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Solar eclipse observations in the time of Copernicus **

IN THE EPOCH BEFORE TYCHO BRAHE and Johannes Kepler, only a handful of astronomical observations were actually used to derive parameters in a theory or to test the structure of a theory. Those observations, usually quoted in scientific treatises, such as the *Almagest* or *De revolutionibus*, have been analysed by historians of astronomy who want to know how observations are to be tied to a theory. Not surprisingly, those records give us very general picture of historical observational practice. However, there are still not fully explored series of observations that allow us to understand details of the observational methods used in the medieval and early modern period and the transmission of those methods. In this paper I offer an examination of such a series of observations made in Frauenburg by Nicolaus Copernicus. The series was recorded by Copernicus in his copy of Johann Stoeffler's *Calendarium Romanum magnum* (Oppenheim, 1518), and concerns four partial solar eclipses that occurred in 1530, 1536, 1540, and 1541. I argue that Ludwik Antoni Birkenmajer was right when in 1900 he hypothesized that Copernicus employed the *camera obscura* (pinhole camera) to measure the magnitude of these eclipses. The main argument goes from an analysis of errors of Copernicus's measurements of eclipse magnitudes.

This conclusion raises two interesting questions. First, how Copernicus might have learned of the astronomical use of a pinhole camera? With appropriate reservation some comments may be offered. The Jagiellonian Library in Cracow, where Copernicus took up his studies, has a rich collection of fifteenth-century optical manuscripts. This collection includes copies not only of John Pecham's *Perspectiva communis*, where the problem is just mentioned, but also the only known copy of the work by Egidius of Baisiu, whose contribution to the problem of pinhole images can be considered superior to that of any other medieval scholar in Europe before Kepler (with the exception of Levi ben Gerson). The manuscript with the treaties composed by Egidius belonged to the library of Matthew of Miechow (Maciej z Miechowa), a Cracow professor of medicine and a historian. (In the catalogue of this library, dated 1 May 1514, was also listed a handwritten treatise maintaining that the Earth moves while the Sun is at rest – the first known description of Copernicus's planetary theory, probably his *Commentariolus*.) As is well known, Martin Biem of Ilkusch (Marcin Biem z Olkusza), a Cracow professor of astronomy and astrology, was a close associate of Copernicus in lunar eclipse observations linking Cracow and Frombork. Although the subjects studied by Copernicus at the University of Cracow during the period 1491–95 are not known, it is certain that in winter term of 1492–93 Martin Biem taught optics and it is very probable that Copernicus attended his astronomy lectures. Martin Biem observed in Cracow and Ilkusch at least three partial solar eclipses from 1 October 1502, 8 June 1518, and 29 March 1530 (the last eclipse was also observed by Copernicus in Frauenburg). Thus the scientific community at Cracow seems the most obvious environment where Copernicus might have learned about the astronomical use of a *camera obscura*, although we cannot exclude another scenario.

The root of the second question is the hypothesis formulated by Birkenmajer. We have the series of four observations which strongly suggests that Copernicus used in his eclipse measurements a pinhole camera. We may safely assume that Georg Joachim Rheticus witnessed two of four Copernicus eclipse observations. We also know that Rheticus, during his sojourn with Copernicus, twice returned to Wittenberg and to his colleague Erasmus Reinhold – at the end of 1540 and in autumn 1541. There is no doubt that Rheticus would have had an opportunity to communicate Copernicus's observational

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method to Reinhold, since the short description of the method appeared in the second edition of Reinhold's commentary on Peurbach's *Theoricae novae planetarum*, launched in the middle of 1542. Reinhold's note appears to have been very influential. Tycho's career in observational astronomy began with the acknowledgement that the best method for eclipse measurements is the use of a pinhole camera. Tycho learned about this technique from Reiner Gemma Frisius's *De radio astronomico et geometrico liber* (Antwerp and Louvain, 1545), in which Gemma Frisius described his observation of a solar eclipse in 1544 by the method recommended by Reinhold. The teaching, presented by Reinhold was adapted and refined by Michael Maestlin. Kepler witnessed eclipse observations conducted by Maestlin and was aware of problems Tycho had with reduction of his own measurements made by the pinhole camera. Eventually Kepler built his own pinhole camera and used it in solar eclipse observations. And it was the need for solving the enigma of Tycho's eclipse observations that led Kepler to a theory of pinhole images and to his foremost treatise in optics, *Ad Vitellionem paralipomena*. Hence, if this reconstruction of Copernicus's method of eclipse observations and of the route of its dissemination through Reinhold's work is plausible, then the Warmian canon not only had taught astronomers how to use a compass to measure the magnitudes of solar eclipses, but also sowed the seeds from which modern optics flourished.