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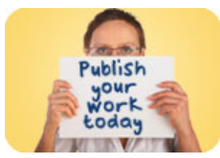

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The Zenith Passage of the Sun and its role in the Planning of Architectures

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Abstract

Summer and winter solstices and equinoxes had great importance in the cultures of peoples all over the world, and these astronomical events had been widely considered in the planning of monuments and other architectures. But in the tropical zone of the Earth, between the Tropics of Cancer and Capricorn, we can see another relevant event, the zenith passage of the sun. In this paper we will see that several examples are existing too, of the role of this astronomic event in the architectures of tropical zone.

Article body

The Zenith Passage of the Sun and its role in the Planning of Architectures

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Abstract: Summer and winter solstices and equinoxes had great importance in the cultures of peoples all over the world, and these astronomical events had been widely considered in the planning of monuments and other architectures. But in the tropical zone of the Earth, between the Tropics of Cancer and Capricorn, we can see another relevant event, the zenith passage of the sun. In this paper we will see that several examples are existing too, of the role of this astronomic event in the architectures of tropical zone.

Keywords: Solar Orientation, Solstices, Azimuth Passage, Architectural Planning, Archaeoastronomy.

Introduction

Zenith is the point of the celestial sphere which is vertically above the observer. Only in the tropical zone of the Earth, which is located in between the Tropic of Cancer and the Tropic of Capricorn, we can see the sun reaching the zenith. Anywhere outside tropics, this is impossible. Inside the tropical zone then, the sun has, besides the astronomical events of solstices and equinoxes, also two zenith passages. On the Tropical lines, only one passage is observed, coincident to one of the solstices. On the Tropic of Cancer for instance, it happens on the summer solstice. At the equator, the zenith passage is on the equinoxes.

The zenith passage of the sun, being the moment when it passes through the top point of the sky, is easily observed using a gnomon, that is a straight vertical pole, because at that moment it casts no shadow on the ground. Or, if we have a deep water well, we can see the sun reflected at noon by the water at the its bottom. Both these facts were well known to ancient people living in the tropical zone. And in fact, Eratosthenes (c.276 BC – c.195/194 BC) used them to calculate the circumference of the Earth [1]. Eratosthenes knew that at local noon on the summer solstice in Syene (the modern Aswan), the sun was reflected by the water of a deep well. By the shadow of a gnomon in Alexandria, he measured the angle of sun elevation at the noon on the same day and found it being 1/50th of a circle. Assuming that the Earth was a sphere and that Alexandria was due north of Syene, he concluded that the meridian arc distance from Alexandria to Syene was 1/50th of the Earth's circumference. From this distance, he evaluated the circumference of the Earth.

Peoples all over the world recognized as very important astronomical events the summer and winter solstices and the equinoxes and celebrated them consequently. It is not surprising then that these astronomical events had been also considered in planning of monuments and other architectures, which are consequently displaying alignments with the direction of sunrise or sunset on these days. As evidenced by several examples [2-11], the planning of the architectonic structure becomes a symbolic local horizon, a microcosm representing the apparent motion of the macrocosm that, thorough the year, is revolving about its “axis mundi”, that is, the axis of the universe. In this paper we will discuss that several examples of the role of the zenith passage of the sun are also existing, displayed by the architectures of the tropical zone.

The Zenithal Sun in America

In the tropical zone, to solstices and equinoxes we have also to add, as relevant astronomic events, the zenith passage of the sun. And in fact, we can find that pillars and wells exist, used by people to observe what happens to light and shadows at the zenith passage of the sun. The people of pre-Columbian Mexico had a specific “astronomical instrument" to observed this passage: a vertical zenith sighting tube inserted in the vault of an underground structure. One of these instruments is at observatory of Xochicalco, in the Mexican state of Morelos. The image in the Figure 1 illustrates how it looks like the beam of light passing through the ceiling of the artificial cave of Xochicalco. A vertical opening produces in a dark chamber a perfectly perpendicular beam of light when the sun is at the local zenith. Besides the cave, at Xochicalco there is a white stone pillar in the ceremonial area that could had been used to observe the shadow disappearing at the zenith passage of the sun (Figure 2).

Figure 1: This image illustrates how it looks the beam of light in a cave passing through a tube in its ceiling.

Figure 2: A pyramid and the ceremonial pillar at Xochicalco, Mexico. Courtesy Maxtreiber, Wikipedia.

For Meso- and South America, several researchers have recognized and evidenced the importance of the zenith passage [12-18]. In [19,20], it is stressed that among that ancient civilizations that recognized the zenith passage, we have also those of the Andean people of Peru, that incorporated it into their cosmology. The Andean people used pillars, such as the Chankillo Towers [18,21], as solar observations and for their calendars.

Let us add to the pillar shown in the Figure 2, another monument that we can easily imagine the ancient architects had built to observe the zenithal sun and for related ceremonial purposes too: it is the Gate of the Sun of Tiwanaku (Figure 3). Being under the linter of this gate, an observed could see the shadow of it coincident to the base. Tiwanaku is a Pre-Columbian archaeological site in western Bolivia. The site was first described by the Spanish conquistador Pedro Cieza de León. He came to the ruins of Tiwanaku in 1549, while searching for the Inca capital Qullasuyu [22]. During the time period between 300 BC and AD 300, Tiwanaku is thought to have been a ceremonial center for the Tiwanaku empire to which people made pilgrimages.

Figure 3: The Gate of the Sun at Tiwanaku.

In Asia

The zenith passage was important also for people of Asia. And in fact, in [24], we have shown that the archaeological complex of Sigiriya, the Lion Rock, in Sri Lanka has its axis oriented to the sunset of day of a zenith passage of the sun. Let us also consider the very important Buddhist religious center of Sanchi, which has interesting astronomical orientations as discussed by N. Kameswara Rao [25]; it possesses a particular alignment of stupas with the sunset direction on the summer solstice. Since Sanchi latitude is close to the Tropic of Cancer, we have also that, on this day, the noon altitude is about 90 degrees. Therefore, the alignment of stupas is also giving the sunset direction of the day of the zenithal sun [26].

The first written mention of zenith passage in Indian literature comes from Varahamihira in the 6th century [27,28], who noted that in the kingdom of Avanti the day of summer solstice and zenith passage were the same (the Avanti Kingdom of ancient India was described in the Mahabharata epic). He further discussed that north of Avanti, no zenith passage occurs. Varahamihira wrote these observations when he was in the ancient city of Ujjain, located at latitude of 23° 10′ 12″ N [27]. In fact, as observed in [27], the ancient India had a “prime meridian” and a north-south “zero” line of latitude crossing at Ujjain and running straight down to the island of Lanka.

The southern part of India is in the tropical zone such as another part of Southeast Asia, like the Indochina. A very interesting paper is discussing the importance of zenith passage of the sun in the architecture of the temples at Angkor Wat, Cambodia. The authors of this paper [27], Edwin Barnhart and Christopher Powell, University of Texas, Austin, in August of 2010 and 2011 investigated the importance of the zenith passage of the Sun for the ancient Khmer culture. They concluded the research with a positive answer. "From architectural features and orientations to art panels and monuments, the evidence that zenith passage was recognized permeates the entire city" [27]. According to the authors, their idea "to search for evidence of zenith passage at Angkor” was inspired by prior research in Mesoamerica. In [27], besides discussing the discoveries at Angkor, the authors are proposing that the Hindu culture was also including some references to the zenith passage of the sun.

Barnhart and Powell have discovered that Angkor temples had vertical zenith sighting tubes too. “Though it is not apparent from the outside, each one of the beehive shaped temples of Angkor are hollow on the inside. Walking in and looking straight up, the roof is open all the way up to the top and that top has a hole where the sun shines in. We were told by the temple attendants that the holes on top of the roofs were there because the capstones had all been knocked off by erosion or more commonly by looters searching for jewels. Finding these fallen capstones among the rubble around the temples was our first surprising clue. Most capstones were beautifully carved as lotus flowers and all had a hollow tube running down their axes. Each had a very straight, long tube that would have let only true zenith passage sun light down into the temples. Whether or not this was their intention, functionally this makes every single temple of this kind at Angkor a zenith tube” [27]. Besides the temples which are beautiful artificial caves for the zenithal sun, the authors have observed that this architectural possesses also alignments to mark the zenith passage at Angkor Wat.

Conclusion

Let us conclude observing that, besides in Meso- and South America, the zenithal sun was important also in the architecture of the tropical Asia as shown by the researches of Barnhart and Powell. Let us add to these fundamental researches a quite recent paper [29] that had evidenced an alignment to the sunrise of the day of the zenith passage of a temple, the Koh Ker temple, in an archaeological site in northern Cambodia, about 120 kilometres from the ancient site of Angkor. In fact, the observations of Barnhart and Powell and the alignment of this temple, are reinforcing the observation I made about the Sigiriya complex, that is was a complex aligned to the sunset of the day of the zenithal sun.

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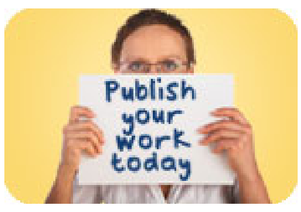

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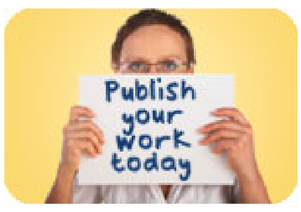

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