

**KONSEP ORBIT DALAM AL-QURAN, HADIS, DAN ASTRONOMI MODEN:
KAJIAN ANTARA DISIPLIN****THE CONCEPT OF ORBIT IN THE QUR'AN, HADITH, AND MODERN
ASTRONOMY: AN INTERDISCIPLINARY STUDY**Mesbahul Hoque¹, Mohd Nor Adzhar Ibrahim^{*2}, Norhasnira Ibrahim³, Mohd Zohdi Mohd Amin⁴¹ Faculty of Quranic and Sunnah Studies Universiti Sains Islam Malaysia 71800, Nilai, Negeri Sembilan, Malaysia. mesbahul@usim.edu.my² Faculty of Quranic and Sunnah Studies Universiti Sains Islam Malaysia 71800, Nilai, Negeri Sembilan, Malaysia. mnor.adzhar@usim.edu.my³ Faculty of Quranic and Sunnah Studies Universiti Sains Islam Malaysia 71800, Nilai, Negeri Sembilan, Malaysia. norhasnira@usim.edu.my⁴ Faculty of Quranic and Sunnah Studies Universiti Sains Islam Malaysia 71800, Nilai, Negeri Sembilan, Malaysia. zohdi@usim.edu.my

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Abstrak

Konsep orbit telah lama menjadi subjek pemerhatian dan refleksi manusia, menghubungkan pemahaman agama dengan penyelidikan saintifik. Artikel ini mengkaji konsep orbit menurut al-Quran, hadis, dan astronomi moden melalui pendekatan interdisipliner. Al-Quran mengandungi beberapa ayat yang merujuk kepada pergerakan badan samawi yang teratur seperti matahari, bulan, bintang, dan planet dalam laluan masing-masing. Ayat-ayat seperti Surah Yasin (36:40) dan Surah al-Anbiya' (21:33) menggambarkan pergerakan berterusan badan samawi, menunjukkan keharmonian, keseimbangan, dan ketepatan ilahi dalam alam semesta. Dalam tradisi hadis, rujukan kepada pergerakan samawi muncul dalam perbincangan berkaitan waktu solat, bulan lunar, puasa, gerhana, dan penentuan arah, mencerminkan kepentingan praktikal pemerhatian astronomi dalam kehidupan Islam. Kajian ini juga meneroka bagaimana astronomi moden menjelaskan orbit sebagai gerakan graviti objek samawi di sekitar badan yang lebih besar, yang dikawal oleh hukum fizikal seperti mekanik Newton dan teori relativiti Einstein. Penemuan saintifik mengenai sistem planet, trajektori satelit, dan gerakan galaksi memberikan pemahaman empirikal yang lebih mendalam tentang fenomena orbit. Berdasarkan perbandingan antara penerangan kitab suci dengan penjelasan saintifik, artikel ini mendapati bahawa pembentangan oleh al-Quran menekankan tujuan, susunan, dan refleksi, manakala astronomi moden menyediakan model gerakan yang boleh diukur dan matematik. Perspektif ini tidak semestinya bercanggah tetapi boleh dilihat sebagai saling melengkapi apabila ditafsirkan dalam kerangka epistemologi masing-masing. Kajian ini menyimpulkan bahawa konsep orbit menunjukkan potensi keharmonian antara wahyu dan sains, di mana teks agama memberi inspirasi kepada renungan kosmos dan astronomi moden mengembangkan pengetahuan manusia tentang mekanik samawi. Pemahaman integratif ini menyumbang kepada perbincangan kontemporari tentang sains dan agama dan menonjolkan kerelevanan sumber Islam dalam melibatkan pemikiran saintifik moden.

Kata kunci

Astronomi, Hadis, Islam, Orbit, Al-Quran

Abstract

The concept of orbit has long been a subject of human observation and reflection, linking religious understanding with scientific inquiry. This article examines the concept of orbit according to the Qur'an, Hadith, and modern astronomy through an interdisciplinary approach. The Qur'an contains several verses that refer to the orderly movement of celestial bodies such as the sun, moon, stars, and planets in their respective paths. Verses such as Surah Yasin (36:40) and Surah Al-Anbiya' (21:33) describe the continuous motion of heavenly bodies, indicating harmony, balance, and divine precision within the universe. In the Hadith tradition, references to celestial movements appear in discussions related to prayer times, lunar months, fasting, eclipses, and determination of direction, reflecting the practical significance of astronomical observation in Islamic life. This study also explores how modern astronomy explains orbit as the gravitational motion of celestial objects around larger bodies, governed by physical laws such as Newtonian mechanics and Einstein's theory of relativity. Scientific discoveries concerning planetary systems, satellite trajectories, and galactic motion provide a deeper empirical understanding of orbital phenomena. By comparing scriptural descriptions with scientific explanations, the article finds that the Qur'anic presentation emphasizes purpose, order, and reflection, while modern astronomy provides measurable and mathematical models of motion. These perspectives are not necessarily contradictory but may be viewed as complementary when interpreted within their respective epistemological frameworks. The study concludes that the concept of orbit demonstrates the potential harmony between revelation and science, where religious texts inspire contemplation of the cosmos and modern astronomy expands human knowledge of celestial mechanics. This integrative understanding contributes to contemporary discussions on science and religion and highlights the relevance of Islamic sources in engaging with modern scientific thought.

Keywords

Astronomy, Hadith, Islam, Orbit, Qur'an

1. Introduction

The concept of orbit occupies a central place in both religious cosmology and modern scientific inquiry. In contemporary astronomy, an orbit refers to the regular motion of a celestial body around another body under the influence of gravity, forming the basis for understanding planetary systems, satellites, stars, and galaxies. Yet long before the rise of modern astrophysics, the movement of heavenly bodies attracted deep reflection in sacred texts and classical civilizations. In the Islamic tradition, the Qur'an repeatedly refers to the orderly motion of the sun, moon, and stars, portraying the cosmos as a sign of divine wisdom and balance. Such scriptural references continue to inspire interdisciplinary discussions between theology and science (Hamwidi, 2026).

Several Qur'anic verses describe celestial bodies as moving in determined paths. For example, Surah al-Anbiya' (21:33) and Surah Yasin (36:40) mention that the sun and moon each "swim" or move within an appointed course. Classical Muslim exegetes generally interpreted these verses as indications of cosmic order rather than technical astronomical formulas. Nevertheless, the language of regular motion has encouraged many modern scholars to revisit Qur'anic cosmology in light of contemporary astronomy.

The dialogue between scriptural meaning and scientific explanation reflects a broader effort to harmonize revelation with empirical knowledge (Morrison, 2022).

Hadith literature also contributes to the Islamic understanding of celestial motion, though usually in practical rather than theoretical terms. Prophetic traditions discuss lunar months, eclipse prayers, prayer times, fasting schedules, and directional orientation, all of which depend upon careful observation of celestial cycles. These narrations demonstrate that astronomy in Islam historically served religious, legal, and social functions. Hence, orbit was not merely a speculative matter but part of daily worship and communal organization.

Modern astronomy, however, provides mathematical precision to the concept of orbit. Through the contributions of Kepler, Newton, and Einstein, orbital motion is now understood through laws of gravitation, inertia, and spacetime geometry. Recent scholarship further integrates computational modelling and artificial intelligence to improve orbit prediction, satellite tracking, and astrophysical simulations (Hamwdi, 2026).

Moreover, recent educational studies emphasize that astronomy is not only scientific but also cultural and philosophical, connecting humanity's search for meaning with observation of the heavens (Salimpour & Fitzgerald, 2024). Therefore, examining orbit through the Qur'an, Hadith, and modern astronomy offers a valuable integrative framework. This study aims to analyze scriptural descriptions of celestial motion, evaluate their interpretive significance, and compare them with modern scientific understandings of orbital mechanics. Such an approach may enrich both Islamic scholarship and contemporary science-religion discourse.

2. The Concept of Orbit in the Qur'an and Hadith

The concept of orbit in Islam is primarily understood through scriptural references that describe the orderly movement of celestial bodies as signs of divine wisdom and cosmic balance. While the Qur'an is not a scientific textbook, it frequently directs human attention to the heavens, the sun, the moon, stars, and the alternation of day and night as evidence of purposeful creation. These descriptions have encouraged Muslim scholars, both classical and contemporary, to reflect on astronomy and celestial motion within a theological framework (Rasheed et al., 2025)

One of the most frequently cited Qur'anic verses related to orbit is Surah al-Anbiya' (21:33): *"And He is the One Who created the night and the day, and the sun and the moon; each floating in an orbit."* A similar statement appears in Surah Yasin (36:40), which states that the sun and moon move according to a determined order. The Arabic term *falak* used in these verses is commonly interpreted as a rounded course, path, or orbit. Classical exegetes such as al-Tabari and Ibn Kathir understood these verses as referring to the regular movement of celestial bodies according to divine decree. Contemporary scholars note that the verses emphasize systematic motion rather than randomness, highlighting harmony in the universe (Naeem, 2025)

Another important verse is Surah al-Rahman (55:5): *"The sun and the moon move by precise calculation."* This verse links celestial motion with measurement, proportion, and timekeeping. Muslim civilization historically developed astronomy partly to understand

calendars, prayer times, and navigation. Thus, the Qur'anic portrayal of celestial order inspired both spiritual contemplation and scientific observation. Recent studies argue that Qur'anic cosmology encourages humans to study nature while acknowledging divine sovereignty over creation (Rasheed et al., 2025). In Hadith literature, references to orbit are usually indirect and practical rather than theoretical. The Prophet Muhammad ﷺ often linked religious observances to observable celestial cycles. For example, the beginning and ending of Ramadan are connected to the sighting of the new moon, showing the significance of lunar motion in Islamic worship. Likewise, prayer times are determined by the sun's apparent movement across the sky, including dawn, noon, afternoon, sunset, and night. These narrations demonstrate that celestial motion was central to the rhythm of Muslim daily life. Hadith also addresses eclipses, which are significant astronomical events. In an authentic narration, the Prophet ﷺ stated that the sun and moon are two signs among the signs of Allah and do not eclipse because of the death or birth of any person. This statement corrected pre-Islamic superstitions and directed people toward rational understanding and spiritual reflection. Modern researchers observe that this Hadith represents an important rejection of mythological interpretations of astronomical phenomena (Rasheed et al., 2025).

Furthermore, Islamic jurists and astronomers later used scriptural principles to develop sophisticated astronomical sciences. Observatories, astrolabes, lunar calendars, and qiblah calculations emerged from the practical need to interpret celestial movements accurately. Hence, although the Qur'an and Hadith do not provide mathematical orbital mechanics in the modern sense, they establish a worldview in which celestial bodies move with order, purpose, and measurable regularity. In conclusion, the concept of orbit in the Qur'an and Hadith is presented through theological language that emphasizes divine order, precision, and usefulness for human life. The Qur'an describes the sun and moon as moving in appointed courses, while Hadith links celestial cycles to worship and rejects superstition. Together, these sources laid an intellectual foundation that historically encouraged Muslim engagement with astronomy and continues to inspire contemporary dialogue between faith and science.

3. The Concept of Orbit in Modern Astronomy

Modern astronomy defines an orbit as the continuous path followed by a celestial body under the influence of gravity around another object, such as a planet orbiting a star, a moon orbiting a planet, or an artificial satellite orbiting Earth. The concept of orbit is fundamental in understanding the structure and dynamics of the universe. It forms the basis of celestial mechanics, a branch of physics that explains the motion of bodies in space using mathematical and physical laws. Contemporary studies show that orbital motion is not random but governed by predictable gravitational interactions that can be precisely modelled using classical and relativistic physics (Hamwadi, 2026; NASA Science Editorial Team, 2024).

The foundation of modern orbital theory was established by Johannes Kepler in the 17th century, who demonstrated that planets move in elliptical orbits with the Sun at one focus. This empirical discovery marked a shift from circular models of ancient astronomy to a more accurate representation of planetary motion. Kepler's laws remain central in astronomy today and are used to calculate orbital periods and planetary distances (Mahmoud, 2025). Later, Isaac Newton provided the physical explanation for Kepler's

laws by introducing the law of universal gravitation, showing that orbits result from the balance between gravitational attraction and inertial motion (Britannica, 2024).

In modern physics, orbit is further explained through Newtonian mechanics and Einstein's general theory of relativity. Newtonian mechanics describes orbit as the result of gravitational force acting as a centripetal force that keeps celestial bodies in continuous motion around a central mass. According to this view, an orbiting body is constantly falling toward the central object but moves forward fast enough to avoid collision (Samboy & Gallant, 2024). In contrast, Einstein's theory of general relativity explains gravity as the curvature of spacetime caused by mass and energy, meaning that planets follow curved geodesic paths in spacetime rather than being pulled by a traditional force.

Modern astronomy also classifies different types of orbits, including circular, elliptical, parabolic, and hyperbolic trajectories. Elliptical orbits are the most common in bound systems, while parabolic and hyperbolic paths describe escape trajectories of comets or spacecraft. Key orbital parameters such as eccentricity, semi-major axis, inclination, and orbital period are used to mathematically define and predict motion with high precision (Zhang et al., 2024). These parameters are essential in space missions, satellite deployment, and deep-space exploration.

Technological advancements have significantly improved our understanding of orbital dynamics (Nadiah & Nurul, 2025). High-resolution telescopes, space probes, and artificial satellites provide continuous data for refining orbital models. In addition, artificial intelligence and computational simulations are increasingly used to predict orbital changes caused by gravitational perturbations, atmospheric drag, and multi-body interactions (Hamwadi, 2026). These developments have expanded the scope of orbital studies beyond the solar system to include exoplanets, binary star systems, and galactic motion.

In conclusion, modern astronomy views orbit as a mathematically precise and physically explainable phenomenon governed by gravitational laws and spacetime geometry. From Kepler's empirical laws to Einstein's relativistic framework, the concept of orbit has evolved into a sophisticated scientific model that underpins space science, satellite technology, and our broader understanding of the universe.

4. Applications of Modern Technology in Understanding Orbit

Modern technology has significantly transformed the study and understanding of orbital motion, making it one of the most precisely measured and modelled phenomena in science today. Orbit, which refers to the gravitational path of a celestial or artificial body around another body, is now studied using advanced observational instruments, computational simulations, artificial intelligence (AI), and satellite-based systems. These technologies have expanded human capability to observe, predict, and utilise orbital behaviour with high accuracy in both scientific and practical applications (Hamwadi, 2026). One of the most important technological applications in orbital studies is the use of space telescopes and ground-based observatories. Instruments such as the Hubble Space Telescope and the James Webb Space Telescope allow astronomers to observe planetary systems, exoplanets, and deep-space objects with unprecedented clarity.

These observations provide empirical data for refining orbital models and understanding gravitational interactions in multi-body systems. Modern observatories also use adaptive optics to reduce atmospheric distortion, improving the precision of orbital tracking (Zhang et al., 2024).

Another major application is the deployment of artificial satellites and global positioning systems (GPS). Satellites operate in different orbital zones such as low Earth orbit (LEO), medium Earth orbit (MEO), and geostationary orbit (GEO). These systems are essential for communication, navigation, weather forecasting, and Earth observation. GPS satellites, for example, rely on precise orbital calculations to provide real-time location data globally, demonstrating how orbital mechanics directly supports modern infrastructure (Samir, 2025).

In recent years, computational modelling and numerical simulations have become essential tools in orbital mechanics. High-performance computing enables scientists to simulate complex orbital interactions, including gravitational perturbations, multi-body systems, and long-term orbital stability. These simulations are critical for space mission planning, asteroid tracking, and collision avoidance in increasingly crowded orbital environments (Hamwadi, 2026).

A rapidly growing development is the integration of artificial intelligence and machine learning in orbital prediction and space operations. AI systems can analyse large datasets from satellites and telescopes to predict orbital changes, detect anomalies, and improve trajectory accuracy. Recent research shows that machine learning significantly enhances orbit determination, especially in environments affected by gravitational disturbances and limited observational data (Kübler et al., 2025). AI is also being used in autonomous satellite navigation, space debris monitoring, and predictive maintenance of orbital systems (Wang, 2025).

Furthermore, federated learning and edge computing in satellites allow onboard processing of orbital data without constant reliance on Earth-based systems. This reduces communication delays and improves real-time decision-making in satellite constellations. Such innovations are particularly important for managing large-scale satellite networks, where thousands of objects must coordinate their orbital paths efficiently (Elmahallawy & Luo, 2024). In addition, modern technology supports space robotics and on-orbit servicing systems, which are increasingly used to repair, refuel, or reposition satellites. These systems depend on precise orbital calculations and AI-driven control mechanisms to ensure safe and accurate operations in space environments (Kalaycioglu, 2025).

Finally, advancements in digital twin technology and orbital intelligence systems enable scientists to create virtual models of satellites and orbital environments. These models help simulate future orbital behaviour, assess risks of collision, and optimise satellite performance in real time (Aerospace Science and Technology, 2025). In conclusion, modern technology has revolutionised the understanding of orbit by integrating observational astronomy, satellite systems, computational physics, and artificial intelligence. These advancements not only enhance scientific knowledge of celestial mechanics but also provide critical applications in communication, navigation, Earth monitoring, and space exploration. The continued development of these technologies is

expected to further deepen our understanding of orbital dynamics and improve humanity's ability to operate in space safely and efficiently.

5. Contemporary Issues and Challenges in the Study of Orbit

The rapid expansion of space activities in modern astronomy has significantly increased the complexity of orbital environments, creating a range of scientific, technological, and environmental challenges. One of the most critical issues is the growing accumulation of space debris in Earth's orbit, particularly in Low Earth Orbit (LEO), where thousands of satellites operate simultaneously. Space debris includes defunct satellites, rocket stages, and fragmented objects that travel at extremely high velocities, posing severe risks to operational spacecraft and future missions (Qureshi et al., 2025). The increasing density of orbital objects has made collision avoidance a major concern for space agencies and private companies (Sharma & Baskar, 2025).

A major contemporary issue is the Kessler Syndrome, a theoretical scenario in which collisions between space objects generate further debris, leading to a cascading chain reaction that could render certain orbital regions unusable. Recent studies highlight that the exponential growth of satellite megaconstellations has significantly increased the probability of such cascading collisions (Ballard et al., 2025). This situation threatens not only scientific satellites but also essential services such as communication, navigation, and weather forecasting (Space Debris Review, 2025).

Another major challenge is the limitation of current space situational awareness (SSA) systems. Although tracking technologies can identify large debris objects, millions of smaller fragments remain undetectable yet still capable of causing catastrophic damage upon impact. This gap between detectable and non-detectable debris creates uncertainty in orbital prediction models and reduces the reliability of collision avoidance systems (Chowdhury et al., 2025). Furthermore, inaccuracies in orbital data propagation due to atmospheric drag, gravitational perturbations, and solar radiation pressure add additional complexity to precise orbit determination (Hamwidi, 2026).

The increasing use of artificial intelligence and autonomous satellite systems introduces both opportunities and risks. While AI improves orbit prediction and collision detection, it also raises concerns about over-reliance on automated decision-making in critical space operations. Errors in algorithmic prediction or data interpretation could result in incorrect manoeuvres and increase collision risks (Hu & Zhang, 2025). Additionally, the lack of standardized global governance for AI-driven satellite operations complicates coordination among spacefaring nations (Kessler Syndrome Analysis, 2025).

Another pressing issue is orbital congestion due to mega-constellations, such as those used for global internet coverage. The deployment of thousands of satellites in similar orbital planes increases the probability of conjunction events and operational interference. Studies show that higher orbital regions are particularly vulnerable due to longer debris lifespan and weaker atmospheric drag effects, making mitigation more difficult (Ballard et al., 2025).

Environmental concerns are also emerging as a contemporary issue. Re-entry of space debris into the Earth's atmosphere can release metallic particles that may affect

atmospheric chemistry and contribute to long-term environmental changes (Qureshi et al., 2025). In addition, satellite light pollution is increasingly affecting astronomical observations, reducing the quality of both ground-based and space-based telescopic data (Hu & Zhang, 2025).

In summary, the study of orbit in the modern era is challenged by space debris proliferation, orbital congestion, technological limitations, AI dependency, and environmental impacts. Addressing these issues requires international cooperation, improved regulatory frameworks, and advanced technological solutions such as AI-based tracking systems and active debris removal strategies. Without coordinated action, the sustainability of Earth's orbital environment may face serious long-term risks.

6. Conclusion and Recommendations

This study has examined the concept of orbit from three integrated perspectives: the Qur'an, Hadith and modern astronomy. The analysis shows that although the Qur'an and Hadith do not present orbit in technical or mathematical terms, they consistently emphasize the orderly, precise, and purposeful movement of celestial bodies. Qur'anic verses such as those describing the sun and moon moving in determined courses highlight a worldview based on cosmic balance and divine regulation. Similarly, Hadith literature connects celestial motion to practical aspects of worship, including prayer times, lunar calendar determination, and eclipse observation. These sources collectively establish an epistemological foundation that encourages reflection on the natural order and the study of the heavens. Modern astronomy, on the other hand, explains orbit through physical laws, particularly gravity, motion, and spacetime geometry. From Kepler's laws of planetary motion to Newtonian mechanics and Einstein's theory of relativity, orbital motion is now understood as a predictable and mathematically modelled phenomenon. The integration of advanced technologies such as satellites, telescopes, artificial intelligence, and computational simulations has further enhanced the accuracy of orbital prediction and expanded human understanding of celestial dynamics. This demonstrates that modern science provides the empirical and quantitative framework that complements the qualitative and reflective descriptions found in Islamic sources.

In the recommendations, several key points are proposed. First, interdisciplinary research between Islamic studies and astronomy should be further developed, particularly in exploring scientific references in the Qur'an and Hadith using rigorous methodological frameworks. Second, educational curricula in Islamic institutions and universities should integrate basic astronomy and space science to strengthen scientific literacy among students of religious studies. Third, greater collaboration between Muslim scholars and modern scientists is encouraged to develop balanced interpretations that avoid both excessive literalism and forced scientific interpretations of sacred texts. Furthermore, future research should explore the ethical and environmental implications of modern orbital technology, especially in relation to space debris and satellite congestion. Finally, investment in technological innovation such as AI-based orbital tracking and sustainable space systems should be prioritized to ensure the long-term safety and usability of Earth's orbital environment.

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