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Celestial Globes Armillary Spheres

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CELESTIAL GLOBES ARMILLARY SPHERES

This short report is on the subject of celestial globes, and in particular the work of Emilie Savage-Smith; who performed an extensive study on Islamicate[1] Celestial Globes, their history, use and construction. This article is based on her book. Some additional material is added on astrolabes and armillary spheres.

Introduction

From early antiquity, many great civilisations, such as the Greek, Islamic, and Chinese, have attempted to model the earth's movements along with its visible stars and other celestial bodies.
These models were done in the form of:

1. Celestial Globes.
2. Astrolabes: [(a)] Planispheric and [(b)] Spherical
3. Armillary Spheres: [(a)] Demonstrational and [(b)] Observational

They were all based on an imaginary model where the earth is in the centre, and an outer sphere of stars and celestial bodies move around the earth *(fig1)*. This suggests that observers of the above devices would view the sphere of stars from the outside, and imagine the earth to be in the centre[2]. These models were built using the vast knowledge of astronomy and planetary movement passed down from antiquity. The models provided a very good way of representing the very complicated movement of bodies.

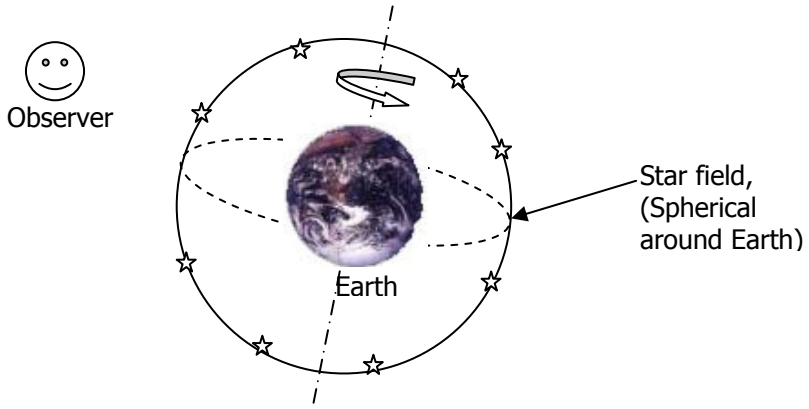

Figure 1 - Model with Surrounded by Stars and Celestial Bodies

A physical model was not necessarily 3-dimensional or spherical, flat models were also built, as was with the case with the planispheric astrolabe. With this particular model, a 3D chart was projected on to a 2D plane, so users could obtain astronomical information with astrolabes that were more portable, and possibly more practical.

[1] The author uses Islamicate to refer to objects or cultural features that are not related directly to the religion of Islam but are often based on traditions taken over from other cultures and nurtured and developed by Muslims and non-Muslims alike. Islamic, however, refers to subjects directly related to, growing out of, or affected by the religion of Islam.
[2] Emilie Savage-Smith, p. 3.

Celestial Globes

History

According to Cicero, who reported the statements of the Roman astronomer Gaius Sulphius Gallus of the second century BC, the first globe was constructed by Thales of Miletus (sixth century BC). It is uncertain as to how celestial globes were used by great astronomers, but we do know they made great contributions and improvements to astronomy:[3]

1 - Eudoxus: Documented the early work on constellations and their movement

2 - Aratus of Soli (ca. 315-240BC): Using the work of Eudoxus, wrote an influential astronomical poem called 'Phaenomena' (Φαινομενα). It gave general workings on the:

a. positions of northern and southern constellations
b. circles of the celestial spheres
c. risings and settings of the fixed stars
d. weather phenomenon

3- Hipparchus: Compiled from his observations the precise rising and setting times of stars, but only from his position in Rhodes. He also discovered the precession of the equinoxes.

4 - Geminus of Rhodes: Realised that the 'Artic' and 'Antarctic' circles were dependant on the observers position on the earth.

5 - Archimedes: Described by Cicero as having constructed two celestial globes in the third century BC, a ringed globe and a solid globe. The ring globe is a more complicated tool, and possibly classed as an armillary sphere.

6 - Ptolemy of Alexandria (fl. CE 127-148): Also catalogued the stars, (3 centuries after Hipparchus), but in much more detail. He considered all the stars, including the northern stars that are always visible. Each star was designated a parameter for its brightness and coordinate.

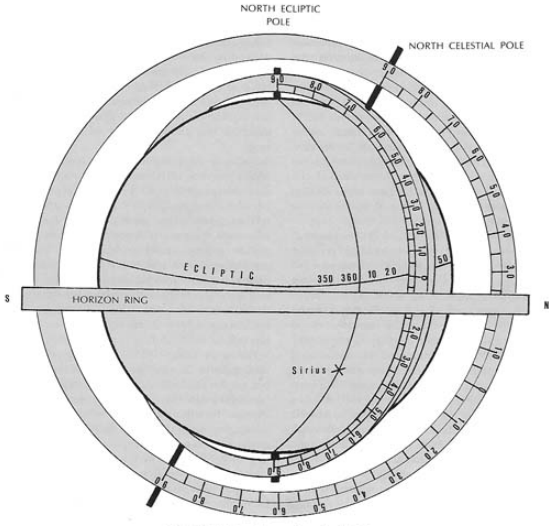

Figure 2 - Ptolemaic Precession Celestial Globe

[3] Emilie Savage-Smith, pg 3-12.

7 - Ptolemy: Used a horizon ring in order to make the celestial globe more universal (*fig 2*), as opposed to the previous globes that only considered the sky from Rhodes.

The above list is brief, but it gives an indication of the type of knowledge that was all potentially passed over to the Islamic world. The above works were not translated until around the ninth century CE, and most influential was the work done by Ptolemy in his 'Almagest'[4].

Islamic Astronomers

After the translations, astronomers in the Islamic world contributed to the accuracy of the information by adding other stars and their coordinates, and also through better predictions of celestial and star movements.

Figure 3 - Al-Battani's Globe Design
1 – Horizon Ring, 2 – Zenith Ring, 3 – Moveable Meridian Ring, 4 – Stationary Meridian Ring, 5 – Outside ring supporting Gnomon.

There were works from an astronomer called Al-Battānī, who wrote a comprehensive astronomical treatise that included star catalogues and planetary tables[5]. Also described in the book, is a celestial globe that is suspended from 5 rings that he calls Al-Baydah (the egg)[6]. The treatise is quite influential as it gives details of how stars should be marked onto the globe. Instrument makers around that time could then form a globe to a particular standard.

[4] Emilie Savage-Smith, pg 18
[5] It is known that Copernicus had relied heavily on this work , see this website.
[6] Emilie Savage-Smith, pg 18

Al-Battānī's treatise is very different to the pre-Ptolemiac design of a celestial globe, which uses 5 parallel equatorial rings and constellation outlines. Instead, Al-Battānī had a more precise method of charting the stars using the ecliptic and equator, and dividing them in to small divisions (*fig.3*). This method then allowed the stars to be given exact coordinates, and thus increased precision[7].

The Muslims were great tool and instrument makers. A name attributed to making celestial globes, was an astrolabe maker called, Abd al-Rahmān al-Sufi (AD 903-986)[8]. He wrote a treatise on the design of constellation images for celestial globe makers, his other treatises were based on how to use celestial globes[9].

Many globes were constructed up to the point of the sixteenth century, and many still exist today, but none prior to the eleventh century have survived[10].

Figure 4 - German stamp celebrating the arrival of an Arabic Globe Europe (1279)

Usage of Globes

Before describing how the globes work, one must understand the terminology used:

Celestial Equator	an imaginary ring around the globe that is equidistant from its poles.
Celestial Poles	points furthest away from the equator, above and below.
Ecliptic	the path of the sun around the earth

[7] Emilie Savage-Smith, pg 20
[8] Emilie Savage-Smith, pg 22
[9] Emilie Savage-Smith, pg 23
[10] Emilie Savage-Smith, pg 24

Ecliptic Poles	points furthest away from the ecliptic, above and below.
Culmination	the highest point of a body, i.e., the sun during the summer solstice.
Equinox	a time when the day and night hours are equal, or where the ecliptic path crosses the celestial equator. This occurs twice in a year, spring (vernal), and in winter.

Celestial Spheres

They were used to give observers a representation of the sky, dependent on the observer's location and time of day (position of the sun). This then enabled astronomers to use a consistent coordinate system and to solve problems involving stars and other heavenly bodies.

The positions of celestial bodies were given in relation to the equator or the ecliptic with a differenct coordinate system for both. The equatorial coordinate uses right-ascension and declination. Right ascension is the angular distance from the spring/vernal equinox, and declination is the distance north or south from the equator along a path that passes through the point in question and the two celestial poles.

Figure 5 - Celestial Sphere

The ecliptic coordinate system uses celestial longitude and latitude. Whereby longitude is the angular distance from the ecliptic and also from the vernal equinox, and lattitude is the distance north or south of the ecliptic. (ref.1)

This enabled astronmers to follow stars, see when the sun was about to rise or set and find the position of the earth by viewing the night sky, possibly using the north star.

Astrolabes

Using stereography, celestial spheres were able to be projected on to a 2D plane and form the important body of an astrolabe. They were based on the ecliptic, and divided into 12 portions, and each portion was given a sign of the zodiac.

The astrolabe has many applications, such as working out heights of inaccessible objects, time of day and its position on earth. This is all done by the use of clever tables and figures that are imprinted on both

sides of an astrolabe. The details of how this is achieved will not be explained here, but it is important to note that charting the stars and the sun's movement across the sky can have so many applications. (ref.2)

Figure 6 - Astrolabe Recently Manufactured by Dr. Hasan Al-Bilani, Aleppo, Syria.

Armillary Spheres

These used rings to represent the circles of the celestial body, i.e. the equator and ecliptic. They did not chart the stars, but were more concerned with planetary movement and position. They were not made with a solid sphere, but with several concentric rings connected in such a way to mimic the rotation of the earth and its surrounding bodies. (ref.3)

The observational sphere is more a tool for astronomers to determine coordinates and other values, while the demonstrational sphere appears to just give the relative motion of bodies about earth.

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