Design methods of Cheops Pyramid

Federico[1]

[1]Istituto Nazionale di Astrofisica (INAF)

June 24, 2019

Federico **Bucciarello**

(*Istituto Nazionale di Astrofisica (INAF)*

Abstract

According to the theory described below, the Great Pyramid of Giza, also known as the Pyramid of Khufu or the Pyramid of Cheops was designed starting from one shadow creation projected by a vertical rod placed at the center of Pyramid base and of the length as the Pyramid height.

The sunlight projected on the rod generates the shadow taken into consideration at a given time of the day, in particular noon on February 29;

the date corresponding to a given solar height attributed to the spatial coordinates is equivalent to the inclination of the sides of the pyramid.

The shadow of this rod generates a three-dimensional triangle whose hypotenuse, height and base correspond the pyramid profile, height and

mid of the pyramid Cheops base.

Introduction

Cheope's Pyramid as already known, is geometrically a pyramid that can be defined regularly, with a height of 146.6m with a square base side equals 230.34m.

The difference about the sides constituting the base has an average error of only 1.52 cm.

From the geometric precision of the construction of the pyramid form, both in relation to the four cardinal points in which its sides are directed, and to the considerable weight of the blocks they constitute, there are many theories that try to explain the construction methods.

If you think of the period when it was built, Man had few tools and few elements available to do this work.

An element that could be served, according to the theory and the following arguments is the Sun.

Astronomical Cycles

Elementary observations are made below.

The earth has an orbit around the sun that takes place in 365 days 5 hours, 48 minutes and 46 seconds, (revolution).

The time when the earth turns the revolution can be considered constant, that is, the period of current revolution is the same as 10,000 years ago.

As mentioned earlier a year is not a made with integers number of days and to remedy this every 4 years we add one day so that we can deny the excess time.

The day added to our calendar is February 29th.

The solutions are very similar to those adopted by us and it is well known that our calendar is very similar to the Egyptian one

To have "always" repeat the same solar height at a certain point you will have to wait 4 years from the first measure so as not to incur these small errors.

Shadows and gnomons

In the third century BC Eratosthenes using the shadow of a grounded vertical rod (gnomon) calculated with a margin of error of 5% the Earth's radius.

His experiment led him to travel from the city of Siene to Alexandria

For those times it was an extraordinary result, but if it had a valid measuring instrument that measured the distance between the two cities and if the second measure had taken it 4 years after the first, the margin of error would have been almost nil.

It is understood that using shadows over time is a practically perfect tool because it is based on a constant that is the revolution of earth around the sun and around its axis.

Solar Height

The solar Height is the angle between the direction of the solar rays and the horizontal plane taken in our case at its peak at noon.

The solar height depends on the latitude of the point where we are and by the declination thath in turn depends on the day included in the solar year in which the measurement was made.

Starting from the formula to calculate the solar height I get the declination ie the angle that forms the sun at noon on the meridian considered with the equatorial plane which can be positive or negative depending on the season.

$\alpha = 90\ ^\circ$ - latitude +/- declination

α = solar height

Latitude of the pyramid of Cheops is 29 ° 58'40.56 ", in degrees 29.977 °

Declination = 90 ° - 29.977 ° -51.84 ° = 8.183 °

Day corresponding

To know the day of the year in which the measure was made I have to apply the following P. I. Cooper formula

Cooper's formula is below

Delta = 23.45 x sen ((360 x (284 + n) / 365))

Delta is declination and **n** is the number corresponding to the days of the year (Cooper table).

I get "n" and get two values that give a very close declination to 8,183 °.

The two values are **60** and **284**

The value of 60 is the 60th day of the year that is in our calendar on

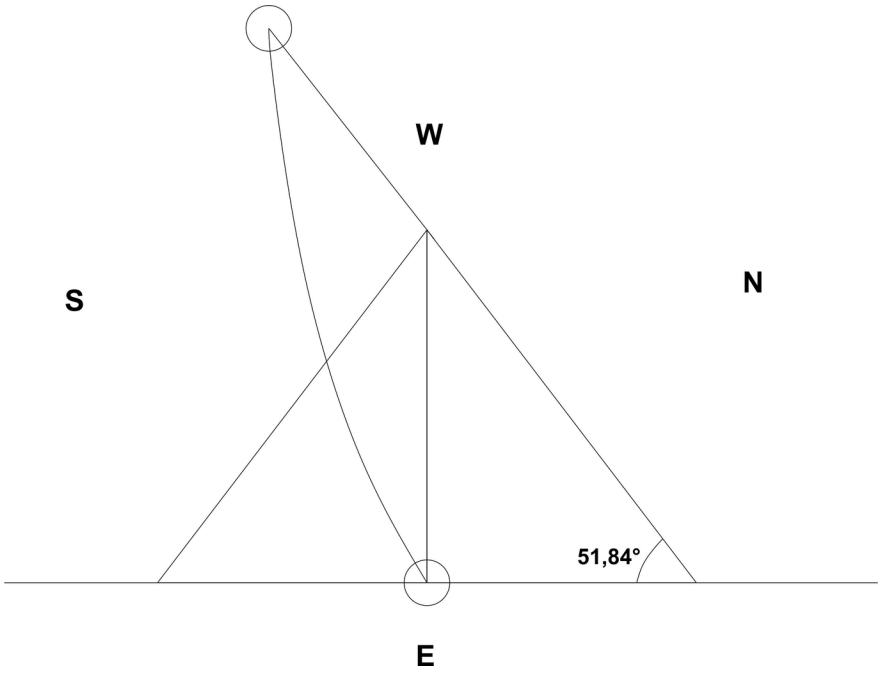

Figure 1: In this image is represented the solar height (angle equal to 51.84 °), taken specially of the same value as the inclination of the sides of the pyramid.

February 29th.

Applying this value to n I get a declination of 8.29 ° value very close to 8.183 °.

At n equal to 284 is October 11

Applying this value to n I get a declination of 8.10 ° also it very close to 8.183 °

Reflecting on the dates it gets is much more impressive but also more realistic to think that the date is that of February 29 because it is the day that is inserted into the leap year and is the only day that exists once every 4 years, doing the Exceptions (see Gregorian Calendar).

Even the resemblance between our Gregorian and Egyptian calendar makes it much more likely that this day of the year is right.

Conclusion

The pyramid in particular its profile was first designed on the field using the shadow of a gnomon of length equal to the height of the pyramid.

This shadow was subsequently served as a guide in the construction, exactly coinciding its limit with the profile.

On February 29th, it was chosen as the starting day for the pyramid's realization and as a day when every four years the limit of each step (figure 4)constituting the pyramid corresponding to the shadow of this auction was completed.

When it falls on February 29 the sun repeats exactly its daytime running, this accuracy is not for any other day of the year.

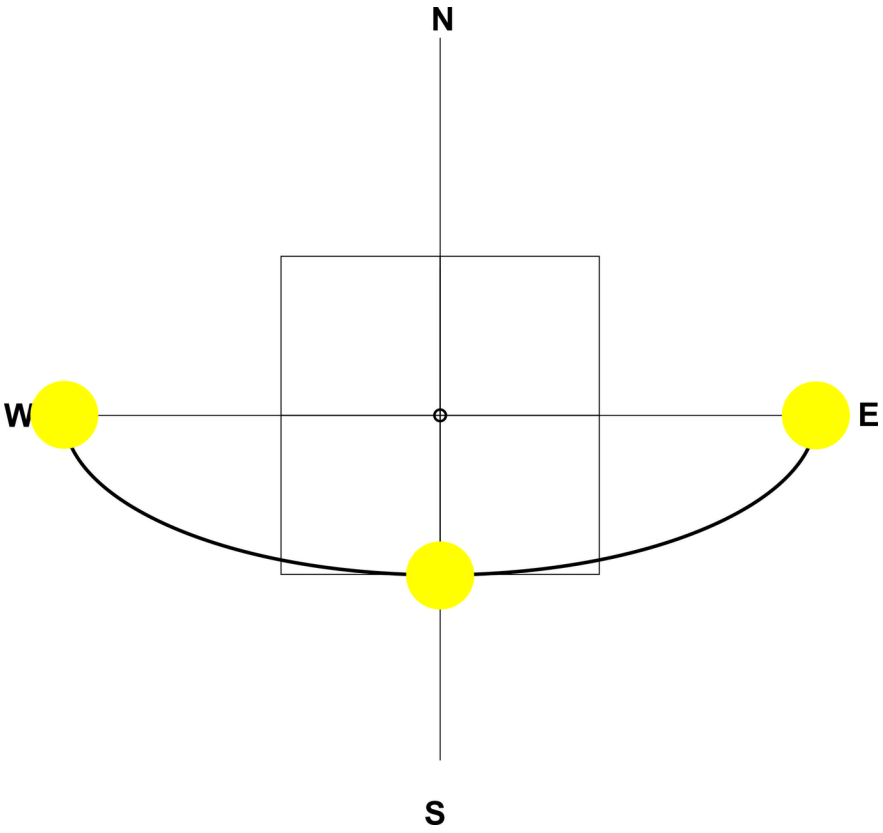

Figure 2: Shows the location of the sun during the day 29 February / 11 October in which the sun is exactly south and illuminates this side of the pyramid with an angle (solar height) which is almost the inclination angle of the sides of the pyramid.

For this reason, the Egyptians chose this date for start from the base and to check every 4 years that their profile was properly aligned.

References

P. I. Cooper,"The absorption of radiation in solar stills", Solar Energy, vol. 12, pp. 333 - 346, 1969.

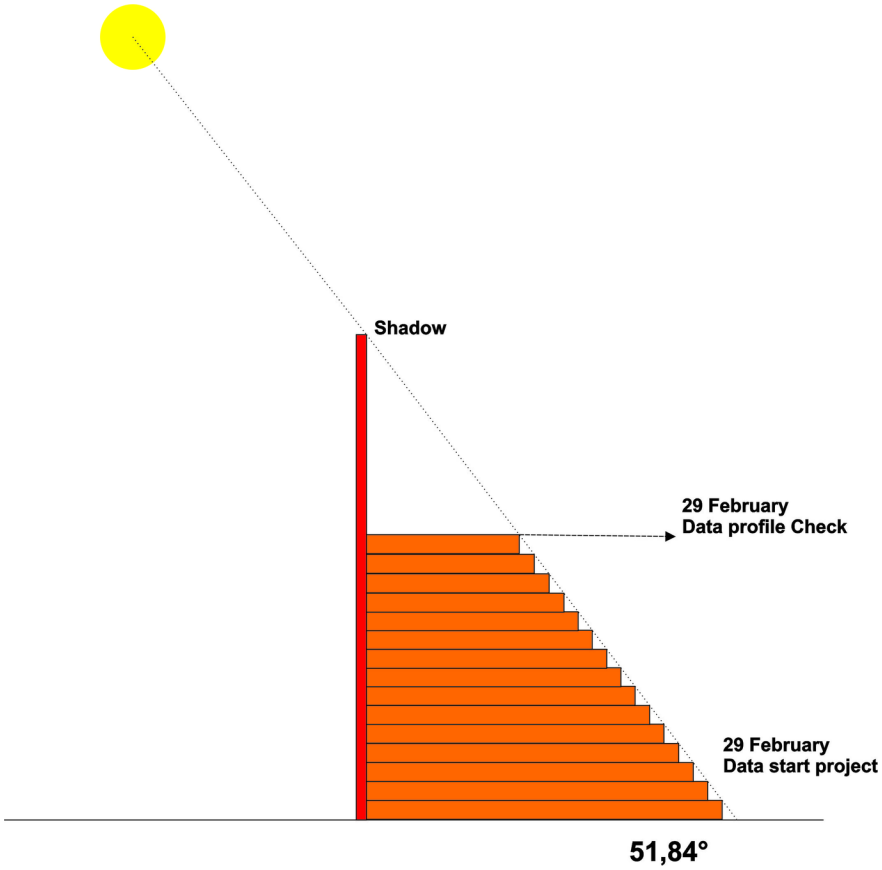

Figure 3: Construction and pyramid design technique