Astrolabe The Ancient Computer

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Astrolabe The Ancient Computer by Abdul Gafur Thottungal

What is an Astrolabe?

Astrolabe is an ancient scienfic instrument used to find the apparent positions of the Sun and other important stars in the sky for any time of the day or night throughout the year. It was used both to make observations and to carry out calculations and was the most widely used scientific instrument in the middle ages and into the early modern period. An astrolabe can be thought as a form of

computer; a multi- function calculator. Its most common usage were Solving problems of geometry ,Converting betweentime-keeping systems , Calculating trigonometric functions , Basic surveying, and much more concerning astronomy and time keeping, but the full range of its capabilities is much larger: Alchemists, astronomers, astrologers, and educated individuals were used astrolabes. Use of the astrolabe would have been taught in the course of advanced classes in

the natural Siences and mathematics, the way slide rules used to be, and high-end calculators are now. Most of the surviving astrolabes are constructed of metal, preserved by their higher value and duability. But there are also several surviving examples from the medieval period of astrolabes constructed of both paper and wood (and sometimes paper laminated wood, so that we can assume that cheap versions where not uncommon.

Basics of Astrolabes

Understanding the various functions of the astrolabe is made easier if you have an understanding of the concepts behind its design, how they are used in the astrolabe and how the various parts work:

The Celestial Sphere . The sky seems to be a hemisphere turned down on us and two hemispherers of day and night can be imagined as a large sphere with the fixed stars attached to it, with the Earth, stationary and non- rotating, at the center. The Sun, the Moon, and the planets all had their own concentric spheres between the Earth and the stars. As the various spheres rotate about the Earth, different parts of the sky would become visible to a viewer standing in any given spot. Like the

Earth itself, this celestial sphere has many fixed landmarks allowing the observer to find his or her way around: The Celestial Poles and Equator At true north, at the point about which the sphere appears to rotate, is Polaris, the North Star, or Pole Star. This point marks celestial north. Opposite it, invisible to viewers in the southern hemisphere, is celestial south. Between these two extremes is a circle marking the celestial equator. As these all lay directly above their earth-bound equivalents, you can think of these points the way you think of Earth âs north and south poles, and equator; and just as you can be defined your position on the Earth using your latitude and longitude, positions on the celestial sphere can be similarly defined.

The Ecliptic

The most obvious object in the sky is the Sun. As the Earth rotates (or as it would have been explained in the days when the astrolabe was current technology, as the Sun rotates around the Earth), the sun rises, moves across the sky from East to West and sets. Over the course of the year the Sun seems to move across the fixed stars, oscillating from north to south and back again. This set path in the sky that the sun moves along is known as the ecliptic and is marked by the zodiac constellations.

The Tropics

As the Sun moves along the ecliptic, it moves toward the north as summer approaches, and back south as winter comes. The circle marking the northernmost point of the sun's path is known as the

Tropic of Cancer and the southernmost the Tropic of Capricorn.

The Celestial Year

There are 4 fixed events in the year, defined by the sun âs motion along the ecliptic.

The Solstices

The solstices mark the longest and shortest days of the year, these are the dates when the sun is at its most northerly and southerly limits. The Equinoxes The ecliptic intersects the equator, on two days of the year. These dates are the spring and fall equinoxes. The spring equinox occurs when the sun moves from the southern hemisphere to the northern; and the reverse is true for the fall equinox.

The Local Sky

In addition to the celestial sphere, the astrolabes function relies on knowledge of the local sky from the point of view of the user âs location. When you look up at the sky you can see half of the celestial sphere; the other half being blocked by the ground you are standing on. What part of the sphere is visible depends on where you are and the time of day and the time of the year.

The Horizon

The horizon is marked, rather obviously, by the line where the sky meets the ground. Of course, your local terrain, mountains and such will alter what can actually be seen, but for the purposes of this manual imagine it as a smooth line all the way round you.

The Zenith and Nadir

The point highest in your local sky (i.e. directly overhead) is the Zenith; its opposite point, directly under your feet, is called the Nadir. The horizon then lies 90 degrees from both.

Almucantars

An almucantar is defined as a line of equal elevation above the horizon. For example: Imagine a line that lays 15 degrees above your local horizon, all around the sky. That would be the 15-degree

almucantar.

The Meridian

The last major landmark we will concern ourselves with is the meridian . This is an imaginary line in the sky, passing from the north celestial pole to the south celestial pole, and passing directly over your head (zenith). This line marks local noon, the sun's highest point above the horizon for any given day. Picture it as a line in the sky running from due north to due south directly overhead.

The Projections

Stereographic projection is a graphical technique for representing the angular relationships between planes and directions in crystals on a 2D piece of paper . If you have done any work with maps, you will be familiar with the concept of projections. The Earth is a sphere; so creating a flat map of the curved surface involves projecting that Sphere onto a flat surface. This is why, on some maps, the continents appear very distorte near the poles. The astrolabe is based on what is known as the planispheric projection. In a planispheric projection, a spherical object is projected onto a plane surface by placing the origin of the projection at one pole of the sphere and projecting the points of the sphere onto a plane surface placed through its equator. The astrolabe is based on what is known as the planispheric projection. In a planispheric projection, a spherical object is projected onto a plane surface by placing the origin of the projection at one pole of the sphere and projecting the points of the sphere onto a plane surface placed through its equator. , With its projection of the local sky. The top half of the plate contains the circular grid that is the projection of the local sky from the

horizon (the bottom most curve of the grid) to the zenith (the cross at the center of the smallest circle). Again, the outermost circumference of the plate is the projection of the Tropic of Capricorn, and its center marks the projection of the celestial pole. If you examine these projections, you will notice that in both cases the projection is oriented the same, with the north celestial pole projecting as a point in the exact center of the projection. This allows us to overlay the projections, the celestial sphere over the local sky, and pivot it on the celestial pole By rotating the rete the user can then display the local view of the sky for any combination of time and day of the year.

The Parts of the Astrolabe

The Mater

The Mater is the main fixed part of the astrolabe; all the other parts connect to it. Permanently fixed to it are the Throne and the Limb.

The Throne

The Throne is attached to the top of the mater, and provides a means of suspending the astrolabe to take sightings. In use, a ring or cord would be attached to the throne, allowing it to hang freely and so allow measuring angles from the horizon accurately. Depending on the time, place and use of the maker, the throne might be anything from a simple bulge, to an impressively ornate decoration almost as large as the rest of the astrolabe.

The Limb

The Limb is the raised ring section on the front of the mater; it encloses a space that contains the plates and the rete. It is commonly marked with the hours of the day and/or a degree scale. The Plates or Climates An astrolabe is a very precise instrument, but its accuracy is tied to a specific latitude because the projection of the visible sky change with the viewer âs latitude. In the example below we see plates (also known as climates) for latitude 20 degrees north, 45 degrees north and 65

degrees north; as you can see the projection on the plate changes radically. Here in these astrolabe plates are not prepared separatly but engraved a permanant plate for 11 degree latitude to use for the

maker. To make the device more flexible, astrolabes were commonly provided with a set of plates, each one for a different specific latitude. The set of plates are stored in the circular hollow formed

by the limb of the mater.

The Rete

The Rete is a cutout overlay that rests on top of the plates. It shows the projection of the celestial sphere. Unlike the plates, the rete is designed to turn freely.

The Rule

The Rule rests on top of the rete, and is designed to turn freely. It is used as a pointer during calculations and, depending on the origin of the astrolabe and the preference of the maker or owner, might be double or single ended; or not be present at all.

The Alidade

On the opposite side of the astrolabe from the rule is the alidade. This is a double-ended

The history of the astrolabes

The history of the Astrolabe begins in the Hellenistic World of Alexandria. From there it spreads north into the Byzantine world and east through the Islamic world and into India. Later, knowledge of the astrolabe traveled west across North Africa and into Mus lim Spain. In the Latin middle ages,

scholars from northern Europe traveled to Spain and returned with astrolabes and texts describing them. The history of the astrolabe is a history of technical, scientific knowledge embodied in instruments, texts, and practices. An Introduction to the Astrolabe introduces the reader to that history, tracing it from antiquity to modern day collections. The origins of the astrolabe remain uncertain. The earliest surviving instruments date from medieval Islam. However, Greek and Syriac texts testify to a long theoretical and practical development that extends back to the second century BCE. The underlying mathematical principle of stereographic projection was described by Hipparcus chus of Nicaea (fl. 150 BCE). Less than two centuries later, Vitruvius (died post 27 CE)

described a type of clock that depended on a similar stereographic projection. His suggestion that Eudoxus of Cnidos (ca. 408-355 B CE) or Apollonius of Perga (ca. 265-170 BCE) invented the rete or spider âthe network of stars âalmost certainly refers to the sundials he was discussing in the passage. Claudius Ptolemy (fl. 150 CE), the most famous astronomer from antiquity, wrote an extensive theoretical treatment of stereographic projection in his Plani sphaerium, which included a short discussion of a horoscopic instrument. Although he described an instrument that resembles an astrolabe, including both a rete and the stereographic projection of a coordinate system, Ptolemy âs instrument does not seem to have included the apparatus needed to make direct observations and thus to measure the altitude of the sun. As early as the fourth century authors began composing manuals on the astrolabe. Theon of Alexandria âs (fl. 375 CE) work âOn the Little Astrolabe â is the earliest text to treat the construction and use and of the astrolabe. It became a model both in form and content for later literature on the astrolabe. After Theon, treatises on the astrolabes became increasingly com mon. Synesius of Cyrene (ca. 370- 415 CE) wrote a short work on the astrolabe and mentions a silver planisphere that he sent to Paeonius in Constantinople. The Byzantine scholar Ammonius (died post 517 CE) reportedly wrote a treatise on the construction and use of the astrolabe. More importantly, Ammonius incorporated the astrolabe into his teaching, thereby introducing a number of people to the instrument. The oldest surviving treatise on the astrolabe comes from his most famous pupil, the mathematician and philosopher John Philopnus (ca. 490-574

CE). In 530 he wrote a work entitled âOn the use and construction of the astrolabe and the lines en graved on it. â Philoponus â text offers a practical description of the astrolabe and surveys its most common uses. In the middle of the seventh century, Severus Sebokht of Nisibis, Bishop of Kennesrin in Syria, wrote a description of the astrolabe in Syriac. Sebokht âs exposition conforms to the patterns established by Theon and completed by subsequent Authers. He eschewed theoretical discussions, concentrating instead on practical description and application. He greatly expanded the standard list of uses. Knowledge and production of the astrolabe spread from the Byzantine and Syro-Egyptian context east through the Syrian city of á¸¤arrÄn and into Persia.

FROM BYZANTIUM TO ISLAM

á¸¤arrÄn had been an important center of pre-Islamic translation activity. With the rise of the âAbbÄsid caliphs came a new interest in Greek science and technology, both of which played a key role in efforts to legitimate their rule. Al-Maná¹£Å«r (712- 775 CE, caliph from 754), the second âAbbÄsid caliph, supported the translation of Greek science into Arabic and promoted various sciences, especially astronomy and astrology. Increasingly he relied on court astrologers: on their

advice he selected 30 July 762 CE as the day to lay the foundations of Baghdad; he consulted with them when his relatives revolted; and they accompanied him on his pilgrimages to Mecca. In this context the astrolabe was a useful tool. Al-Maná¹£Å«r âs great grandson, al- Ma âmÅ«n (787-833 CE, caliph from 813) consolidated and extended this policy. In addition to their political uses, astrolabes had immediate religious applications. The close connection between astronomy and Islam provided an obvious incentive for developing the astrolabe. Finding the times of the five daily prayers as well as the direction of Mecca are both complicated astronomical and geodetic operations. Makers quickly perfected techniques that made it possible to determine through direct observation both the time of prayer and the direction of Mecca. Over the next few centuries Arab, Persian, and Jewish scholars produced numerous systematic treatises on the astrolabe. The earliest of these was written by Messahalla, a Jew from Basra, whose work dates from before 815 CE. The original Ara bic treatise has been lost, but numerous Latin translations of it survive. The oldest surviving Arabic treatises date from the early ninth century. Al-KwÄrizmÄ« (fl. 825 CE) wrote two short texts, one on

the construction and one on the use of the astrolabe. Other early texts by âAlÄ« ibn âÄªsÄ (fl. 830 CE) and Aá¸¥mad ibn Muá¸¥ammad ibn Katir al-FargÄnÄ« (fl. 857 CE) also survive. Along with his treatise on the astrolabe, âAlÄ« ibn âÄªsÄ made various astronomical observations in Baghdad and Damascus under the patronage of al-Ma âmÅ«n. In the early eleventh century al-BÄ«rÅ«nÄ« (973 â1048 CE), a Persian scholar, wrote his Book of Instruction in the Elements of the Art of Astrology, which included detailed descriptions of the construction, parts and uses of the astrolabe. During this same period, making astrolabes developed into a well respected profession. Arab crafts men developed their skills and tacit knowledge, creating family workshops that continued for a number of generations. Oldest surviving Astrolabe is from this periode was the intelectual efforts supported

by the early Islamic caliphs.

INTO INDIA AND CHINA

Traveling Persians scholars like al-BÄ«rÅ«nÄ« probably introduced the astrolabe to the Hindus quite early, and later scholars brought astrolabes to the court in Delhi. During the fourteenth century,

the Sultan FÄ«rÅ«z ShÄh Tughluq (1300-1388 CE, reigned from 1351) sponsored the manufacture of astrolabes. The first Sanskrit treatise on the astrolabe, entitled Yantraraja (âKing of astronomical instruments â), was written in 1370 by a Jaina monk, Mahendra SÅ«ri (1340-1410 CE). Mughal India adopted the instrument with great enthusiasm in the mid-sixteenth century. The new rulers relied heavily on astrology to regulate their affairs and considered the astrolabe a valuable astrological and political tool. Contemporary chronicles emphasize Emperor HumÄyÅ«n âs (1508-1556 CE, reigned from 1530-40 and 1555-6) interest in astrolabes. Under HumÄyÅ«n âs patronage, Lahore, in present-day Pakistan, became the center of production of Indo-Persian astrolabes. One family came to dominate the manufacture of astrolabes in Lahore, producing more than 100 astrolabes over the next century. The most prolific and famous member of this family was á¸iyÄ â al-DÄ«n Muá¸¥ammad (fl. 1645-1680 CE), who produced more than 30 astrolabes between 1645 and 1680 CE. Much later, Jaipur, in northern India, developed into an important city for the production of Indian astrolabes. Jaipur âs rise to prominence corresponds to the Maharajah Sawai Jai Singh II âs (1686- 1743 CE) efforts to build the great observatories in the city. Jai Singh had also written a book on the construction of the astrolabe and founded a center for their manufacture. Indian instruments from

Jaipur are often notable for their size and by the fact that they have a single plate engraved for the 27Â°, the latitude of Jaipur. By the thirteenth century knowledge of the astrolabe had reached China. In 1267 Jamal al-Din brought Kublai Khan models of various astronomical instruments that were in use at the observatory in Maraghah. Marco Polo claimed to have seen astrolabes in Beijing and within a century, The Travels of Sir John Mandeville describe astrolabes at Kublai Khan âs court. Despite these reports, which are themselves problematic, the astrolabe does not seem to have been as popular in Chinese culture as it was elsewhere.

BYZANTIUM AND NORTH AFRICA

Numerous treatises testify to the importance of the astrolabe in the Byzantine Empire. Greek scholars profited from having uninterrupted access to the earliest treatises on astrolabes and composed numerous manuals on the astrolabe. A long tradition of texts extend from Philoponus â treatise in the early sixth century to Isaac Argyros âs (1300-ca. 1370 CE) treatise in the late fourteenth. Byzantine interest in astrolabes increased markedly in the late twelfth century during Emperor Manuel Komnenos reign. Komnenos was an avid proponent of astrology and related astronomical activities. The Byzantine scholar Johannes Kamateros dedicated a poem to the emperor in which he described the astrolabe and explained some of its uses. In the fourteenth century, astronomical knowledge and the role of the astrolabe in producing that knowledge assumed a still larger role in Byzantine society. Nikephoros Gregoras (ca. 1292- 1360 CE) used his treatise on the origins and construction of the astrolabe to establish his expertise at the imperial court. He also set up a school and attracted a number of students. His most famous pupil was Issac Argyros, who also composed a text on the astrolabe. These Byzantine manuals, especially Gregoras âs, played an important role in later European texts of the sixteenth and seventeenth centuries. Surprisingly, only one complete Byzantine astrolabe, dated 1062, has been identified. The lack of surviving instruments presents something of a puzzle. It is possible that Byzantine craftsmen used cheaper, less durable materials to construct their astrolabes, perhaps a soft metal or wood and some

sort of paper. In that case, the astrolabes would have worn out through use. By the tenth century, astrolabe production spread west across North Africa and into Muslim Spain. In direct contrast to the history of the astrolabe in Byzantium, its history in North Africa is characterized by a wealth of instruments and dearth of texts. North African, or Maghribi, astrolabes share conservative stylistic

features that set them apart from the eastern Is lamic instruments. They also reveal a closer connection to Christian Europe, most notably in the presence of the Christian calendar frequently found on the back of theseinstru ments. Although astrolabes were produced and used across North Africa, the tradition was strongest in Morocco, where they were manufactured and used for more than 500 years. By the early fourteenth century, sophisticated universal astrolabes were being produced in the Moroccan city of Taza. Meknes became Along with Taza, cities like Marrakesh, Fez and associated with both the manufacture and use of astrolabes. Muá¸¥ammad ibn Aá¸¥mad al-Baá¹á¹uá¹Ä«, one of the most prolific makers from North Africa, was still producing astrolabes in Morocco as late as the eighteenth century.

HOW TO USE AN ASTROLABE ?

Omer Abdul R ahiman Al Sufi, a medival mathematician and astronomer explained about 1000 mathematical and astronomical problems using an Astrolabe. Important of them are some calculations in trigonometry, spherical geometry and astronomy. Rising and seting of the Sun varies from place to place on Earth and this can be calculated for any day of the year using an Astrolabe. The plate is marked with almucantars (lines of altitude) and lines of azimuth (direction). - The almucantars are 30 degrees apart and 0 (horizon) to 90 deg are marked.(in this astrolabe) - Where

the lines cross in the center of the 90 deg almucantar marks the zenith (the point directly overhead) The lines of azimuth (direction) are also marked every 30 degrees The line below the horizon line is

the almucantar marking the end of twilight. The vertical line through the zenith is the Meridian. It marks a line passing overhead that runs North-South. The Sun crossing the meridian marks local

noon/midnight. The time scale on the mater limb is marked in degrees, each mark is 30 minutes, and the hours are marked in degrees . From the horizontal lines 1 to 90 degrees are marked in Arabic ABJD notations from both sides. How to find the Sunrise and Sunset

for a given day. Let the day be 21 st of July Find the equalant day of zodiac calendar using the calendar scale and alidada of back side of Astrolabe. (in the Arabic Astrolabes time scale is marked with degrees and ABJD notation of the Arabic alphabets.) A degree can be converted in to minuts by multiplying with 4. See the date is 29 of Cancer in the zodiac scale. Put the rule on 29 of Cancer in the ecliptic of the Rete of Astrolabe. Rotate the rete alongwith the rule till the point align with the

horizon of Almuqandar on the left side. Read the time on time scale and find it is 6.12 am. To find Sunset time of July 21 rotate the rete and rule to the right side of the west horizon of Almuqantar and read the time on time scale and find it is 5.48 pm. How to find local coordinate of a given celestial body for a given date and time? Let the star be Altir (Alpha aquilae) and the date and time be 15 August 9 pm. Find the zodiac date equalant to 15 August using calendar scales and Alidade in the back side of Astrolabe. See it is 23 of Leo in zodiac calendar scale. Find the time 9 pm in time scale and rotate rule and rete together till it align with 9 pm marking. Find Altair star in the rete and read it's positions of altitude and azimuth. See it is Altitude 45 degree and Azimuth 310 degrees.