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Astronomy (Quick Study Science)



Astronomy
A comprehensive guide to the universe

HISTORY OF ASTRONOMY

Ancient Times

- Stonehenge, on the Salisbury Plain in southern England, was built in stages from about 2400 BC–2070 BC to observe the sun and the moon, and thus bring regularity to the builder's calendar.
- The Big Horn Medicine Wheel, an arrangement of rocks resembling a 28-spoke wheel in the Big Horn Mountains of Wyoming, was used as a calendar by the Plains Indians from about 1500–1700 AD.
- The Great Temple on the Yaxchilan peninsula in a 1000-year-old astronomical observatory.

The Astronomy of Greece

Greek astronomy was based on the astronomy of Babylon and Egypt, which was heavily influenced by astrology.

- Plato (427–347 BC) argued that the reality we see is only a distorted shadow of the reality that exists in the abstract realm of perfect forms and numbers.
- Aristotle (384–322 BC) organized two reasons to believe the Earth was round. First, when a ship sailed over the horizon, the mast was initially visible, then the deck, and then the entire ship. Second, he observed that the Earth's shadow on the moon during a lunar eclipse was curved, only an Earth which was curved could produce this. He also proposed a geocentric (Earth-centered) solar system.
- Aristarchus (ca. 280 BC) proposed a theory that the Earth revolved on its axis and orbited around the Sun.
- Eratosthenes (ca. 276 BC) derived a method for determining the Earth's circumference by noting 8% of the distance occupied by the shadow of the sun.
- Hipparchus (ca. 140 BC) discovered axial precession and made the first catalog of star magnitudes.
- Claudius Ptolemy (Ptolemy, ca. 100–160 AD) lived and worked in the Greek colony of Alexandria (now Egypt). He assumed spherical trigonometry's geometric properties by fitting it to a geocentric mathematical model.
- Ptolemy found that simple epicycles were not enough to account for the motion of the planets. Planets sometimes move faster, sometimes slower, and occasionally appear to move in a step and then backtrack over a period of days or months. This is called retrograde motion. He accounted for this motion by placing the planets on small circles (epicycles) that moved along larger circles (deferents).
- His work was published in 140 AD in what is now known as the Almagest.

Pioneers of Astronomy

Copernicus

- Nicolaus Copernicus (1473–1543) lived and worked in what is now Poland. Because of his long and abiding relationship with the Christian Church, he hesitated to publish his revolutionary ideas in astronomy, so he distributed an anonymous pamphlet in 1507 that outlined his heliocentric (sun-centered) solar system.
- Copernicus died in 1543 while he believed he was dying.
- The Copernican system explained retrograde motion without epicycles and was elegant and simple compared to the Ptolemaic system.

Tycho Brahe

- Tycho Brahe (1546–1601) was a Danish astronomer. He developed new and better instruments for recording the stars, sun, moon, and planets. (Telescope had not yet been invented.)
- Brahe recorded his results, as what we now call the BraheTables. After his death, Tycho Brahe's stepson, Johannes Kepler, discovered he had other mathematical and astronomical, including volume Kepler's
- Kepler

 - Kepler (1571–1630) was born in what is now southern Germany. Ten days before Kepler died, in 1630, he noted that Kepler's death would expand mathematics. (Kepler's death, Kepler, affected his results.)
 - Using the recorded positions of the planets, Kepler was able to deduce his three laws of planetary motion:

a. The orbits of the planets are ellipses with the sun at one focus.
b. A planet's speed is proportional to its distance from the sun.
c. A planet's orbital period is proportional to the cube of its average distance from the sun, where P is the orbital period in years, and a is the distance in AU. One AU is the average distance from the Earth to the Sun, which is about 93 million miles. $P^2 \propto a^3$

Galileo

 - Galileo Galilei (1564–1642) was born in Pisa, Italy. Galileo was the first to use a telescope to make systematic use of the telescope in looking at the stars.
 - Galileo's observations with the telescope include:
 - The moon is not smooth; it has valleys and craters. This discovery contradicted the notion that all heavenly bodies were perfect spheres.
 - The Milky Way is made up of thousands of stars too distant to be seen with the unaided eye.
 - The discovery of Jupiter's moons lent credence to the Copernican model, as it became apparent that objects in the Earth's orbit could have their own orbiting bodies. These Galilean moons are in, Europa, Ganymede, and Callisto, all of which orbit Jupiter.
 - Galileo later observed that the Sun has sunspots and rotates with a period of 25 days.
 - Galileo saw that Venus passes through phases similar to those of the moon, indicating that it orbits around the sun, not the Earth.
 - Galileo published two major works, Sidereus Nuncius and Dialogue Concerning the Two Chief World Systems. The publication of the second of these works in 1632 caused his own sentencing four times by the Inquisition, and in 1633 he was forced to recant his views of the Sun-centered Sun, meaning Galileo was put under house arrest until his death in 1642.

Isaac Newton

 - Isaac Newton (1642–1727) was born in the English village of Woolsthorpe. In 1665–1666, when the Black Plague struck Cambridge where he was studying, he returned to Woolsthorpe and discovered his famous three laws of motion. These laws are important not only for objects in the heavens, as well as objects on Earth, thereby making Newton the first astrophysicist. His laws of motion are:
 - A body continues in motion in a straight line at a constant speed, or remains at rest, unless it is acted upon by some external force.
 - A body's change of motion is proportional to the force on it and the direction of the force. $F = ma$, where F is force, m is mass, and a = acceleration.
 - When one body exerts a force on a second, the second body exerts an equal and opposite force on the first.
 - Newton distinguished between an object's mass, which is how much matter it contains, and weight. A person on the moon is attracted by the moon's gravity less than that same person will be attracted to the Earth by Earth's gravity. That person's mass is the same in both places, but the weight is different. Weight is a force, mass is the amount of matter.
 - Newton determined that for the planets to orbit the sun in elliptical trajectories, they must be subject to a force that decreases proportionally to the square of their distance from the sun. In addition, the force must be proportional to the masses of the sun and the planet. In equation form, this is stated by: $F \propto \frac{m_1 m_2}{r^2}$
 - In the equation above, F is the mutual force of attraction between the planets. m_1 is the universal gravitational constant, $6.67 \times 10^{-11} \text{ N} \cdot \text{kg}^{-2} \cdot \text{m}^3 \text{ s}^{-2}$, r is the distance between the sun and the planet. m_1 is the mass of the sun, and m_2 is the mass of the planet. This is the law of universal gravitation because we can extend this equation to any two objects in the universe.



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Book Information

Series: Quick Study Science

Paperback: 6 pages

Publisher: Barcharts; Lam Rfc Cr edition (May 31, 2014)

Language: English

ISBN-10: 1423234650

ISBN-13: 978-1423234654

Product Dimensions: 0.2 x 8.8 x 11.5 inches

Shipping Weight: 1.6 ounces (View shipping rates and policies)

Average Customer Review: Be the first to review this item

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