Angelo Secchi, the tradition of Gnomonics at the Collegio Romano, and the Equation of Time during the centuries

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Angelo Secchi, following the tradition started with father Christopher Clavius (1535–1612) who wrote a mathematical treatise (1581) on Gnomonics, realized sundials and quadrants. The equation of time determines the difference between the mean solar noon and the transit of the Sun at the meridian line. Its behavior depends on two facts: the obliquity of the ecliptic and its eccentricity. The first is determinant for the double sinus curve during a year and the second for the asymmetry of the approach to the solstices, which determines some cares when the parabolic fit is adopted. It confirms the difficulty of measuring the solstices with respect to the equinoxes already evidenced in Ptolemy's Almagest.

Keywords: Angelo Secchi, Astronomy, Gnomonics, Christopher Clavius, meridian line, Santa Maria degli Angeli.

1. The book on Gnomonics of Clavius and the Sundials at Collegio Romano

Fig. 1. The Clavius sundial at the Collegio Romano between the Calandrelli tower (right) and the top of the façade (left): the Italic hours, with Sunset at 23:30 and Ave Maria half hour later at 24 h.

2. Sundials at the time of Father Secchi

Secchi built some sundials in Grottaferrata and in Sicily, but Gnomonics at his time was a subject of study of some extent. The priest Angelo Giuseppe Sarto, born in

1835, built two sundials in his parish at Tombolo and Fontaniva in Veneto. He later become pope Pius X (1903–1914). When he was pope had to answer about the equation of time to his former parishioners, because in the passage between the local time to the European one, TMEC, every sundial and also his own showed immediately the equation of time to everyone.

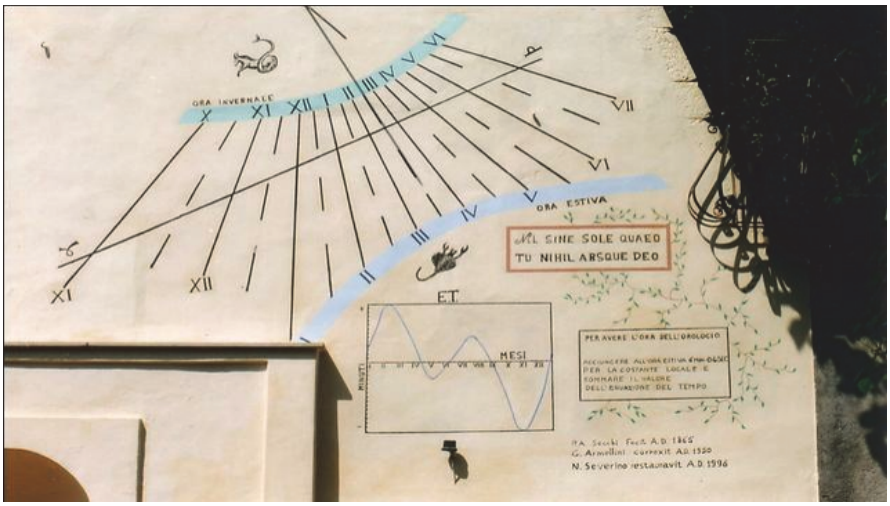

Fig. 2. The equation of time obtained with approximation.

3. Cause of the equation of time and first representations

Se puoi Jean des Murs e gli altri se no solo Tolomeo in Almagesto.

4. The bisection of the eccentricity from Ptolemy to Kepler

Kepler introduced the elliptical orbits, but it happened, already with Cassini data, that the ptolemaic eccentricity was exactly the double of the keplerian one, by definition of eccentricity of an ellipse. Therefore the introduction of an eccentricity, well before Ptolemy, after Eudoxus with Apollonius that in 3rd century BC who explained the equivalence with epicycles, already was an early evidence that the orbit of the Sun or of the Earth was showing different velocities in time and the existence of two opposite apsides. The perigee and the apogee become perihelion and aphelion, but the date remained the same. Arab astronomers understood their westward rotation, and between 15 and 17 centuries the astronomers tried to measure these modifications to the perfect two-body problem with increasing accuracy.

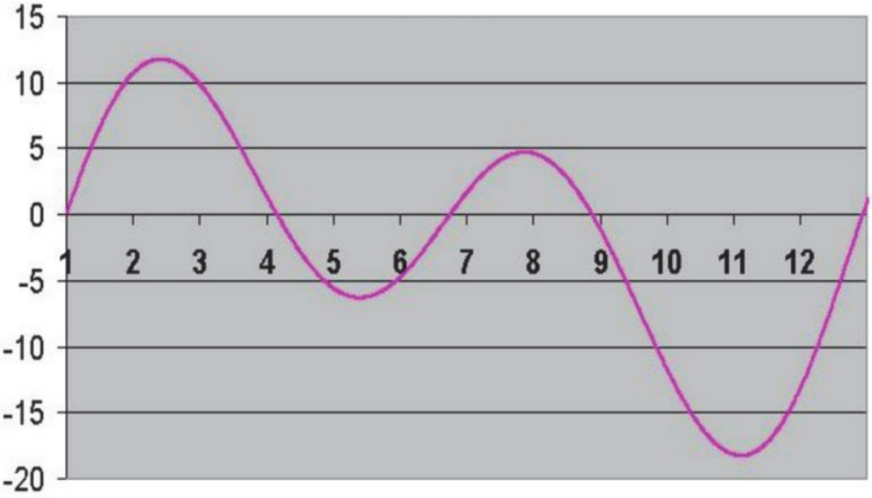

Fig. 3. The equation of time obtained with approximation.

The presence of the axis of apsides now occurring on 3–4 January and 3–4 July determines an asymmetry in the solar approach to the solstices: slower before the perigee on January with a faster farthening, conversely the summer solstice of June 21 is approached with a faster speed than later. This fact produces an estimate of the solstice instant which is sistematically earlier than the true instant as we increase the timespan between symmetric dates with the meridian Sun at the same heigth. Example the cardinal Nicholas Cusano estimated the winter solstice averaging the two dates in which his pinhole allowed the sunlight entering in his room at Andraz Castle. Now it happens between 2 February and 18 November at the 19 of December is the result of this estimate, because the Sun reach the same height of 18 November slightly faster after the perigee which now is Jan 4. At the time of Cusano the perigee was in January 1st 1450 and dividing by 2 the timespan the solstice estimate yielded probably 13 of december (the tradition of St. Lucy in Italian sounds "santa Lucia il giorno più corto che ci sia" says that st Lucy feast on Dec. 13 is the shortest day. Cusano already was able to measure that the solstice occurred well earlier than 21 december. The difference between the legth of the days near the winter or the summer solstice was not measurable accurately without chronometers. Cusano and other scholars already knew that the solstice was a minimum in the meridian height of the Sun, then its estimate by symmetry was one rapid solution to obtain that day, and the proverb tells us that the people was aware of the true solstice at the beginning of the Renaissance.

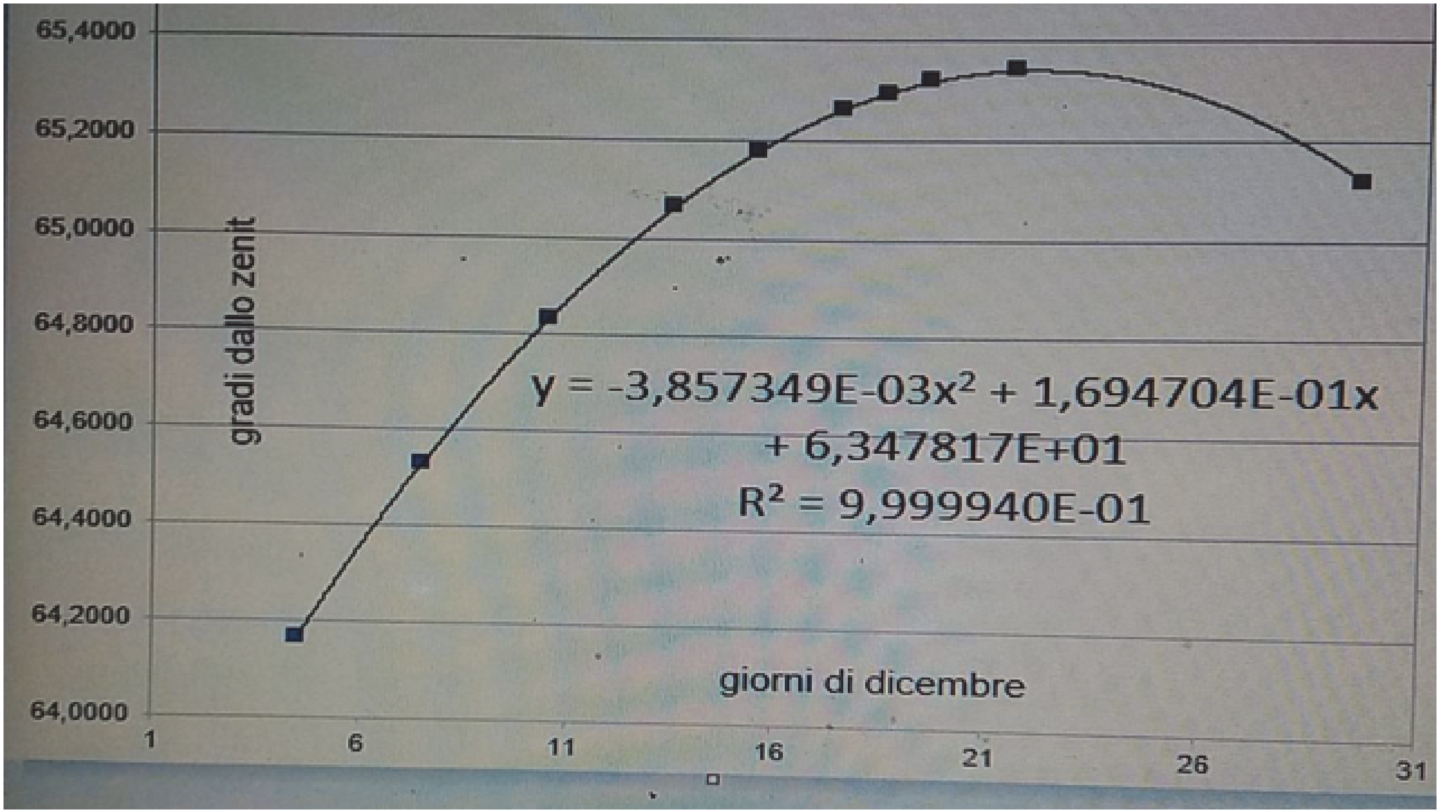

Fig. 4. The winter solstice measured in S. Maria degli Angeli in 2018–19 until December 29, with the asymmetry not yet evident.

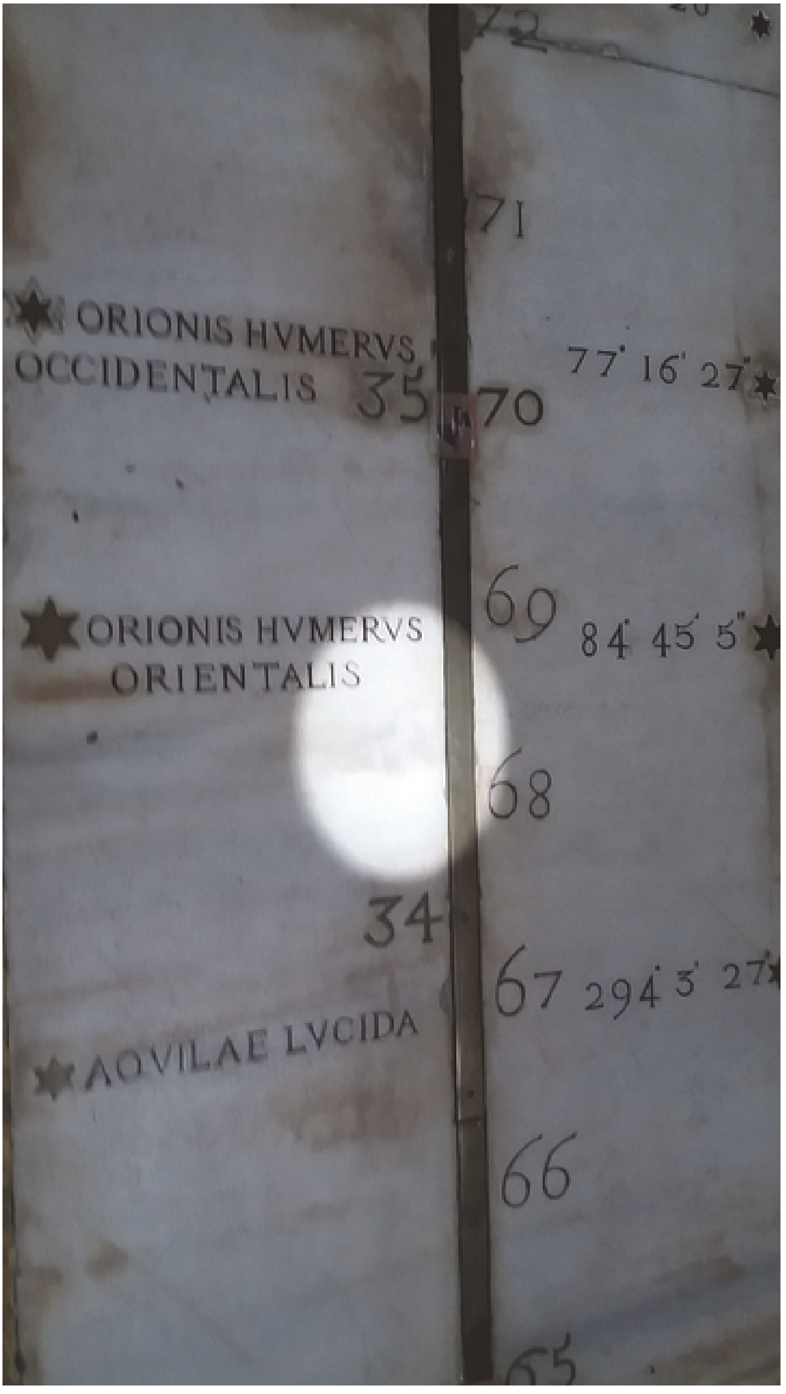

Fig. 5. The position of Betelgeuse, Humerus Orientilis Orionis, in 1701 atlas of Philippe de la Hire. The Southern solar limb was on it near April 10; nowadays the Sun is much southern with respect to Betelgeuse, for the precession. Betelgeuse is in the opposite direction of local motion of the Celestial North Pole from 1701 to present.

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