

# Evolution of Astronomical Knowledge: From Ancient Civilizations to Modern Physics

**Dr. N. Ragini**

M. Sc., Ph.D., Principal and Professor of Physics, Government First Grade College. Kuvempunagar  
Mysore-570023

## **ABSTRACT:**

This paper embarks on a captivating journey, tracing the evolution from ancient civilizations to contemporary Astronomy, encompassing a spectrum of cultures, including Indian contributions and the advancements of Modern Astronomy. Despite the passage of 5,000 years, our comprehension of the solar system and the greater Cosmos remains profound, evoking a sense of wonder akin to the earliest observers. This article accentuates the pursuit of fresh educational prospects and vitality in life's exploration. Through the scrutiny of celestial domains beyond our world, it furnishes imperative insights into the foundational forces governing the Universe. The boundless expanse of the Cosmos continues to invigorate our inquisitiveness, propelling the innovation of scientific methodologies that exert extensive influence on our society. As our capabilities in space exploration advance, a cascade of new opportunities emerges, unfurling novel avenues for astronomical investigation.

**KEYWORDS:** Astronomy, natural sciences, antiquity, religious, mythological, cosmological, calendrical, and astrological prehistory

## **INTRODUCTION**

This paper explores the enchanting realm of the night sky and the captivating celestial bodies that have fueled wonder and speculation since the earliest civilizations emerged. The evolution of our understanding of the cosmos has followed distinct epochs: Indian, Medieval, and Modern Astronomy.

Indian Astronomy flourished during the 5th to 6th centuries, exemplified by the contributions of Aryabhata, and this period marked a significant stride in comprehending celestial phenomena.

Medieval Astronomy underwent remarkable advancements in the Islamic world during the Islamic Golden Age (9th to 13th centuries). This epoch unfolded across regions such as the Middle East, Central Asia, Al-Andalus, North Africa, the Far East, and India. It witnessed the refinement of astronomical knowledge and its diffusion across cultures.

Modern Astronomy, the contemporary pursuit of comprehending the Universe and its constituents—ranging from stars and planets to galaxies and comets—found its genesis in the 16th century. Notably, the pivotal figure of Nicolas Copernicus emerged as a trailblazer, earning him the epithet "father of Modern Astronomy."

Humanity's ceaseless and intellectual curiosity has driven the quest for cosmic knowledge throughout these historical phases. The night sky, once a source of mystique, has gradually unfolded its secrets through the persistent efforts of thinkers, scientists, and visionaries.

Dark matter constitutes 90% of the Universe's composition, despite being impervious to direct detection. Black holes, on the other hand, embody extraordinarily dense matter, possessing gravitational forces so overpowering that even light succumbs to their pull.

The tapestry woven by space and time is truly expansive. A span of 15 billion years has transpired since the Big Bang, during which the entire cosmos occupied a space no larger than that of a subatomic particle. Fast forward 5 billion years from then, and a cloud of gas and dust collapsed, giving birth to the star that fosters life on Earth.

This manuscript aims to enrich our understanding of the universe and delve into the latest exhilarating advancements in space exploration.

## **ASTRONOMY**

Astronomy derives from the Ancient Greek Phrase, meaning the laws or science governing stars. It is also the study of celestial phenomena. Astronomy is also the oldest of sciences.

## **MESOPOTAMIA:**

The Babylonians, an ancient Mesopotamian people who flourished between the Tigris and Euphrates rivers in modern-day Iraq, were one of the earliest civilizations known to have adopted a scientific outlook towards stars and planets. Pre-Mesopotamian civilizations had usually linked the celestial objects to the spirits. However, the record shows that in early 3000 B.C., the Babylonians recorded discoveries in some constellations and mapped the recurrence of astronomical events. One of the oldest surviving astronomical documents is the Venus Tablet of Ammisaduqa, discovered in the remains of the Babylonian library Nineveh in 1700 B.C. Moreover, it records the times Venus appeared and disappeared in the morning and evening sky. Records of the movements of Mercury have also been found, detailing the times when it could be seen and when it passed in front of or behind the Sun, hiding it from view.

## **CHINESE DRAGONS:**

Ancient Chinese civilization paid close attention to the night sky because an essential part of the culture's Philosophy was the harmony between man and nature. As a result, Chinese astronomers correctly calculated the eclipse cycle; this was likely the first civilization to have determined that there were 365 days in a year by calculating the movement of the Sun against the background stars.

Chinese mythology held that an ellipse occurred when a dragon was eating the Sun and that the only way to defeat the dragon was to make as much noise as possible. In the event of an ellipse, people would make a mighty racket, which would scare the dragon off, and naturally, the Sun would return.

## **GREEK'S PYTHAGORAS GLOBE:**

The ancient Greeks significantly advanced the scientific study of Astronomy by emphasizing observation and data collection. In 240 B.C., Eratosthenes, a Greek mathematician, successfully calculated the circumference of the Earth. Amaximander was the first to suggest that the Earth floated freely in space rather than being suspended as a ball on a chain.

Another Greek, Hipparchus, invented the astrolabe instrument, which could predict the position of the stars and the Sun among several of its functions, and the famous Pythagoras was the first to assert that the Earth was a globe rather than a cylinder. The Greek scientists can also be credited with establishing

the geocentric theory idea that the Earth lies at the center of the Universe. Although this was incorrect, it was the dominant belief in Europe and the Middle East for many centuries.

### **MAYAN PYRAMIDS.**

Despite no known information exchanges, the Maya in Central America reached similar conclusions to their European counterparts. They developed a solar calendar more sophisticated than the Julian calendar without ever knowledge of the Romans. This civilization devised the idea of the leap year to allow for the fact that the Sun does not fit neatly into a 365-day orbit.

The Sun, the moon, and Venus held religious significance for the Maya. They aligned their pyramids, religious statues, and temples with the points at which these three objects set and rose at various times in the year. The religious emphasis placed by the Maya on the planet Venus meant that they were ahead of their time in understanding Earth's nearest neighbor. They recognized that the morning and evening appearance of Venus were not separate entities as the Greeks had thought, but they were, in fact, one. Documents show that the Mayans had also calculated the movement of Venus several years in advance and had even worked out Venus's synodic period- the time elapsed between successive conjunctions of the planet.

### **ASTROLOGY:**

Astrology stems from the belief that the position and movements of the celestial bodies directly influence our lives here on Earth, and that influence can be divined by 'reading' signs in the skies. In essence, space is employed to tell fortunes. More recently, technologies have scientifically explained the movement of these heavenly bodies. However, many people today continue to prefer to interpret these movements through astrology, and horoscopes can be widely found in magazines and newspapers.

### **ISLAMIC ASTRONOMERS**

The knowledge of astronomy was sound in Islamic rituals, which interpreted the heavens as a guide to ensure prayer four times a day, to date religious festivals correctly, and to locate Mecca accurately. Islamic scholars contributed widely to astronomy. A.L. Battani calculated the Sun's apogee-the point during orbit at which the Earth is farthest from the sun-is variable. This meant that the Earth's farthest from the Sun was variable. This meant that the Earth's orbit of the Sun was discovered not to be a perfect circle.

### **LEGACY OF ANCIENT INDIA ARYABATTA:**

The research article titled "Legacy of Ancient India: Aryabhata" explores the significant contributions of the renowned Indian mathematician and astronomer Aryabhata. Aryabhata, who lived during the 5th century C.E., made pioneering advancements in mathematics and astronomy. His work laid the foundation for various mathematical concepts and astronomical calculations influencing modern science and technology.

In mathematics, Aryabhata's most notable achievement was developing the decimal number system, which introduced the concept of place value and zero as a placeholder. This revolutionary system became the basis for the modern numeral system used worldwide. Aryabhata's work also included advancements in algebraic techniques and trigonometry, with his sine table considered a precursor to modern trigonometric functions.

In astronomy, Aryabhata's contributions were equally significant. He formulated a heliocentric solar system model, where he correctly deduced that the Earth rotates on its axis and that the apparent movement of celestial bodies was due to the Earth's rotation. His observations and calculations led to improved predictions of planetary positions and eclipses.

The article also discusses Aryabhata's notable works, primarily his treatise "Aryabhatiya," which covers various mathematical and astronomical topics. The legacy of Aryabhata's work extends beyond his own time, as his ideas and methodologies influenced subsequent generations of mathematicians and astronomers in India and worldwide.

### **VARAHAMIHIRA:**

Varahamihira, a distinguished sage, astrologer, astronomer, and polymath, lived during the Gupta period (505-587 CE). His contributions to understanding celestial bodies were remarkably ahead of his time. Among his accomplishments, he accurately estimated the diameters of several planets, including Mercury, Venus, Mars, Saturn, and Jupiter. Notably, he also posited the presence of water on Mars, a concept that gained validation much later through modern space exploration by organizations like NASA and ISRO. These agencies' recent discoveries of water and iron on Mars support Varahamihira's assertion, indicating that ancient Indian knowledge, dating back to 500 AD, was remarkably insightful.

#### **Transition in Astronomical Thought: From Ancient Insights to Modern Discoveries**

The transition from ancient to modern astronomy marked a profound evolution in human understanding of the cosmos. Johannes Kepler (1571-1630), a German astronomer, played a pivotal role during this transition by formulating the three fundamental laws of planetary motion. Based on meticulous observations by Tycho Brahe and Kepler, these laws revolutionized the perception of planetary orbits. Kepler's first law introduced elliptical paths for planets, with the Sun located at one focus of the ellipse. The second law revealed that a planet's speed increases as it approaches the Sun. Kepler's third law established a mathematical relationship between a planet's distance from the Sun and its orbital period. These laws were integral to Isaac Newton's subsequent development of the theory of gravity.

### **CHALLENGING GEOCENTRISM: THE COPERNICAN REVOLUTION**

The Copernican Revolution marked a turning point in astronomical thought, overturning the long-held geocentric model proposed by Aristotle and further supported by Claudius Ptolemy. In the geocentric view, Earth was considered the center of the Universe, a notion aligned with the religious beliefs of the time. However, this notion faced opposition when Aristarchus proposed the heliocentric model, suggesting that Earth orbited the Sun. Despite the resistance, the Middle Ages in Western Europe saw the geocentric model entrenched, backed by the Church's support.

Nicolaus Copernicus emerged during this period of transition. Born in 1473 in Torun, Poland, Copernicus challenged the prevailing view by placing the Sun, rather than Earth, at the center of the solar system. His groundbreaking work, "De Revolutionibus Coelestium," published in 1543, posthumously introduced the heliocentric model. Building upon Tycho Brahe's observations, Johannes Kepler further refined our understanding by proposing elliptical planetary orbits.

### **GALILEO'S TELESCOPIC INSIGHTS**

Galileo Galilei, a seventeenth-century scientist, employed telescopic observations to support the heliocentric model. His observations of Jupiter's moons and Venus' changing phases provided evidence

against the geocentric model. Through his telescope, Galileo discovered that Jupiter had moons orbiting it, challenging the notion of everything orbiting Earth. Moreover, he noticed the changing phases of Venus, which only made sense if Venus orbited the Sun. Galileo's meticulous observations paved the way for a new understanding of our place in the cosmos.

### **NEWTON'S LAWS AND UNIVERSAL GRAVITATION**

Isaac Newton's contributions were monumental in shaping modern astronomy. Through his "Principia," published in 1687, Newton formulated the three Laws of Motion and the Law of Universal Gravitation. He conceptualized gravity as a force of attraction between objects, proportional to their masses and inversely proportional to the square of the distance between them. Newton's theory elegantly explained why planets move in their orbits, confirming Kepler's laws and providing a comprehensive framework for understanding celestial mechanics.

### **ALBERT EINSTEIN:**

Newton's concepts were revolutionary, earning admiration and respect for two centuries by explaining how the Earth could spin without people falling off and elucidating why an apple descended to the ground. Furthermore, they provided insight into the mechanics that kept planets in orbit around the sun. Nevertheless, Newton's gravitational theory could not encompass every circumstance. A particular challenge arose from the orbit of Mercury. The planet's perihelion, its closest point to the sun, exhibited a non-static behavior, shifting by a small fraction during each orbit. This minuscule movement meant Mercury required over a million orbits to return to its initial position. Newton's gravitational theory struggled to account for these deviations.

Enter ALBERT EINSTEIN, a young physicist born in Germany. In 1905, he unveiled his particular theory of relativity, building upon the groundwork laid by Galileo. Einstein demonstrated that light travels at a constant speed, just under 300,000 kilometers per second, relative to an observer in a vacuum. His theory also established that the velocity of light in a vacuum represents the ultimate speed achievable in the cosmos. His General Theory of Relativity, published in 1915, introduced a fresh interpretation of gravity.

Einstein's particular theory of relativity had already demonstrated the variability of both time and distance. This implied that the three spatial dimensions—height, width, and depth—also possessed flexibility. In his General Relativity, Einstein embraced the perspective championed by German mathematician Hermann Minkowski: space and time are intertwined in a four-dimensional construct known as 'spacetime.' According to Einstein's General Theory of Relativity, mass warps spacetime. The distortion of spacetime caused by mass, rather than the mass of an object alone, gives rise to gravitational attraction. While Newton's framework explained an apple falling to Earth due to the planet's greater mass tugging at it, General Relativity envisions the apple descending into a crease in spacetime created by Earth's mass. American physicist John Wheeler encapsulated this notion aptly: "Matter tells space (time) how to bend, space (time) tells matter how to move."

Einstein meticulously calculated the mathematical foundations of General Relativity, and to his delight, it even accounted for the advancing perihelion of Mercury. This revelation demonstrated the comprehensive nature of General Relativity, a realm Newtonian gravity could not assert, given the peculiarity of Mercury's orbit.

The actual positions of stars behind the sun deviated from their apparent locations because light originating from these stars was observable during an eclipse. Only General Relativity could explain this phenomenon: the sun distorts spacetime's fabric, causing the starlight to bend.

Einstein instantly became a celebrity, becoming the preeminent scientist of the 20th century. Nevertheless, despite his contributions, many individuals beyond the scientific community continued to hold onto a Newtonian understanding of gravity.

General Relativity has endured by successfully accommodating all the universe's scenarios. However, it is essential to recognize that current gravitational theories might undergo revisions in the centuries to come.

### **STEPHEN HAWKING'S CONTEMPORARY CONTRIBUTIONS**

Moving forward to more recent times, the legacy of astronomy continued with Stephen Hawking. Born in 1942, Hawking overcame physical challenges to become a renowned theoretical physicist and cosmologist. His collaboration with Roger Penrose resulted in ground breaking work on gravitational singularities and Hawking radiation, revolutionizing our understanding of black holes. Despite his debilitating motor neuron disease, Hawking's intellectual prowess and popular science writings, like "A Brief History of Time," made profound cosmological concepts accessible to a broad audience.

### **CONCLUSION:**

In summary, this paper explores the journey of human discovery in astronomy, from ancient civilizations to modern times. It covers various aspects, including early civilizations, Indian contributions, and the evolution of astronomical knowledge. Despite our advanced understanding of the Universe, the wonder and amazement felt by ancient observers persist. The exploration of space provides valuable learning opportunities and insights into universal forces.

The paper traces the history of astronomy, starting with the Babylonians in Mesopotamia, who documented celestial events and constellations. Chinese astronomy's connection to nature led to accurate celestial phenomena and eclipse predictions. Greeks like Eratosthenes and Hipparchus furthered observational astronomy, understanding Earth's position and celestial motion.

The Mayans in Central America independently created advanced solar calendars and recognized Venus's importance. The link between astronomy and astrology, the belief in celestial influences on humans, is discussed, along with its modern continuation. Islamic astronomers integrated astronomy into religion and improved understanding, including calculating Earth's elliptical orbit. Ancient Indian astronomers proposed Earth's rotation, planetary sizes, and even water on Mars.

The paper highlights the Copernican Revolution by figures like Copernicus, Kepler, and Galileo, challenging the Earth-centred model. Newton's laws explained celestial motion, and Einstein's relativity and Hawking's black hole work are acknowledged.

Finally, the paper underscores how astronomy continues to captivate our curiosity and drive scientific advancement. From ancient times to today, studying the cosmos has yielded profound insights shaping our view of the Universe. Advancements in space exploration promise more discoveries and broader horizons.

**References**

1. Aaboe, A. (2001). *Episodes from the Early History of Astronomy*. Springer-Verlag. ISBN: 0-387-95136-9.
2. Aveni, A. F. (1980). *Sky watchers of Ancient Mexico*. University of Texas Press. ISBN: 0-292-77557-1.
3. Berry, A. (1898). *A Brief History of Astronomy*. Retrieved from Internet Archive.
4. Dreyer, J. L. E. (1953). *History of Astronomy from Thales to Kepler* (2nd ed.). Dover Publications.
5. Eastwood, B. (2002). *The Revival of Planetary Astronomy in Carolingian and Post-Carolingian Europe*. Variorum Collected Studies Series CS 279. Ashgate. ISBN: 0-86078-868-7.
6. Evans, J. (1998). *The History and Practice of Ancient Astronomy*. Oxford University Press. ISBN: 0-19-509539-1.
7. Gautier, A. (2005). *L'âge d'or de l'astronomie ottomane*. *L'Astronomie*, 119.
8. Hodson, F. R. (Ed.). (1974). *The Place of Astronomy in the Ancient World: A Joint Symposium of the Royal Society and the British Academy*. Oxford University Press. ISBN: 0-19-725944-8.
9. Hoskin, M. (2003). *The History of Astronomy: A Very Short Introduction*. Oxford University Press. ISBN: 0-19-280306-9.
10. McCluskey, S. C. (1998). *Astronomies and Cultures in Early Medieval Europe*. Cambridge University Press. ISBN: 0-521-77852-2.
11. Pannekoek, A. (1989). *A History of Astronomy*. Dover Publications.
12. Pingree, D. (1998). *Legacies in Astronomy and Celestial Omens*. In S. Dalley (Ed.), *The Legacy of Mesopotamia* (pp. 125–137). Oxford University Press. ISBN: 0-19-814946-8.
13. Rochberg, F. (2004). *The Heavenly Writing: Divination, Horoscopy, and Astronomy in Mesopotamian Culture*. Cambridge University Press.
14. Stephenson, B. (1987). *Kepler's Physical Astronomy*. *Studies in the History of Mathematics and Physical Sciences*, p. 13. Springer. ISBN: 0-387-96541-6.
15. Walker, C. (Ed.). (1996). *Astronomy before the Telescope*. British Museum Press. ISBN: 0-7141-1746-3.