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Ibn al-Shāṭir: ʿAlāʾ al-Dīn ʿAlī ibn Ibrāhīm

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Born **Damascus (Syria)**, *circa* **1305**

Died **Damascus (Syria)**, *circa* **1375**

Ibn al-Shāṭir was the most distinguished Muslim astronomer of the 14th century. Although he was head *muwaqqit* at the Umayyad mosque in Damascus, responsible for the regulation of the astronomically defined times of prayer, his works on astronomical timekeeping are considerably less significant than those of his colleague **Khalīlī**. On the other hand, Ibn al-Shāṭir, continuing the tradition of Ibn al-Sarrāj, made substantial advances in the design of astronomical instruments. Nevertheless, his most significant contribution to astronomy was his planetary theory.

In his planetary models, Ibn al-Shāṭir incorporated various ingenious modifications of those of **Ptolemy**. Also, with the reservation that they are geocentric, his models are the same as a number used by **Nicolaus Copernicus**. Ibn al-Shāṭir's planetary theory was investigated for the first time in the 1950s, and the discovery that his models were mathematically identical to those of Copernicus raised the very interesting question of a possible transmission of his planetary theory to Europe. This question has since been the subject of a number of investigations, but research on the astronomy of Ibn al-Shāṭir and of his sources, let alone on the later influence of his planetary theory in the Islamic world or Europe, is still at a preliminary stage. It is known, however, that Copernicus' Mercury model is that of Ibn al-Shāṭir and that Copernicus did not properly understand it.

Ibn al-Shāṭir appears to have begun his work on planetary astronomy by preparing a *zīj*, an astronomical handbook with tables. This work, which was based on strictly Ptolemaic planetary theory, has not survived. In a later treatise entitled *Taʿlīq al-arṣād* (Comments on observations), he described the observations and procedures with which he had constructed his new planetary models and derived new parameters. No copy of this treatise is known to exist in the manuscript sources. Later, in *Nihāyat al-suʾl fī taṣḥīḥ al-uṣūl* (A final inquiry concerning the rectification of planetary theory), Ibn al-Shāṭir presented the reasoning behind his new planetary models. This work has survived. Finally, Ibn al-Shāṭir's *al-Zīj al-jadīd* (The new astronomical handbook), extant in several manuscript copies, contains a new set of planetary tables based on his new theory and parameters.

Several works by the scholars of the mid-13th century observatory at Marāgha are mentioned in Ibn al-Shāṭir's introduction to this treatise, and it is clear that these were the main sources of inspiration for his own non-Ptolemaic planetary models.

The essence of Ibn al-Shāṭir's planetary theory is the apparent removal of the eccentric deferent and equant of the Ptolemaic models, with secondary epicycles used instead. The motivation for this was at first sight aesthetic rather than scientific, but his major work on observations is not available to us, so this is not really verifiable. In any case, the ultimate object was to produce a planetary theory composed of uniform motions in circular orbits rather than to improve the bases of practical astronomy. In the case of the Sun, no apparent advantage was gained by the additional epicycle. In the case of the Moon, the new configuration to some extent corrected the major defect of the Ptolemaic lunar theory, since it considerably reduced the variation of the lunar distance. In the case of the planets, the relative sizes of the primary and secondary epicycles were chosen so that the models were mathematically equivalent to those of Ptolemy.

Ibn al-Shāṭir also compiled a set of tables displaying the values of certain spherical astronomical functions relating to the times of prayer. The latitude used for these tables was 34°, corresponding to an unspecified locality just north of Damascus. These tables display such functions as the duration of morning and evening twilight and the time of the afternoon prayer, as well as standard spherical astronomical functions.

Ibn al-Shāṭir designed and constructed a magnificent horizontal sundial that was erected on the northern minaret of the Umayyad Mosque in Damascus. The instrument now on the minaret is an exact copy made in the late 19th century. Fragments of the original instrument are preserved in the garden of the National Museum, Damascus. Ibn al-Shāṭir's sundial, made of marble and a monumental 2 m × 1 m in size, bore a complex system of curves engraved on the marble that enabled the *muwaqqit* to read the time of day in equinoctial hours since sunrise or before sunset or with respect to either midday or the time of the afternoon prayer, as well as with respect to daybreak and nightfall. The gnomon is aligned toward the celestial pole, a development in gnomonics usually ascribed to European astronomers.

A much smaller sundial forms part of a compendium made by Ibn al-Shāṭir, now preserved in Aleppo. It is contained in a box called *ṣandūq al-yawāqīt* (jewel box), measuring 12 cm × 12 cm × 3 cm. It could be used to find the times (*al-mawāqīt*) of the midday and afternoon prayers, as well as to establish the local meridian and the direction of Mecca.

Ibn al-Shāṭir wrote on the ordinary planispheric astrolabe and designed an astrolabe that he called *al-āla al-jāmiʿa* (the universal instrument). He also wrote on the two most commonly used quadrants, the astrolabic and the trigonometric varieties. Two special quadrants that he designed were modifications of the simpler and ultimately more useful sine quadrant. One astrolabe and one universal instrument actually made by Ibn al-Shāṭir survive.

A contemporary historian reported that he visited Ibn al-Shāṭir in 1343 and inspected an “astrolabe” that the latter had constructed. His account is difficult to understand, but it appears that the instrument was shaped like an arch, measured three-quarters of a cubit in length, and was fixed perpendicular to a wall. Part of the instrument rotated once in 24 hours and somehow displayed both the equinoctial and the seasonal hours. The driving mechanism was not visible and probably was built into the wall. Apart from this obscure reference we have no contemporary record of any continuation of the sophisticated tradition of mechanical devices that flourished in Syria some 200 years before his time.

Later astronomers in Damascus and Cairo, none of whom appear to have been particularly interested in Ibn al-Shāṭir's non-Ptolemaic models, prepared commentaries on, and new versions of, his *zīj*. In its original form and in various recensions, this work was used in both cities for several centuries. His principal treatises on instruments remained popular for several centuries in Syria, Egypt, and Turkey, the three centers of astronomical timekeeping in the Islamic world. Thus Ibn al-Shāṭir's influence in later Islamic astronomy was widespread but, as far as we can tell, unfruitful. On the other hand, the reappearance of his planetary models in the writings of Copernicus, especially his misunderstood Mercury model, is clear evidence of the transmission of some details of these models beyond the frontiers of Islam.

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