An ace observer

The Danish astronomer, Tycho Brahe, was one of the finest observers of his time. His work provided the basis for modern celestial mechanics. By Anthony Kinder.

It has been claimed, and with some justification, that Tycho Brahe was the last of the great naked-eye observers of the pre-telescopic era. Paradoxically he was to play a significant role in the overthrow of the Ptolemaic-Aristotleian cosmology which was to be replaced by that devised by Copernicus. The paradox exists because, although he knew of the Copernican system, he did not support it, and in fact was to devise a system of his own.

Tycho Brahe 1546-1601. Picture courtesy Dee Levers.

Early days

Brahe was born on December 14, 1546 in Skåno, now in Sweden but then a part of Denmark. He came from a family who were members of the Danish nobility, and who had played a significant role in Danish political life.

Raised by his paternal uncle, Jörgen Brahe, Tycho was educated privately before entering the university of Copenhagen in 1559. There he studied the traditional curriculum of the Trivium (grammar, logic and rhetoric) as well as Greek; because of his noble birth he did not need to receive his first degree before proceeding on to study the higher subjects of the Quadrivium (astronomy, arithmetic, geometry and music).

It was while a student at Copenhagen he made an observation of a solar eclipse which may well have stimulated an interest in astronomy.

Despite being sent to Leipzig University to study law (1562), he continued to develop his interest in astronomy in secret. It was while observing a conjunction of the planets Saturn and Jupiter in the following year that he noticed major discrepancies between the computed times of the positions of the two planets given by the *Prutenic Tables* and the much older *Alphonsine Tables*. It is said that he saw this as a turning point in his life, as he saw a need to re-determine the positions of the stars and planets in order to compile a new catalogue. Before he was able to achieve this he engaged in further travel and study.

Over the following years he went back to Copenhagen (1565), then on to Wittenberg and Rostock (1566). It was in this year that occurred the first of a series of events which will always be connected with his name, namely a duel with another Danish nobleman which resulted in him loosing part of his nose. He had the missing part replaced with a compound of gold, silver and probably copper.

Despite the disruptions caused by all this, he continued his astronomical observations and by the time he moved to Augsburg he was also making his own instruments.

A new star

The second event associated with his name, and the one which was to start his rise from that of an ordinary competent astronomer to one of European stature was the observation of the 'new star' that appeared in the constellation Cassiopeia in 1572.

It was at sunset on November 11, 1572, that he noticed one of the stars in Cassiopeia was much brighter than the others. Using a sextant of his own construction, he made observations of this new star. Over the following months he was to find that there was not any discernible parallax (movement against the background stars), that it varied in colour and magnitude and as it did not show a tail, it could not be a comet.

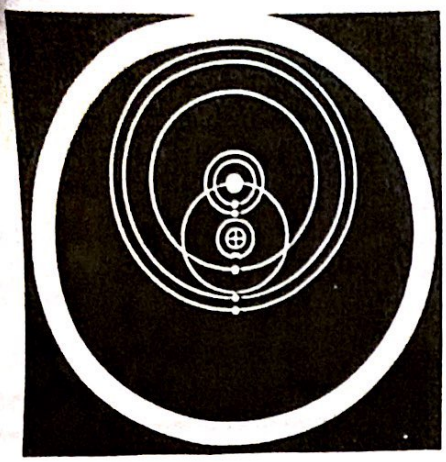
If the star was as close to the Earth as the Moon then it should show a discernible parallax. The fact that it did not, obviously indicated the opposite and it must therefore be situated amongst the stars themselves. According to Aristotelian cosmology this could not be possible as the orbs of the planets and stars were perfect and could not be subject to corruption as was the Earth.

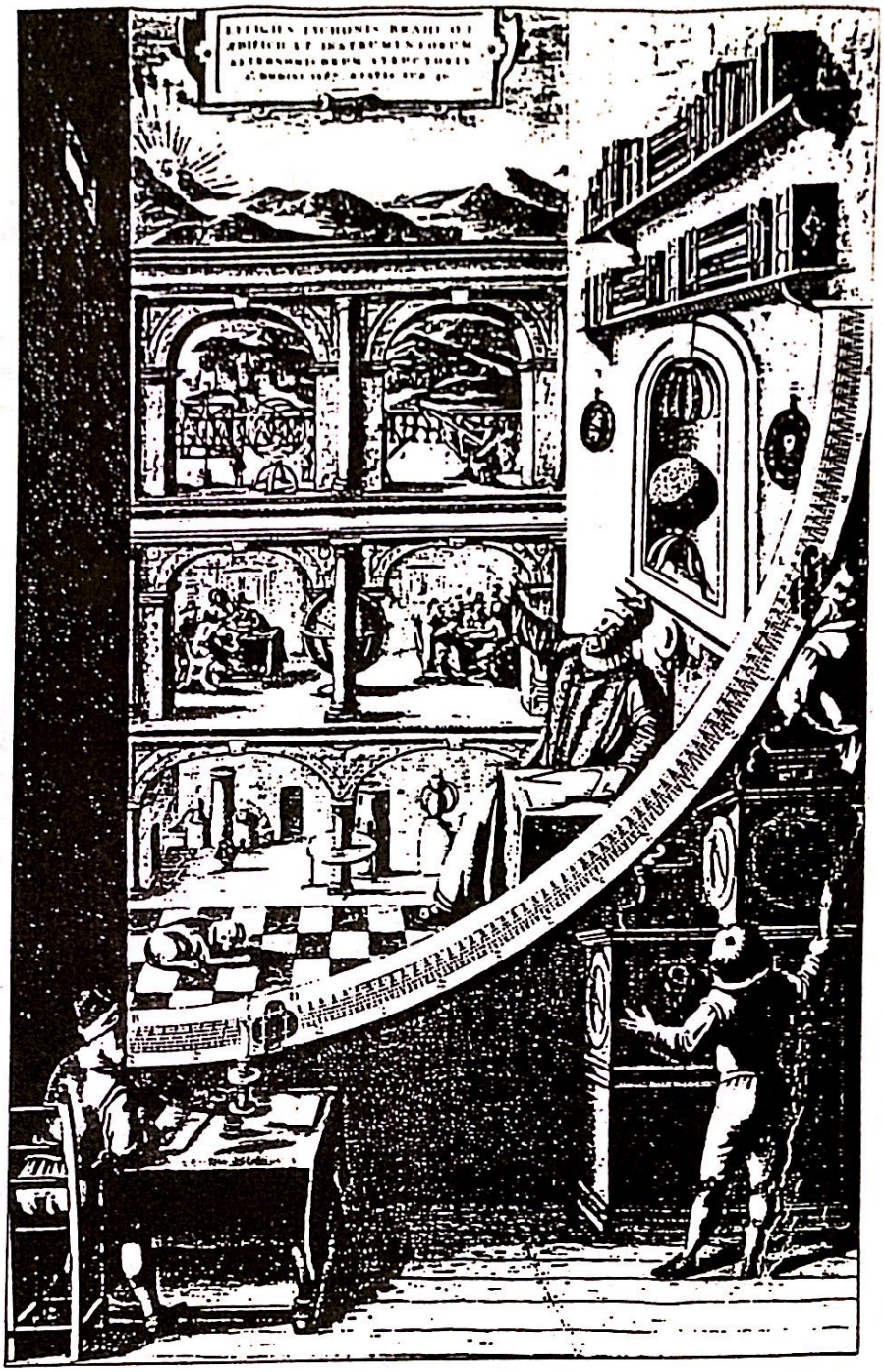
Tycho's observations and conclusions formed the subject of a tract *De Nova... Stella* (Copenhagen 1573) and later of a more in-depth work, the *Progymnasmata* (1602), and which made his name known to many European astronomers.

In 1575 he visited the Landgrave Wilhelm IV of Kessel, an amateur astronomer, and from there he journeyed to Frankfort am Main, Basel, Venice and Augsburg, before visiting Regensburg where he obtained a copy of the *Commentariolus* of Copernicus. By this time he wished to establish himself in a permanent location in order to establish an observatory.

The Danish king, Frederick II, offered him the island of Hven early in 1576, which was to lead to the development of the observatory of *Uraniborg* (castle of astronomy), and in 1584 a second one called *Stjerneborg* (castle of the stars), as well as a printing press, meteorological station and instrument work shop.

The observatories were equipped with instruments of Brahe's own design and making, as well as those made in Augsburg and elsewhere. With this he was to establish a centre of excellence for astronomy,





Tycho Brahe's planetary system (above) and (right) his mural quadrant at Uraniborg. Top graphic by Mark McLellan.

and the first major Danish school. Several of his assistants were themselves to become noted for their work, including Longomontanus, Sascerides, Blaeu and Wittich; and the observatory was part of the itinerary for visitors to Denmark, including James VI of Scotland (later James I of England).

The comet of 1577

The third main event of Brahe's life was to occur at Hven, with his observations of the comet of 1577. Although discovered by others earlier, the comet, as with the star of 1572, will always be connected with Brahe as, using his observations he showed that the comet could not have originated from the Earth or even the Moon (again as claimed by Aristotle), and that it must have originated from the sphere of the stars.

Using both the nova of 1572 and this comet, Brahe was to provide further nails for the coffin of Ptolemaic-Aristotleian cosmology. It was in his work on this comet *De Mundi Aetherei Recentionbus Phaenomenis* (1588) that he presented his own planetary system.

For religious and other reasons Brahe could not accept the system as proposed by Copernicus, and therefore devised a compromise. It was essentially a geo-heliocentric system, composing of two essential parts. The first is the Earth, at rest, in the centre of the Universe with both the Moon and the Sun circling about it. The other planets were in orbit about the Sun. Orbiting all of this was the sphere of the stars. Although it did have a large number of supporters, it never really became accepted, and from about the 1650s it was obsolete.

Tycho's observatories continued to be used in the quest for more precise determinations of the positions of stars and planets. From the observations made, Brahe was able to produce more accurate data for astronomers, data which were to prove central to the work of Kepler and the determination of the three laws of planetary motion and also to the discovery of various anomalies in the orbit of the Moon.

In the latter part of his life, Tycho Brahe suffered a number of personal set backs, the most serious one of which resulted from the death of his patron, Frederick II. A deterioration in his relationship with various members of court (already very low) and the lack of enthusiasm for astronomy by the new king Christian IV, plus major problems on the island of Hven due to his not meeting the obligations of a landlord, led to him moving first to Copenhagen, and then to Hamburg.

In 1598, with the hope of securing patronage, Brahe dedicated his *Astronomiae Instauratae Mechanica* (a description of his observatory, equipment and methods of observation at Hven) and a star catalogue to the Emperor Rudolph II. His ploy was successful which resulted in him moving to Prague in 1599.

Although he was not to make any further major contributions to astronomy, and managed to only have a few of his instruments erected, Brahe did manage to gather some disciples around him, including Fabrucius, Johannes Müller and, most importantly, Johannes Kepler.

Brahe died in Prague on October 24, 1601. Unfortunately for historians his instruments were dispersed or lost. However his papers were largely saved, and after a long dispute with his heirs, Kepler was able to use them to compile the *Rudolphine Tables*, the most accurate then known. Brahe's observations provided the necessary data to enable Kepler to devise the laws of planetary motion which form the basis of modern celestial mechanics.

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