

The Islamic Astrolabe

An Indicator of the Role of Islamic Astronomy During the Middle Ages

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Astronomical Knowledge Migrates with the Astrolabe

Tracing the development of one of astronomy's earliest measuring tools, the astrolabe, illustrates the significance of the migration of ancient Babylonian and science to the Islamic regions during the Middle Ages.

Simply stated, an astrolabe is an ancient and sophisticated instrument used to measure the position of celestial objects. The astrolabe has a history that spans more than 200 years and it is often heralded as the world's oldest scientific instrument. Ancient Greek astronomers invented the astrolabe in the second century BC for the purpose of determining the altitude of celestial objects.

During the Dark Ages, many early Greek astrolabes and manuscripts were lost. The burning of the great library in Alexandria, Egypt heralded the beginning of the massive losses of knowledge that characterizes this period in history. The sequestering of knowledge by the Church as well as the provincial nature of the fiefdoms and the isolated villages of the age all contributed to the losses of astronomical knowledge to the Western world.

Meanwhile, Islamic astronomers sought out and collected many of the remaining astrolabes and Greek manuscripts. These astronomers preserved and expanded upon many of the uses of the astrolabe and upon many of the discoveries of ancient astronomy. The improved Islamic astrolabes along with new and ancient astronomic concepts were re-introduced to the Western world by 12 AD with the migration of Islam through southern Europe.

The Inventors

Archeoastronomy references agree that the concept for the astrolabe appeared around the second century BC. Some historians credit Apollonius (225 BC) with the initial concept and design (Jakubowski screen 1). The earliest known forms of the astrolabe date back to 150 BC. Hipparchus (150 BC) is credited with constructing the first 4 ring astrolabe. However, written descriptions of the concept, design and use of the instrument do not appear until 150 AD when Ptolemy scripted *Mathematical Syntaxis*, known as *Almagest* in Islamic Astronomy.

Ptolemy's *Mathematical Syntaxis* was the definitive reference for the mathematical investigation of celestial objects and was used in the universities of the world. Ptolemy and many of his contemporaries taught and studied at Alexandria, Egypt – then the knowledge capital of the world. Here the astrolabe evolved into a 9 ring version that some historians credit to Synesius of Cyrene (400 AD), a student of Hypatia, the world's first renowned woman of science and the last librarian of the great library of Alexandria (Jakubowski screen 1).

These early versions of the astrolabe were used primarily to measure the altitude of the sun and stars. The purposes of the measurements appear to include the investigation of geometrical concepts in astronomy, establishing calendars and determining time.



Technology Transfer to the Middle East and North Africa

In the middle of the 4th century AD, St. Ephram founded a school in Edessa, a town in Mesopotamia. The Greek manuscripts studied here were translated into Syriac, the 4th century language of this middle eastern region. Among the documents translated were the writings of Aristotle and Ptolemy's *Mathematical Syntaxis*. With the translations of Ptolemy's work, the astrolabe technology was transferred to the Middle East. The school in Edessa was later closed and relocated to Jundishapur by Emperor Zeno where additional Greek works of science were translated into Syriac (Hoskins 50).

By the 8th century, the successors to Muhammad had established a new capital in Baghdad – a region within reach of the Christian school at Jundishapur. Harun al-Rashid (caliph, 786) established a center of learning and science called the House of Wisdom where many Islamic astronomers and astrologers taught and studied (Wilson 46).

The astrolabe was incorporated into the studies at this great center of Middle Eastern learning. Furthermore, here many additional Greek manuscripts purchased from the Byzantine Empire were translated into Syriac and Arabic. The Arabic translation ensured the propagation of the astrolabe and the works of the Greek astronomers throughout the Middle East and across North Africa. (Cambridge 50-51).

Islamic Uses and Modifications of the Astrolabe

Historians studying the earliest surviving Islamic astrolabes (9th century) agree that the tools developed in the Mideast were indeed modifications of the early Greek designs. More than 40 uses of the astrolabe are documented, most of which were developed by Islamic astronomers (Eagleton screen 1).

Islamic astronomers used the astrolabe primarily to:

develop a calendar of astrological events significant to the Islamic faith.
ascertain appropriate prayer times (e.g. exact moments of sunrise and sunset).
orient mosques and the direction of prayer toward Mecca at any latitude and longitude (Hoskins 51; Wilson 46-47).

Over the span of the Middle Ages, Islamic astronomers/astrologers designed three styles of astrolabes:

- a flat style derived from the Greek versions.
- a linear type called the Staff of Tusi (invented by Muzaffar Sharaf al-Din al-Tusi).
RARE (Hoskins 64)
- a spherical instrument – only one of these remains. (Astrolabe screen 2).

See photo at: <http://www.kol.org/astrolabe.html>

Among the most notable innovations are those that led to the calibration of the astrolabe to minimize numerical calculations for geographic position and altitude. In 4th century Damascus, a Muwaqqit (a timekeeper – astronomer), by the name of al-Khalili used the astrolabe and mathematics to develop a table that gave the qibla, or sacred orientation, for each degree of latitude between 10⁰ and 56⁰ north and for each degree of longitude from 10⁰ to 60⁰ east of Mecca. This table provided a reference for prayer and mosque orientation that eliminated the re-calculation of the position of Mecca each time it was needed (Hoskins 55).

To further improve the efficacy of the instrument, al-Farghani, a 9th century astronomer, listed the radii of altitude and azimuth circles on the plate of the astrolabe for each degree of latitude. This simple innovation eliminated the need to re-calculate the radii values at each use (Eagleton screen 1).

These early modifications may have inspired the 10th century astronomer Ali ibn Khalaf to create a more convenient way of calibrating the astrolabe to the appropriate latitude. To use the astrolabe effectively, a plate depicting variations in circles of altitude and azimuth was developed for each latitude. The astronomer would need to carry these heavy accessories, called climates, to ensure his instrument was appropriately calibrated for latitude. Ali ibn Khalaf developed a universal plate to replace the set of climates (Astrolabe screen 5).

The Astrolabe Returns to the Western World

With the Muslim conquest of Spain in the 12th century, the astrolabe entered the Iberian Peninsula and spread throughout the Mediterranean and then to Europe (Hoskins 72-73; Saunders screen 1). These instruments were accompanied with zij (tables of observational data including planetary and stellar positions) and other Muslim astronomical manuscripts. Later the development of the printing press facilitated the astrolabe technology transfer to Western Europe. A case in point is the work of the Muslim astronomer and geometer, Muhammad al-Battani.

Islamic astronomers used astrolabes to develop zij. Muhammad al-Battani is credited with improving the delineation of the ecliptic, the path of the sun in relation to earth, in his zij. With the migration of Islamic astrolabes and tables through Muslim Spain and with the application of the 16th century printing press, al-Battani's zij was widely distributed in the western world and attracted the attention of a renowned western astronomer – Nicolaus Copernicus. Copernicus relied heavily upon the observations noted in the al-Battani zij. According to Cambridge historians, Copernicus cites al-Battani no less than 23 times in his manuscripts (Hoskins & Gingerich 59). In fact, Copernicus is known to have quoted from many astronomical observations and tables of planetary motions compiled by various Islamic astronomers.

By the 15th and 16th centuries, the astrolabe in western Europe was a basic education tool in mathematics and astronomy -a science now advanced by the advent of the telescope. The astrolabe also took on practical applications when it was modified to meet the navigational requirements of mariners thereby facilitating the Age of Discovery. However, the invention of the pendulum clock and later the chronometer led to the decline in the use of the astrolabe for time keeping. Despite the waning use of the astrolabe for measuring celestial objects, a 16th century person's ability to employ the astrolabe was an indication that he was well schooled.

Image of mariners astrolabe at: <http://www.astrolabes.org/MARINER.html>

The Astrolabe Today

Satellite geographic positioning systems have automated navigation of the seas, skies and continents. Time is measured precisely with the advent of the atomic clock. Earth based telescopes are targeted using automated, computer supported drive systems and many current observations are made from telescopes aboard satellites. These modern technologies far outpace the basic navigational and time keeping capabilities of the astrolabe.

However, one may catch a glimpse of the mariner's version of the astrolabe on board ships, particularly for life raft applications when the conveniences of electrically generated technologies fail. Versions of the astrolabe are also used in mathematics and astronomy classrooms to illustrate basic observation concepts of altitude and azimuth. Collectors can purchase reproductions of antique astrolabes while many ancient versions are preciously maintained at museums and planetariums worldwide.

Significance of the Islamic Astrolabe

Many Islamic scientists, mathematicians and astronomers are renowned for their contributions to the advancement of science and mathematics during the Middle Ages. Thanks to these works, the world did not face the tedium and delay of re-discovery, re-creation of tools such as the astrolabe or the astronomical observations and concepts developed by the ancient astronomers over 2000 years ago. One might wonder how navigation and astronomical observations might be conducted today were it not for the curiosity and ingenuity of Islamic astronomers in astrolabe technology.

Additional Astrolabe Internet Sites of Interest

History of Astronomy at Adler Planetarium adlerplanetarium.org/history/instruments/astrolabes.html

Make your own astrolabe <http://www.ifa.hawaii.edu/tops/astlabe.html>

Carnegie Observatories Persian Astrolabe
adlerplanetarium.org/history/instruments/astrolabes.html

The Electric Astrolabe <http://www.astrolabes.org/electric.html>

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