

Biographical Encyclopedia of Astronomers

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Brahe, Tycho [Tyge] Ottesen

Born Knudstrup, Scania, (Sweden), 14 December 1546

Died Prague, (Czech Republic), 24 October 1601

Author of the Tychonic system, the great observer Tycho Brahe was raised as the only child of his father's brother Jørgen Brahe, who had decided that Tycho should have a law education. The fields of astronomy and chemistry were not considered suitable backgrounds for the life of a nobleman. Twelve-year-old Brahe went to the University of Copenhagen and began a period of study and travel that was to last for the next twelve years. He possibly observed that a solar eclipse event predicted for 1560 actually took place at the predicted time. This may have led him to begin studying astronomy on his own

In 1562, Brahe traveled to the University of Leipzig, where he added the study of astronomy to his study of law and bought astronomy books and instruments. He studied with a critical eye and soon saw that only direct observation of the sky could resolve the contradictory ideas in all the books he had read. In 1563, Saturn and Jupiter were in a position close to each other, and Brahe found that the ancient Alphonsine tables gave the date with an error of one entire month, whereas the new Prutenic method, calculated according to the theories of Nicolaus Copernicus, had an error of only a few days. Subsequently, Brahe devoted his life to a renovation of astronomy based on more reliable observations. His first instrument, an approximately 3-foot-long Jacob's staff, was not perfect, but, regardless, he calculated a correction table so that the results were usable

In 1565, Brahe embarked on his second study trip, to Wittenberg and Rostock, Germany. It was here that during a dueling match he lost part of his nose; ever afterward, he had to wear a prosthesis. Brahe now openly studied alchemy and astrology in addition to routinely making astronomical observations. In 1568, he enrolled at the University of Basel with the intention of settling in the city or its vicinity at a later date. Now at the age of 22, Brahe had acquired all the knowledge of chemistry and astronomy of his time. He spent most of 1569 and 1570 in Augsburg, Germany, as an astronomy assistant to the mayor. Brahe was in charge of constructing a quadrant with a radius of 19 feet, intended to be capable of measuring every arc minute. However, his experience was that an instrument that was so heavy and clumsy could not yield the expected measuring accuracy

Brahe also constructed the shell of a wooden sphere with a diameter of 5 ft. Ten years later he had ensured that this globe retained its rounded form and was marked with poles and divided into circles for reading and recalculating celestial coordinates. After another 15 years of work, Brahe had the surface accurately marked with definite positions for 1,000 fixed stars, and this celestial globe stood as an impressive monument to his life's work. The globe traveled with Brahe to Bohemia and was later brought home to Denmark, as a war treasure, to the Round Tower (in Copenhagen) where it burned in 1728

After his father's death in 1571, Brahe moved into Steen Bille's home on the Herrevad estate (in Denmark) and devoted himself more heavily to the study of alchemy. But on November 11, 1572, in the constellation Cassiopeia, he spotted a great wonder: a new star that we know today as a supernova. Brahe measured the star's (SN B Cas) distance from the so-called fixed stars in its vicinity and recorded how its brightness gradually diminished. He proved that the star was

situated farther from the Earth and the Moon than could be explained away as an atmospheric phenomenon; rather, it must belong among the fixed stars. But this meant that the star would have appeared (in an Aristotelian view of the sky) in the region of imchangeability. That prevailing thesis had to be refuted in light of what this 26-year-old, well-educated astronomer had seen in the sky

Brahe's first book, *De Nova Stella*, was published in 1573. Only after his death was Brahe's comprehensive astronomical work about the new star, *Astronomiae Instauratae Progymnasmata*, published in three volumes. The first volume included Brahe's new theories about the Sun and the Moon, as well as his revised star catalog. The second volume was about the new star, and the third volume was a critical review of the works of others about the new star.

With the publication of *De Nova Stella*, Brahe's position as an astronomer had been firmly established within the learned society of Europe. The problem now was finding a suitable way of life for this nobleman researcher. In the fall of 1574, he lectured in Copenhagen about the movements of the celestial bodies according to Copernicus' theories, but related them to a stationary Earth. In this way, Brahe avoided an open conflict between traditional cosmology and Copernican astronomy

For most of 1575, Brahe was traveling and preparing for his emigration to Basel. First, he visited Landgrave William IV of Hesse in Kassel, who was himself an astronomer. They embarked on a friendship that can be traced in many letters containing astronomical themes. In 1596, Brahe published his correspondence with colleagues from Kassel as the first, and only, volume of his *Epistolae Astronomicae*.

King Frederick II of Denmark offered Brahe the island of Hven, situated between Scania and Zealand, and, in addition, the means for the construction of a suitable residence and observatory. Brahe agreed to the king's wishes, being attracted to the idea of a secluded island that would be a haven free from the disturbance of visitors. On 8 August 1576, the cornerstone was laid for Uraniborg, built in Gothic Renaissance style. So from the date of his 30th birthday on 14 December 1576, Brahe could engage in routine observations and began 20 years of happy work. Uraniborg was not finished until 1580, by which time it was equipped with a laboratory basement, residence, library, and observatory. In 1584, Brahe had Stjerneborg (a sort of star castle) built, with five cupolas over corresponding vaults where the larger instruments would have a permanent place protected from the wind. The island of Hven became the home of an exemplary research institution where Brahe developed instruments, carried out a vast number of observations and calculation programs, and finished his work in the form of scientific publications.

At Hven, everything was in a class of its own, including the expenses. Apart from the island being free of charge for his lifetime, a separate building subsidy, and an annual cash payment, Brahe could also enjoy the income from several personal endowments. His activities cost the crown between 1% and 2% of its total annual revenue. In return, Brahe delivered an annual almanac to the king and, in addition, he constructed horoscopes, issued prescriptions, and prepared medications. The endowments came with some obligations from which Brahe tried to withdraw, but for a long time, most of the resulting conflicts found a reasonable solution. However, when Christian IV succeeded his father in 1596, Brahe wished to save on research grants. He misjudged the importance of his scientific reputation compared to the grudges his arrogance had caused. In April 1597, he left Hven to take up residence first in Copenhagen, then in Rostock, and finally, from October 1597, at Wandsborg Castle near Hamburg. His

attempts to have his former privileges reinstated were in vain, as Christian IV wanted to set his own terms for his mathematician.

Early in 1598, Brahe printed a small edition of his *Astronomiae Instauratae Mechanica* with pictures and descriptions of his most important instruments, as well as a short survey of the theoretical results of his work. Moreover, his star catalog from *Progymnasmata* was expanded and copied in several copies under the title *Stellarum Inerrantium Restitution*. These two publications were sent to several colleagues and princes. After an invitation from Emperor Rudolph II, Brahe traveled to Prague, arriving in June of 1599. It was not until late 1600 that he succeeded in having all of his instruments moved to join him. Frequent relocations and economic problems hindered a sensible work schedule. It was a disappointment to Brahe that the institution from Hven did not take root in Bohemia. However, this move became very important in the history of astronomy, because it was in Prague that Brahe gained the assistance of Johannes Kepler, who was to be his scientific heir

Brahe had developed instruments of various types, including the sextant for measuring visual angles in random planes, quadrants for altitude measurement, and armillary spheres erected for measuring coordinates in relation to the ecliptic or the celestial equator. He constructed new and more accurate sights, and he equipped

his measuring areas with transverse lines for more precise readings than previously available. After 10 years at Hven, Brahe was satisfied with his instruments, whose resolving accuracy had been increased to about 1 arcminute. Brahe was already dead when Galileo Galilei first directed telescopes toward the heavens, and yet another two generations were to pass before telescopes were equipped with the crosshairs and micrometers that could match Brahe's naked-eye instruments

Brahe had found it necessary to take into consideration the previously unrecognized effects of atmospheric refraction. He investigated these and then constructed tables of their influence. Only one astronomical parameter, the all-too-large solar parallax of 3 arcminutes, did Brahe adopt from his predecessors. This is the reason his refraction tables are not correct. Even so, in his day and age they represented progress

Brahe observed more frequently and routinely than any other early astronomer. His results were collected and easily accessible for later developments. Among the theoretical results was his star catalog, the first real improvement in this area since ancient times. Brahe found it necessary to revise the theories of wandering stars by pinpointing more accurate positions of the fixed reference points. He calculated better solar tables, and his theory of the Moon's movement included descriptions of four previously unobserved irregularities, which he partly derived using the hypothetical-deductive method. Brahe did not manage to develop complete planetary theories, but he was the first to know that the nodal line of each planetary orbit moves with its own rate of slow rotation

Brahe observed seven comets and wrote his main astronomical work, *De Mundi Aetherei Recentioribus Phaenomenis*, about the first and largest of these. This was printed at Hven in 1588. He proved that comets move among the planets much farther away than the Moon, and thus were no more mere atmospheric phenomena than the new supernova. This enabled him to strike a further blow against Aristotelian cosmology, disproving the existence of hard, impenetrable planetary spheres.

In describing the structure of the Universe, Brahe had only a few dubious observations to build upon. Before 1588, he still considered the possibility of proving the view of Copernicus, and he was reluctant to bring arguments against the idea of a moving Earth. Yet, this idea appeared

unreasonable to him. It conflicted with several Biblical passages, and the thought of the Universe having a wide empty space of no use between the outer planet of Saturn and the fixed stars seemed absurd. Therefore, Brahe formulated his own compromise: The Sun and Moon circle around the unmoving Earth at the center of the Universe, and the five other planets circle around the Sun as a second but movable center. Brahe had worked on this Tychonic System since 1578 and published it in his work on comets. Oddly enough, he subsequently used arguments against the Earth's movement, copied from the Aristotelian philosophy that his own work had helped to break down. Nevertheless, Brahe could not be an orthodox believer in Aristotelian philosophy; he preferred Pythagorean and Platonic arguments about harmony and symmetry connected with religious and astrological considerations. According to this line of thought, all movements in the sky should be described by circular components of motion. Brahe adhered to this principle and did not live to see Kepler's theory of elliptical planetary orbits incorporated into the Copernican Universe.

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Selected References

Christianson, John Robert (2000). *On Tycho's Island: Tycho Brahe and His Assistants, 1570–1601*. Cambridge: Cambridge University Press.

Christianson, John Robert et al. (eds.) (2002). Tycho Brahe and Prague: Crossroads of European Science. *Acta Historica Astronomiae*, Vol. 16. Frankfurt am Main: Deutsch.

Dreyer, J. L. E. (1963). *Tycho Brahe: A Picture of Scientific Life and Work in the Sixteenth Century*. New York: Dover.

(ed.) (1913–1929). *Tychonis Brahe Dani opera omnia*. 15 Vols. Copenhagen.

Gade, John Allyne (1947). *The Life and Times of Tycho Brahe*. New York: Greenwood

Gingerich, Owen and James R. Voelkel (1998). "Tycho Brahe's Copernican Campaign." *Journal for the History of Astronomy* 29: 1-34.

Hellman, C. Doris (1975). "Kepler and Tycho Brahe." *Vistas in Astronomy* 18: 223-230.

Mosley, Adam, Nicholas Jardine and Karin Tybjerg (2003). "Epistolary Culture, Editorial Practices, and the Propriety of Tycho's Astronomical Letters." *Journal for the History of Astronomy* 34: 421-451.

Rosen, Edward (1986). *Three Imperial Mathematicians: Kepler Trapped between Tycho Brahe and Ursus*. New York: Abaris Books.

Thoren, Victor E. (1990). *The Lord of Uraniborg: A Biography of Tycho Brahe*. Cambridge: Cambridge University Press

Thyker, Claus (1992). "Tycho Brahe's Empiric Methods, His Instruments, His Sudden Escape from Denmark, and a New Theory about His Death." *Meteoritics* 27: 297. (Paper abstract.)

Vinter Hansen, Julie M. (1946). "Tycho Brahe Statue on Hven." *Publications of the Astronomical Society of the Pacific* 58: 351.

Wesley, Walter G. (1979). "Tycho Brahe's Solar Observations." *Journal for the History of Astronomy* 10: 96-101.

West, Richard M. (1997). "Tycho and his Observatory as Sources of Inspiration to Modern Astronomy." In *Optical Telescopes of Today and Tomorrow*, edited by Arne L. Ardeberg, pp. 774-783. Bellingham, Washington: Society of Photo-optical Instrumental Engineers.