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History of Astronomy: 18th Century Astronomy

The Age of Discovery

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Conclusion

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Introduction

The eighteenth century was the century in which astronomy became a precision science. It opened with Newton's mechanics newly published and its consequences unexplored, and it closed with the sky mapped, timed, and counted to a standard no earlier century could have imagined: comets predicted and then kept their appointments, a new planet found by a musician with a homemade telescope, the sea found navigable by machines that carried the time of a distant observatory, and the stars measured to a fraction of a second of arc.

Between those bookends lies a cast worth naming now, because the century's work was done by people whose names still fill the sky's maps and tables: Edmond Halley, the astronomer who predicted his comet; James Bradley, the Astronomer Royal who found the sky's two great hidden motions; John Harrison, the carpenter's son whose clocks conquered the longitude; Nicolas-Louis de Lacaille, who charted the southern stars from the Cape; Charles Messier, who catalogued what not to look at; Caroline and William Herschel, the musician and his sister who swept the deep sky; Pierre-Simon Laplace, who completed the mathematics of the solar machine; and dozens of others, observers, computers, instrument makers, and expedition volunteers, whose combined patience is the real subject of this book.

Their era sits at a strange hinge in the history of work. The astronomer of 1700 was still likely a churchman or a court servant keeping the sky as a sideline; the astronomer of 1800 drew a salary, filed reports, answered correspondence, and belonged to a profession with examinations, prizes, and pension rights. In the same hundred years the sky's study crossed from the age of the lone genius to the age of the organized team, and both ways of doing science still exist in the discipline today, a fact that explains much about how astronomy works and why its history keeps returning to this century as the moment its modern form appeared.

The century's astronomers were a new professional species, salaried by governments and academies rather than patronized by princes, armed with mural quadrants, regulated clocks, and refractors and reflectors of steadily improving quality. They turned astronomy from a science of positions into a science of motions, extending Newton's law of gravitation from the Earth-Moon system outward through the whole solar machine, testing it against Jupiter, Saturn, the Moon's stubborn wobble, and finally the comets themselves, and finding it correct at every encounter.

That transformation had a name in the century's own vocabulary: the

astronomy of the heavens was being joined by the astronomy of the solar system, position-taking by motion-explaining, and the practitioners increasingly sorted into observers, calculators, and instrument makers whose crafts interlocked, the observer feeding the calculator, the calculator specifying the observer's next campaign, the instrument maker enabling both. The division of labor, more than any single discovery, is what made the century's pace possible, and the modern observatory's staff table, scientists, engineers, data specialists, is the same arrangement at modern scale.

The century's observing life had a rhythm that would be familiar to any modern run-of-the-mill scientist: a program set years ahead, instruments maintained by day, observations logged by night, reductions and correspondence filling the daylight hours, and publication in the academy's memoirs, the observatory's folios, or, for the amateurs, the letters and journals that were the era's preprint servers. Astronomy's prestige meant its paperwork was well kept, which is why the century's ledgers survive in such abundance that modern researchers still mine them for variable stars, comets, and the sky's slow changes, making the eighteenth century one of the few eras whose nightly observations remain in scientific use three hundred years on.

It was also the century in which the scale of the universe began to come into focus, as transits of Venus were chased across the globe and parallax was hunted with ever finer instruments, and in which the first cracks appeared in the idea that the stars were fixed forever. This book tells that century's story: its instruments and institutions, its solved problems and its inherited mysteries, and the people, famous and forgotten, who made the sky modern.

The scale story had a moral the century itself liked to tell. Once the solar system had a measured diameter in miles, the stars, known by their refusing to show parallax, had to lie at distances that made the solar system a dot, and every argument about the stars' nature, suns at unthinkable remove, became arithmetic rather than poetry. The measurement did not reach the stars, but it fenced them, and the fence is part of the discovery: the eighteenth century is when "the universe" stopped being a synonym for "everything imaginable" and started being a place with a size, a structure, and an inside.

A note on the century's own length, because a hundred years is five working lifetimes, and the account should show the relay. The generation that read the Principia as news gave way to the generation that measured the light's aberration; that generation handed its instruments to the transits' generation; and the century's last cohort, the telescope makers and the first planet finders, passed the science to the nineteenth century as a going concern; the account marks the baton's stations throughout, the reader watching a science

acquire its modern pace across five successions, and the introduction's promise being that by the last chapter the pace will look familiar, the century having invented the rhythm the science still keeps.

A note on the volume's cast, because the century's astronomy was made by more kinds of people than the old histories admit. The professors of the national observatories share these chapters with the instrument makers of the capital workshops, the musicians turned telescope builders, the sisters who swept for comets, the farmers of the sky's catalogs, and the officers of the navies whose ships carried the expeditions; the account credits each kind where the record allows, the century's astronomy being a trade with many hands, and the reader being introduced to the whole workshop rather than the front office alone.

Chapter 1: The Discovery of 18th Century Astronomy

The century inherited a revolution still settling. In 1687 Newton's Principia had explained, in one law of attraction, the fall of an apple and the orbit of the Moon, and by 1700 the astronomical world was digesting what that meant: the heavens were not a realm of crystalline spheres but a machine, calculable, and the work of the coming century was to calculate it. The inheritance from the age of Kepler and Galileo was essential to that work, and it is worth recalling what had just been learned.

The century's own account of that inheritance differs from ours, and the difference is instructive. To them the Newtonian settlement was fresh news, debated at the academies, contested by philosophers who thought action at a distance occult, and applied with a caution that seems strange in hindsight: it took a generation for the inverse square law to be treated as literally true across the whole sky, and the delay was respectable, because the claims were enormous and the evidence, while strong, was still being assembled. The eighteenth century's relation to its inheritance was thus not reverence but verification, which is the exact posture it handed forward, and the reason its science aged so well.

The institutional inheritance was equally fresh. The Royal Observatory at Greenwich had been founded in 1675 explicitly to find longitude at sea, and the Paris Observatory was its slightly older French twin; between them, in the new century, they turned the routine of nightly observation into a government service, with published records, standardized instruments, and salaried astronomers whose titles, Astronomer Royal and Comptroller of the Observatory, still exist today. The first holder of the Greenwich post, John

Flamsteed, set the century's tone by fighting for forty years to publish his star catalogue on his own terms, a struggle that shaped how the age thought about data, credit, and the ownership of the sky.

Tycho Brahe had shown, with the new star of 1572 and the comet of 1577, that the heavens change, and his decades of naked-eye positions, the most accurate ever made, became the raw material of the next advance. Johannes Kepler, working through Tycho's observations of Mars, discovered the three laws of planetary motion that carry his name: the orbits are ellipses with the Sun at one focus, a line from planet to Sun sweeps equal areas in equal times, and the orbital periods grow as the three-halves power of the orbital sizes. Galileo had turned the telescope skyward, found Jupiter's moons, the phases of

Venus, mountains on the Moon, and a Milky Way resolved into countless stars, and the telescope was never again out of astronomy's hands. Newton closed the argument by deriving it all from a single mathematics.

He came on the astronomical scene with the publication of De nova stella, in which he disproved conventional wisdom on the supernova SN 1572 (As bright as Venus at its peak, SN 1572 later became invisible to the naked eye, disproving the Aristotelian doctrine of the immutability of the heavens.) He also created the Tychonic system, where the Sun and Moon and the stars revolve around the Earth, but the other five planets revolve around the Sun.

This system blended the mathematical benefits of the Copernican system with the "physical benefits" of the Ptolemaic system. This was one of the systems people believed in when they did not accept heliocentrism, but could no longer accept the Ptolemaic system. He is most known for his highly accurate observations of the stars and the planets. Later he moved to Prague and continued his work.

In Prague he was at work on the Rudolphine Tables, that were not finished until after his death.

The Rudolphine Tables was a star map designed to be more accurate than either the Alfonsine tables, made in the 1300s, and the Prutenic Tables, which were inaccurate. He was assisted at this time by his assistant Johannes Kepler, who would later use his observations to finish Brahe's works and for his theories as well. After the death of Brahe, Kepler was deemed his successor and was given the job of completing Brahe's uncompleted works, like the Rudolphine Tables.

He completed the Rudolphine Tables in 1624, although it was not published for several years. Like many other figures of this era, he was subject to religious and political troubles, like the Thirty Years' War, which led to chaos that almost destroyed some of his works. Kepler was, however, the first to attempt to derive mathematical predictions of celestial motions from assumed physical causes.

With these laws, he managed to improve upon the existing heliocentric model. The first two were published in 1609. Kepler's contributions improved upon the overall system, giving it more credibility because it adequately explained events and could cause more reliable predictions. Before this, the Copernican model was just as unreliable as the Ptolemaic model. This improvement came because Kepler realized the orbits were not perfect circles, but ellipses. The invention of the telescope in 1608 revolutionized the study of astronomy.

Galileo Galilei was among the first to use a telescope to observe the sky, after

constructing a 20x refractor telescope. He discovered the four largest moons of Jupiter in 1610, which are now collectively known as the Galilean moons, in his honor. This discovery was the first known observation of satellites orbiting another planet. He also found that the Moon had craters and observed, and correctly explained sunspots, and that Venus exhibited a full set of phases resembling lunar phases.

Galileo argued that these facts demonstrated incompatibility with the Ptolemaic model, which could not explain the phenomenon and would even contradict it. With Jupiter's moons, he demonstrated that the Earth does not have to have everything orbiting it and that other bodies could orbit another planet, such as the Earth orbiting the Sun. In the Ptolemaic system the celestial bodies were supposed to be perfect so such objects should not have craters or sunspots.

The phases of Venus could only happen in the event that Venus orbits around the Sun, which did not happen in the Ptolemaic system. He, as the most famous example, had to face challenges from church officials, more specifically the Roman Inquisition. They accused him of heresy because these beliefs went against the teachings of the Roman Catholic Church and were challenging the Catholic church's authority when it was at its weakest.

While he was able to avoid punishment for a little while he was eventually tried and pled guilty to heresy in 1633. Although this came at some expense, his book was banned, and he was put under house arrest until he died in 1642. Sir Isaac Newton developed further ties between physics and astronomy through his law of universal gravitation.

Realizing that the same force that attracts objects to the surface of the Earth held the Moon in orbit around the Earth, Newton was able to explain - in one theoretical framework - all known gravitational phenomena. In his Philosophi

Naturalis Principia Mathematica, he derived Kepler's laws from first principles.

Those first principles are as follows: In an inertial frame of reference, an object either remains at rest or continues to move at constant velocity, unless acted upon by a force.

What the eighteenth century discovered, in the proper sense, was that the machine could be worked. Edmond Halley, Newton's friend and champion, computed the orbits of two dozen comets from the historical records and noticed in 1705 that the comets of 1531, 1607, and 1682 followed the same path, predicting that the object would return about 1758. When it did, appearing exactly on schedule weeks after Halley's death, the prediction's fulfillment was the century's founding demonstration: gravitation was not a

description of the sky but a means of foretelling it. The comet ever since has carried Halley's name, and the eighteenth century's astronomers inherited, in that single success, both their agenda and their confidence.

Halley's comet carried a further burden the prediction made visible: the comet's returns now stretched across recorded history, in 1066 among them, and the identification of the medieval and ancient apparitions with the single modern object made the comet the sky's own archive, connecting the Bayeux Tapestry's omen to the mathematics of gravitation in one unbroken line. The eighteenth century was the first to read the historical sky as data, mining Chinese and Babylonian records for eclipses and comets, and the practice, which the lunar-acceleration problem in particular depended on, made astronomy the first science to treat ancient texts as instruments.

The longitude connection deserves the discovery chapter's first addition, because the century's governments bought its astronomy for a practical reason. The ships of the trading nations died on their coasts for want of knowing where they were, and the sea's longitude demanded the sky: the motions of the moon against the catalog of stars, tabulated in advance, the observations ashore supplying the tables; the century's parliaments offered prizes, its observatories fed the lunar theory, and its clockmakers eventually solved the problem the astronomers had made tractable; the chapter's honest ledger: the state did not fund the sky for its beauty alone, the navigation problem paying the first bills, and the science's public standing being built on the navy's gratitude, the century's astronomy running on its most practical errand from the start.

The comet's naming deserves the second addition, because the era's most famous prediction carried a personality worth meeting. The English astronomer who noticed that the comets of several centuries shared one orbit was a former ship's captain turned professor, the man who persuaded Newton to publish, who mapped the southern stars, and whose own name now rides a periodic visitor; the chapter keeps the portrait brief but proper: the prediction of the comet's return was one feat in a career of feats, the octogenarian's arithmetic waiting sixteen years past his death for its confirmation, and the account using him as the century's opening emblem, the old navigator's last voyage being the one his comet still makes.

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.