MEASURES OF THE EARTH OBLIQUITY DURING THE 1701 WINTER SOLSTICE AT THE CLEMENTINE MERIDIAN LINE IN ROME

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ABSTRACT. The great meridian line in the Basilica of Santa Maria degli Angeli in Rome was built in 1701/1702 with the scope of measuring the obliquity of the Earth's orbit in the following eight centuries, upon the will of Pope Clement XI. During the winter solstice of 1701 the first measurements of the obliquity were taken by Francesco Bianchini. He was the astronomer who designed the meridian line, upgrading the similar instrument realized by Giandomenico Cassini in San Petronio, Bononia. The accuracy of the data is discussed from the point of view of the use of the pinhole.

1. THE ASTROMETRIC PINHOLE

All ancient meridian lines have been re-measured after some decades of duty, in order to verify their alignment and the position of the pinhole. These instruments have been built to measure the variation of the obliquity along the centuries, and the need of a re-calibration was part of the observational duties. The Cassini meridian line in San Petronio, Bologna, made in 1655 was revised in 1695 by the same astronomer Giandomenico Cassini. Similarly Leonardo Ximenes in 1761 restored the meridian line in Santa Maria del Fiore in Florence, made by Paolo del Pozzo Toscanelli in 1475. The great Clementine gnomon of Santa Maria degli Angeli in Rome, completed by Francesco Bianchini in 1702, was studied and remeasured by Anders Celsius in 1734 and Ruggero G. Boscovich in 1750. They found the deviation of the azimuth from the true North, respectively of $2'$ (1734) and $4'30''$ (1750). Our measurements of 2006 (Sigismondi, 2013), used the Polaris transits technique, yielding $4'28''.8 \pm 0.6''$, in agreement with the measurements made by Boscovich.

In the recognitions of Cassini and Ximenes the main issue was the movement of the pinhole with respect to the original position.

This was due to the fact that the pinhole in Bologna was on the roof, and in Florence was in the dome of the church: both positions were subjected to motions of the buildings due to thermal response, winds and settling of the walls.

For this reason Francesco Bianchini chosen the basilica of Santa Maria degli Angeli in Rome to build the meridian line upon the will of Pope Clement XI (1700–1721): this church was built by Michelangelo in the original roman hall of the Diocletian baths, a 1500 years old structure, with no more settling ongoing.

2. RESULTS

On Figure 1 we can see that the center of the Sun has $c \sim 67.6$ in remarkable agreement with the IMCCE/Observatoire de Paris ephemeris for the day — z=34°.0548, equivalent to c=67.590. Bianchini could measure the nearest arcsecond by drawing both the locations of the Southern and the Northern limbs of the Sun.

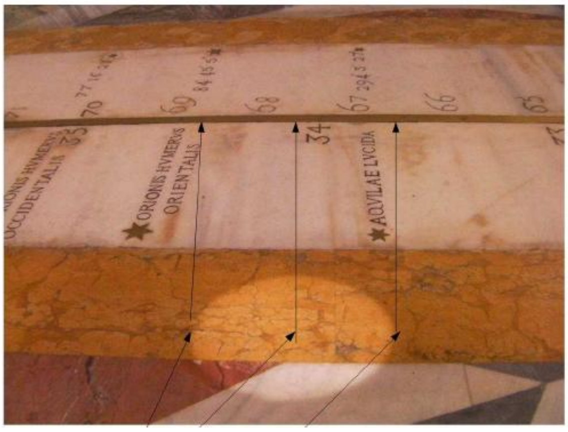

Figure 1: The image of the Sun is projected through a pinhole on the floor moving up on September 2^{nd} 2014.

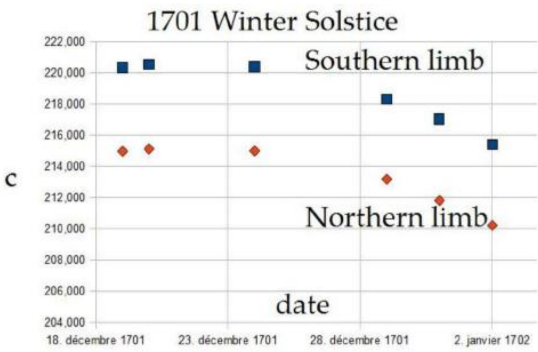

Figure 2: Graphical representation of the data in the letter of Francesco Bianchini to Pope Clement XI.

On Figure 2 the quadratical fit with the Southern limb yields 22.17 December for the solstice, and 21.94 December. The average gives the solstice at 22.06 December 1701 at 00:26 UT. For the same solstice, the IMCCE ephemeris give 21 December at 23:35.

The same quadratic fit yields for the extreme positions of the two limbs of the Sun at the solstice time: Southern 220.597 and Northern 215.228.

Correspondingly the unperturbed center of the solstitial Sun has declination $\delta = 23°28'48''$, being $41°54'11''.2$ the latitude of the pinhole.

Thus the observed mean Obliquity can be derived as $\epsilon = 23°28'54''.3$.

This is in excellent agreement with modern calculations for the mean obliquity in 1702.0. Laskar method gives $\epsilon = 23°28'40''.9$, whereas Duffet-Smith method gives $\epsilon = 23°28'58''.6$.

3. REFERENCES

Sigismondi, C., 2013, "The astrometric recognition of the Solar Clementine Gnomon (1702)", Intern. J. of Modern Physics, Conference Series, vol. 23, 454.