Biographical Encyclopedia of Astronomers

Huygens, Christiaan

Born The Hague, the Netherlands, 14 April 1629

Died The Hague, the Netherlands, 8 July 1695

Christiaan Huygens correctly interpreted the nature of Saturn's rings and made significant contributions to mathematics and to telescope and clock design. Huygens was the second son of Constantijn Huygens and Suzanne van Baerle. His father was the highest-ranking Dutch civil servant, secretary of state to several stadholders. Interested in arts and sciences, he was a patron of René Descartes. Christiaan, educated by private governors and tutors, enrolled in law and mathematics at Leiden University in 1646. He became an enthusiastic student of Frans van Schooten, Jr., who had just published the works of François Viète and was then editing an annotated Latin translation of Descartes's *La Géométrie* for publication. Both works were crucial for the new analytical geometry. Van Schooten and Huygens became friends; later Huygens contributed a paper on probability theory to Van Schooten's *Exercitationes mathematicae* (1657). In 1649, Huygens returned home and, after briefly considering a diplomatic career, chose science and mathematics. In the 1650s, his skills in both grew steadily and were noticed by the international community, particularly in Paris. Having met Robert Boyle and the Gresham College circle in London, Huygens was nominated, in the autumn of 1663, as a Fellow of the Royal Society

Huygens made several trips to Paris, and the news that Jean-Baptiste Colbert was organizing an academy of science, financially supported by Louis XIV, brought hope for a paid scientific career.

Constantijn promoted Christiaan's career in France. Christiaan was invited to compose the draft of a foundational text that could define the goals and rules of the new institution. In 1666, Christiaan was among the first nominated members of the Académie royale des sciences and moved to Paris. There, in 1676, he met Gottfried Leibniz, who asked his advice on mathematics; within a decade, Leibniz would become a leading mathematician

Huygens remained in Paris until 1681, when he retired to The Hague for health reasons. (On the death of Colbert, in September 1683, Huygens's presence in Paris would no longer have been appreciated: The revocation of the Edict of Nantes in 1685 by Louis XIV made it impossible for Protestants to be nominated for important posts.) Until his death, Huygens lived and worked either in The

Hague or at the family's country estate at Voorburg, interspersed with trips abroad such as one to London in 1689 to meet with Isaac Newton, Fatio de Duillier, Edmond Halley, and Boyle

In the early 1650s, Huygens and his brother Constantijn started grinding lenses to construct Keplerian telescopes. Christiaan was well aware of the ratio of focal distances as the magnification factor and tried to grind ever-greater objectives. In March 1655, while trying out

one of his first telescopes, he began to observe Saturn, the most intriguing of all planets since Galileo Galilei's noticing its "ears" (ansae). His short work *De Saturni luna observatio nova* (1656) summarized his first discovery, the new satellite, and announced the solution to the riddle of Saturn's appearances

(Using the same eyepiece, he made two objectives such that the length of his tubes became either 377 cm or 722 cm. The magnification of the first was about 50 times, that of the second twice as much. It has been deduced that the eyepiece was adjustable in the tube. Huygens used a diaphragm just behind the objective in order to reduce aperture and chromatic aberration.)

On March 25, Huygens began his observations of Saturn, which was retrograding in Pisces at the time; its shape appeared to be almost spherical, the *ansae* being rather narrow. Huygens noticed two stars in its vicinity. Within a few days, he concluded that one of these was following the planet. This was the first satellite discovered since Galileo. Three years of observations from March 1655 yielded the sidereal and synodic periods. From the end of November 1655, the *ansae* became invisible, and the round phase remained, along with the dark equatorial band. The *ansae* reappeared in June 1656; by October, the entire Saturn had recovered almost the same form as before in November 1655. From February 19, 1656, onward, Huygens used the long telescope and now definitively noticed the elliptical form of the *ansae* and the dark band that connected them. On March 5, 1656, he was certain enough to summarize his conclusion

In his view, the ring would be a stable entity because of its symmetrical form and its position in Saturn's vortex. The ring was inclined to the ecliptic by about the same angle as our equator, so Saturn should manifest equinoxes, just like the Earth. He realized that the "ringless" appearance showed up when the Earth passed through the ring plane

At this time, Huygens studied the problem of accurate time measurement. Aware from Galileo of the isochronous nature of the pendulum, Huygens was the first, in 1657, to maintain the swing and transmit the sequence to the indicator plate of a clockwork. He developed the mathematics and the mechanical method for achieving perfect isochronicity. To correct for the day's inconsistency, he developed equation-of-time tables (1662). In 1673, Huygens summarized his research in *Horologium oscillatorium*. He later became aware of the spring balance (1675); in nautical practice, the rapid corrosion of the spring metal and its temperature dependence proved to be insurmountable obstacles

He invented the Huygens eyepiece, named for him in 1662, a compound lens consisting of two parallel plano-convex lenses with focal distances in a ratio of about 1:4. When mounted such that the focal point of the objective is within the focal reach of the outer ocular lens, sharp, hardly distorted images in an enlarged field of view result. In grinding ever-larger objectives up to one with a focal length of about 60 m, Huygens was held back by the dimensions of the tube. In the 1680s he tried a huge tubeless construction (an aerial telescope). Being too sensitive to wind, it was unsuccessful

In 1676, Ole Rømer worked out his proof for the finite velocity of light and the technique for measuring it by comparing the time intervals of eclipses of Io near Jupiter's opposition and conjunction. Jupiter's satellites had been studied in the hope that they might provide a measurement for longitude at sea. Huygens's pendulum clocks, with their increasing accuracy

over long periods, had arrived at the right time. The difference Rømer measured of 22 minutes over half a terrestrial year constituted the time for light to travel across the diameter of the Earth's orbit. Given the astronomical unit [AU] in terms of Willibrord Snel and Huygens's data of 1.54×10^{-5} km, Rømer calculated a value of 1.17×10^5 km/s for the velocity of light. This was the missing link in Huygens's theoretical considerations of light from 1665 onward. His mature thoughts appeared in his 1690 *Traité de la lumière*.

In 1687, Newton sent Huygens a copy of his *Principia*. Huygens was not convinced by Newton's plea for gravitation as an action at a distance that followed an inverse square law, but was impressed.

Huygens's last contribution concerned the relative distances of the fixed stars, all considered as suns of the same brightness as ours and having planets. This appeared posthumously in his *Kosmotheoros* (1698). The first book opens with a discussion of the plurality of worlds, an issue of interest thanks to Bernard de Fontenelle. Huygens's system is Copernican with Keplerian ellipses, which he defends on various grounds. Huygens then discusses the relative dimensions of the planets and the Sun. For Mercury, he used Johannes Hevel's value of 1/290th of the Sun's diameter Huygens argues that all planets are similar, and what holds true for Earth must necessarily hold true for all: solid, massive objects with flora and fauna, and also human-like inhabitants. Kepler's laws have been verified for the moons of Jupiter and Saturn. The thickness of Saturn's ring is estimated at 600 German miles (about 4,519 km). The inhabitants of the other planets will, of course, have the same view of the fixed stars. What may be said of our Moon applies equally to those of Jupiter and Saturn. If it is evident that there are mountains and valleys on our Moon, then there are on the others. However, there is in all probability neither water nor air on either our Moon or those of the outer planets. Indeed, the observed disk of the Moon, with its sharp boundary, does not allow for an atmosphere, so life is unlikely.

Recent determinations of the Earth's diameter (AU) by Giovanni Cassini and John Flamsteed, employing parallax measurements, are mentioned (10,000–11,000 Earth diameters), but Huygens's value was 12,000 given the uncertainty of parallax measurements. For the Earth's diameter, he adopted Jean Picard's 1671 value (1.27×10^{-6} km). Huygens then proposes a way to determine the distances between our Sun and the stars: Reduce the Sun's appearance until it is like that of Sirius. This may be achieved by reducing the aperture of the 12-ft. telescope with a very small pinhole of 0.19 mm, which works in the proportion of 1:182. A second reduction, 1:152, is brought about by placing a microscope's spherical lens in the pinhole Thus, when the Sun has about the same brightness as Sirius, so that Sirius is 182×152 times smaller than the Sun, its distance will be about $182 \times 152 = 27.664$ AU. The Universe is otherwise of undetermined dimensions, since the stellar magnitudes suggest ever-growing distances.

Huygens designed the first Copernican orrery using the method of continued fractions—that was executed by Johannes van Ceulen in 1682.

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