plotting the deviation from north against time, Spence showed that the corresponding straight line fits well with the deviation of the pyramids w.r. to true north in the beginning of the 25 century BC, if a certain couple of bright stars is considered (this is the line reported in the figure). Subsequently Belmonte, using two different stars, obtained a slightly earlier chronology which is closer to the dates currently accepted by most Egyptologists.

Although the Spence-Belmonte theory is extremely sound, the orientation of the Khafre pyramid (point 5 in figure 3) fits in their calibration lines if and only if the corresponding point is "lifted up" in the positive region (point 5* in Figure 3). This is of course a serious objection to the method. To solve the problem, Spence speculates that the orientation of the second pyramid was carried out in the opposite season with respect to the others, while in Belmonte's proposal this pyramid was the unique one to be oriented with the two stars in lower culmination, all other pyramids being oriented with the stars in the upper culmination. In both cases, it is clear that the proposed exception for the second pyramid is a drawback, since the orientation procedure (called, at least for temples, the "Stretching of the cord") was certainly of religious type, and one would expect that it was carried out always in the same way and in the same period of the year. As a consequence, I have made a different proposal in order to explain the "anomaly" (Magli 2003, 2005). The proposal originally was that the standard *relative* chronology between the pyramids was wrong. In other words, the idea was that the "second" pyramid was actually constructed *a few years* before the "first" pyramid. This leads to the consequence that the point 5 can be moved back in time to point "X" in the figure. In this way, the plot fits perfectly well.

Of course, an inverse chronology at Giza raises problems from the historical point of view; as first observed by Juan Belmonte, these problems can be more easily solved adopting a slightly different viewpoint (Belmonte & Shaltout 2006). Namely, one can think to a *unitary* project of construction of the two giant Giza pyramids. In this case, both were planned by Khufu, and orientation errors are actually so close each other that the two might have been oriented at the same time. After the death of Khufu, his son would have taken the "second" one for himself.

This interpretation actually turns out to be in good agreement with various facts; for instance, the father of Khufu, Snefru, actually constructed *two* pyramids at Dahshur; secondly – as first observed by the Egyptologist Mark Lehner - the two giant Giza pyramids, when viewed from the temples at sunset, seem to belong to a global project which - together with the setting sun - forms an image of the hieroglyph *Akhet* (horizon, sun between two mountains) associated with the afterworld (Lehner, 1999) and with Khufu's pyramid name. Further, according to other Egyptologists, the Sphinx might have been originally constructed by Khufu, or in honour of him, and not as an image of Khafre (Stadelmann, 1997). Actually, there is no direct evidence of construction of the second pyramid by Khafre since his name is not mentioned on the pyramid (there are no inscription *at all* on the second pyramid, and the name of the Pharaoh appears only on the statues which were found in the Valley Temple).

The validity of this proposal has many chances to be tested; in particular, I have collected a series of convincing hints to a global Khufu project which are related to the symmetry of the astronomical alignments of the temple complexes at Giza. These hints are based on the likely position of Khufu's Valley Temple (Magli 2009, 2010). The validity of these ideas could be therefore put at serious trial by a (long-awaiting) excavation project of this temple, which lies under the modern village of Nazlet el-Samman.

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