Studies of the astronomical array at the castle in Olsztyn

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The paper describes a mathematical model simulating the operation of the board for Sun observation located in Olsztyn castle. The board was made around 1517, when Nicolaus Copernicus held the office of the property administrator of the Warmian Chapter. The idea of the functioning of the array is adapted to the lighting conditions of the cloister. As an indicator of the instantaneous position of the Sun and the moment of time a ray of sunshine reflected from the mirror mounted horizontally on the windowsill of arcade was used. The paper presents the results of the analysis of the calendar lines as well as the hour lines. The architectural conditions determining the hours of operation of the array in different months and the factors affecting its accuracy has also been examined.

1 Introduction

Paul of Middelburg issued an invitation for Copernicus to participate in the calendar reform undertaken by the Fifth Lateran Council (1512-1517) (O'Connel, 1975). Copernicus decided to reconsider an astronomical context of the calendar imperfection. He suspected that the year's length varied and to check this fact, he made up to several observations of the Sun in 1515 and 1516 in his Frauenburg observatory. Unfortunately, Copernicus could not finish his work because he was appointed the administrator of the Chapter properties in the southern part of the Warmia province. For that reason on November 8$^{\text{th}}$ 1516, he arrived at the castle of Olsztyn. The proof that Copernicus continued his observations in new place is an astronomical table designed for the surveillance of the annual movement of the Sun. The table is distinguished by its operational innovation. There is no known evidence that anybody before Copernicus used a reflective method for observing the apparent motion of the Sun. It is the only observational instrument designed and used by him which is preserved to this day.

2 The model of the astronomical table

The architectural elements essential for the operation of the array, is shown in Fig. 1. The azimuth of the wall on which it resides is AT=123.56°and latitude is 53°46'36".

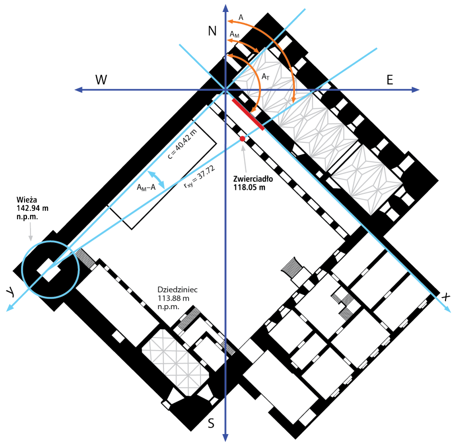

Fig. 1: The plan of the first floor of the castle of Olsztyn. According to the drawing by K. H. Clasen (Czubiel, 1986).

The geometry of the observational system is shown in Fig. 2. The mirror, as it is assumed to have been located in the centre of the sphere of the radius d, in the horizon plane. The table is tangent to this sphere. The Cartesian system (x,y,z), which originates at the tangential point, is introduced. The instantaneous position of the Sun in the plane of the horizon determines its azimuth A. The sunray light on the mirror at an angle equal to the current zenith distance of the Sun z=90°-h and it is reflected entering the plane of the table at the point (x, z).

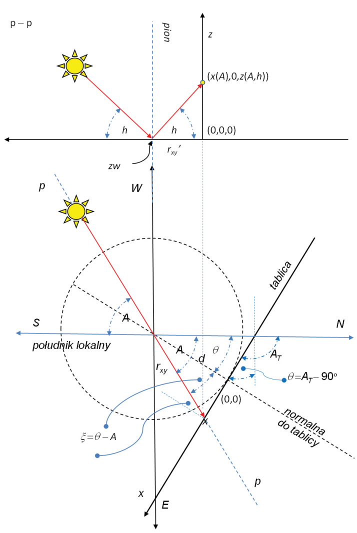

Fig. 2: The geometry of the observation of the Sun with the table.

For the analysis of lines of dates, it is sufficient to know the daily path plotted by the nodus. The elimination of time and transformation from horizontal coordinate frame (A, h) to the equatorial (δ, t) system facilitates the study of the functions of the table. The resulting quadratic forms represent hyperboles in the (x, z) plane.

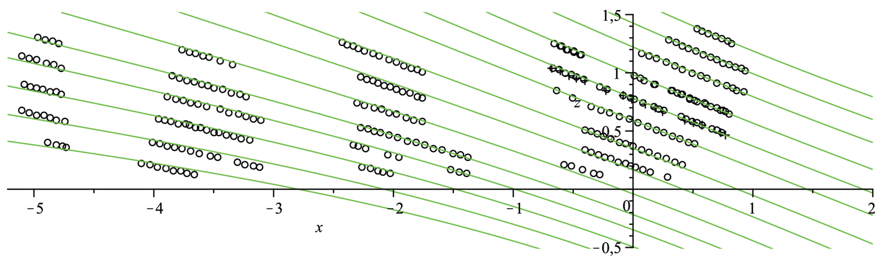

Fig. 3: Hyperbolic traces fitted to points on the preserved fragments of the date lines. Each line is marked with a corresponding value of the length ecliptic longitude.

In the history of the studies of the astronomical table the interpretation of black straight lines, was the most difficult problem (Przypkowski, 1973). Formally, these lines are the result of stereographic projection, of hours wheels on the plane of the table. To draw an hour line, in the case of the reflective clock, one should appoint at least two points, corresponding to the same time on different days. As a result of fitting function describing the position of the light spot on the board, a striking compliance of the lines' descriptions with the values of time obtained for lines marked as hours XI and II was found. These lines are related to the time 10:58:12, and 1:53:23 p.m., respectively.

3 Summary

There seems to be two likely hypotheses concerning the motive that led Copernicus to construct the table. The first of them it is the aspiration to attain the exact determination of the equinox and the length of the tropical year. The second, more interesting, explanation of the table's origin, can be traced to the heliocentric model of planetary system. Copernicus it was thought that the planet was firmly fixed to its sphere. Such a mechanism would result in the lack of succession of the seasons. To get out of this impasse, Copernicus attributed the Earth a so-called "third movement" (Copernicus, 1978). Its properly adjusted rate could also explain the phenomenon of the precession of the Earth axis, for the first time in the history of science. Hence the supposition that the astronomical table could have been designed for the studies of long term variations in the duration of the tropical year.

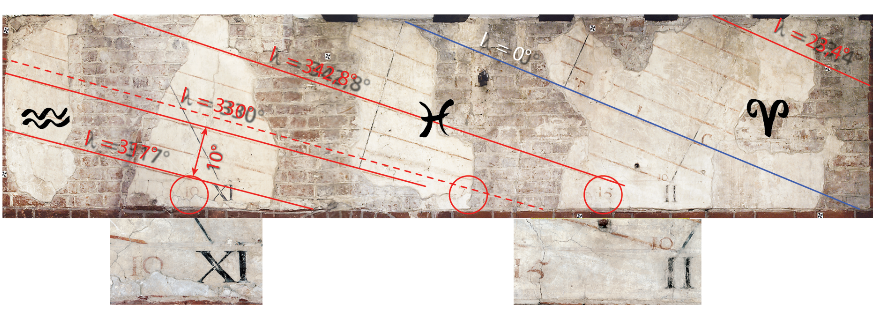

Fig. 4: The lines of dates on the astronomical board with their markings. Photographs of the board were used courtesy of the Museum of Warmia and Mazury in Olsztyn.

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