Rashed, Roshdi. **Les mathématiques infinitésimales du IXe au XIe siècle. Vol. 5. Ibn al-Haytham: Astronomie, géométrie sphérique et trigonométrie.** *Al-Furqān Islamic Heritage Foundation,* London, 2006. xiv+972+v pp. ISBN 1-905122-09-8

This book contains Arabic editions and French translations of the following five texts by the medieval Islamic mathematician Ibn al-Haytham (ca. 965-1041):

(1) The first section covers pages 1-615 and 881-894: "On the form (*hay'at*) of the motions of each of the seven stars (i.e., the sun, moon and the five visible planets), and on the proof that each of the seven stars can have, in the same day, equal altitudes (above the horizon) east (of the meridian) at all localities of the earth where the day arc of the star is bisected (i.e., where the planet is not circumpolar),... and that in some localities and at some moments, the (planet) can set in the east and then rise in the east, and that in the same localities it can set in the west and rise in the west." The following serves as an explanation of the title of this hitherto unpublished treatise. Consider a locality in the temperate regions of the northern hemisphere of the Earth, and a fixed star near the ecliptic. Such a fixed star will, during its (apparent) daily motion, rise in the east, culminate in the south, exactly in the local meridian, and set in the west. [We now know that the daily motion of the fixed stars is due to the rotation of the Earth, but Ibn al-Haytham assumed that the earth is at rest and the stars rotate around it.] The altitude of the star increases when it is in the eastern part of the sky, and in the western part it will decrease.

Because the five planets as well as the sun and moon have a slow proper motion with respect to the fixed stars, their daily culmination may be at a point which is a very small distance east of the local meridian. This will happen if the declination of the planet (or sun or moon) decreases. Between the point of culmination and the local meridian, the altitude of the planet will decrease. Then, at two different moments of the same day, the planet can have the same altitude above the horizon and be east of the local meridian.

Next consider a fixed star whose northern declination is 90 degrees minus the geographical latitude of the locality on the northern hemisphere. During its (apparent) daily motion, the star will describe a circle tangent to the local horizon at the north point. If the locality is in or near the arctic regions, then the declination of the sun, moon or planet is sometimes approximately 90 degrees minus the geographical latitude of the locality. Ibn al-Haytham argues that in such cases, it is theoretically possible that the sun, moon or planet describes in its daily motion a path tangent to the horizon. If the celestial body has a proper motion, the point of tangency of its (apparent) orbit to the horizon can be at a small distance of the north point. If the northern declination of the planet is a bit less, it is also possible that the planet is below the horizon for a very brief time, while it is east or west of the north point. Thus the planet can 'set in the east' or 'rise in the west'.

Ibn al-Haytham studies the subject in great detail in a geometric way, using a highly intricate argumentation. He does not provide numerical estimates. Given the slow proper motions of the sun, moon and planets, and the limited accuracy of the astronomical instruments that were available in the Islamic period, it is doubtful whether culminations west or east of the meridian could ever have been observed, let alone planets rising in the west or setting in the east. Treatise (1) does not belong to practical astronomy, but it is an exercise in spherical geometry. Ibn al-Haytham does not provide geometric models for the motion of the sun, moon and planets in the universe, similar to those in the *Almagest* of Ptolemy.

Treatise (1) has come down to us in a unique manuscript, which is now in St. Petersburg, and which was described in B. A. Rosenfeld, A medieval physico-mathematical manuscript newly discovered in the Kuibyshev Regional Library, [*Historia Mathematica* 2 (1975), no.1,67-69]. The author has further explained his interpretation of treatise (1) in The celestial kinematics of Ibn al-Haytham [*Arabic Sciences and Philosophy* 17 (2007), no. 1, 3, 4, 7-55].

(2) The second section covers pages 617-679: "On the difference which happens in the altitudes of stars." This is a much more elementary treatise, in which Ibn al-Haytham essentially studies the altitude of a fixed star above the horizon during the (apparent) daily motion of the star. The main question is whether the change in altitude of the star in one time interval is greater, equal or less than the change in altitude in another equal time interval. The treatise is hitherto unpublished and is extant in a single Arabic manuscript in Istanbul.

(3) The third section covers pages 683-801: "On the hour lines." In this hitherto unpublished treatise, Ibn al-Haytham studies the celebrated problem of determining the hour lines on a horizontal sundial. In civil time reckoning, the period between sunrise and sunset was divided into twelve hours. These hours are called seasonal hours in the modern literature, because their length varies with the season. Now consider a horizontal sundial with a vertical

gnomon perpendicular to it. We obtain the hour line for the second (seasonal) hour if we mark, on all different days of the year, the shadow of the tip of the gnomon at the end of the second seasonal hour. The hour lines of the seasonal hours look like straight lines. It is easy to see that the hour line for the sixth seasonal hour (noon) is a straight line. Ibn al-Haytham's predecessor Ibrahim ibn Sinan (907-946) proved that, for localities between the equator and the arctic circle, the other hour lines are not straight lines, but his proof was incomplete. In treatise (3) Ibn al-Haytham completes the proof, and he also shows that the deviation between the hour lines and straight lines is so small that it can be ignored in practice. Treatise (3) has been preserved in two manuscripts in Istanbul. It is one of the highlights of Ibn al-Haytham's mathematical work.

(4) The fourth section covers pages 803-849: "Treatise on horizontal sundials." This is a more elementary treatise on the construction of sundials, without any technical intricacies. The treatise had not been published before, and it has been edited by Rashed on the basis of two manuscripts in Berlin and Teheran.

(5) The fifth and last section covers pages 851-879: "On the compass for (drawing) large circles." A German translation of the same text can be found in [E. Wiedemann, Über geomerische Instrumente bei den muslimischen Völkern, *Zeitschrift für Vermessungswesen,* 22-23 (1910), 585-592.].

In previous publications, Rashed claimed that there were two Ibn al-Haythams, a philosopher-physician from Baghdad and a mathematician and astronomer from Basra. In Appendix 1 (pp. 883-894), he aims to determine which Ibn al-Haytham wrote treatise no. 1. Rashed's hypothesis of the two Ibn al-Haythams has been criticized in [see A. I. Sabra, One Ibn al-Haytham or Two? An exercise in reading the bio-bibliographical sources, *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 12 (1998), 1-50; 15 (2002/03), 95-108, 10 (Arabic pp.)].

In Appendix 2 (pp. 892-896), Rashed translates a section of another work by Ibn al-Haytham, "On the correction of astronomical instruments", in order to obtain some more information on an instrument which supposedly could be used to measure the altitude of celestial bodies above the horizon in minutes and seconds of arc. The reference to such an instrument shows again that Ibn al-Haytham was a mathematician but not a practicing astronomer.