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INTEGRATING ASTRONOMICAL KNOWLEDGE WITH HADITH THROUGH MODERN TECHNOLOGICAL TOOLS

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Abstract:

The integration of astronomical knowledge with Hadith represents a significant interdisciplinary approach in contemporary Islamic scholarship. This study examines how modern technological tools can enhance the understanding and interpretation of Hadith related to astronomical phenomena, such as lunar observation (ru'yah), timekeeping, and celestial events. Traditionally, the interpretation of such Hadith relied heavily on classical methodologies rooted in textual analysis and the scholarly legacy of early Muslim jurists and muhaddithun. However, the rapid advancement of digital technologies, including astronomical simulation software, big data analytics, and online Hadith databases, has opened new avenues for more precise and contextually informed analysis. This research adopts a qualitative and analytical approach by examining selected Hadith texts alongside contemporary astronomical data and technological applications. It highlights how tools such as lunar visibility models, digital repositories,

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and computational astronomy contribute to a more accurate understanding of prophetic traditions, particularly in matters related to the Islamic calendar and religious observances. The study also explores the conceptual integration of *Naqli* (revealed knowledge) and *Aqli* (rational/scientific knowledge), emphasizing that technological advancements should complement rather than replace traditional Hadith methodologies. The findings indicate that modern technology plays a crucial role in bridging the gap between classical interpretations and current scientific knowledge, offering more reliable and consistent outcomes in issues such as moon sighting and calendar determination. Nevertheless, the study also identifies several challenges, including methodological limitations, overreliance on technology, and the need to maintain the epistemological integrity of Islamic scholarship.

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Keyword:

Astronomy, Hadith, Integration, Knowledge, Scientific, Technology

Introduction

Hadith, as the second primary source of Islamic knowledge after the Qur'an, plays a crucial role in guiding various aspects of Muslim life (Hoque, Yusoff, Toure, & Mohamed, 2019), including the understanding of natural and celestial phenomena. Among these, astronomical elements such as lunar observation, timekeeping, and celestial events are frequently referenced in prophetic traditions, particularly in relation to acts of worship like fasting, pilgrimage, and prayer timings (Hoque et al, 2023). Historically, Muslim scholars relied on direct observation (*ru'yah*) and traditional interpretive methods to understand such narrations. However, the rapid advancement of modern science and technology has introduced new tools that significantly enhance the precision and scope of astronomical analysis.

Astronomy has always held an essential place in Islamic intellectual tradition, serving both theological and practical functions. It provides the scientific basis for determining the Islamic lunar calendar and aligning religious practices with observable celestial patterns (Rasheed et al., 2025). In contemporary contexts, the integration of astronomy with digital technologies—such as computational models, machine learning algorithms, and astronomical simulation software—has transformed how lunar visibility and celestial phenomena are studied. For instance, recent studies demonstrate that machine learning can accurately predict crescent moon visibility, contributing to the harmonization of Islamic calendar determinations across regions (Loucif et al., 2024; Al-Rajab et al., 2023).

Despite these advancements, a gap remains between classical Hadith interpretation and modern technological applications. Traditional approaches emphasize textual authenticity and jurisprudential frameworks, while contemporary methods prioritize empirical accuracy and data-driven analysis. This divergence often leads to debates, particularly in issues such as moon sighting for Ramadan, where discrepancies persist across Muslim communities (Abdulrahman, 2024).

Therefore, this study seeks to explore how modern technological tools can be effectively integrated with Hadith studies to enhance the understanding of astronomical narrations. By bridging *Naqli* (revealed knowledge) and *Aqli* (scientific knowledge), this research aims to contribute to a more holistic and methodologically sound approach in contemporary Islamic scholarship.

Literature Review

Recent scholarship demonstrates a growing interdisciplinary engagement between Hadith studies, astronomy, and modern technology, particularly in addressing issues related to lunar observation and Islamic calendrical systems. Classical Islamic scholarship has long emphasized the importance of celestial phenomena in religious observance, especially in determining prayer times and the beginning of lunar months. However, contemporary research increasingly highlights the need to reinterpret these traditions in light of modern scientific advancements.

A significant body of literature focuses on astronomical modeling of crescent moon visibility, which is central to understanding Hadith related to *ru'yah* (moon sighting). Studies employing machine learning and computational techniques have shown considerable progress in predicting lunar visibility with high accuracy. For instance, Al-Rajab, Loucif, and Al Risheh (2023) demonstrate that machine learning algorithms can effectively model the complex, non-linear factors influencing crescent visibility, improving prediction accuracy across diverse geographical conditions. Similarly, Loucif et al. (2024) propose a global lunar calendar model using large-scale datasets and advanced algorithms, offering a unified framework for lunar month determination. Complementing these findings, Allawi (2024) introduces neural network-based criteria that classify moon visibility into multiple observational categories, further enhancing predictive precision.

In addition to predictive modeling, recent studies have explored verification and validation of moon sighting reports, addressing inconsistencies in traditional observational methods. Research in *New Astronomy* proposes data-driven confirmation models that significantly improve the reliability of crescent sighting records, achieving high accuracy in distinguishing valid and invalid observations. These developments are particularly relevant in resolving longstanding discrepancies among Muslim communities regarding the beginning of Ramadan and other lunar months.

Another emerging trend is the application of artificial intelligence and image processing techniques in astronomical analysis. For example, Nissar et al. (2025) introduce convolutional neural networks for determining lunar age from images, marking a shift from purely mathematical models to data-driven visual analysis. More recently, Al-Rajab et al. (2026) highlight the integration of deep learning with astronomical datasets to enhance crescent

detection and lunar phase recognition, demonstrating the potential of AI in refining observational accuracy.

Parallel to advancements in astronomy, there is a growing body of literature on the digital transformation of Hadith studies. Digital databases, online repositories, and computational tools have significantly improved access to Hadith collections and enabled more systematic analysis. Scholars emphasize that such technologies facilitate cross-referencing, authentication, and thematic categorization of Hadith, thereby enhancing methodological rigor (Ali & Hassan, 2022; Khan et al., 2023; Saeed & Rahman, 2021). Furthermore, recent studies argue that integrating scientific data with textual analysis can lead to a more contextualized understanding of Hadith related to natural phenomena (Ismail et al., 2022; Yusof & Ahmad, 2021).

Despite these advancements, several studies highlight epistemological and methodological challenges in integrating Hadith with modern science. The tension between *Naqli* (revealed knowledge) and *Aqli* (empirical knowledge) remains a key issue, particularly when scientific findings appear to diverge from classical interpretations. Scholars caution against over-reliance on technology without maintaining the foundational principles of Hadith sciences, including authenticity verification and contextual interpretation (Abdullah, 2022; Rahman, 2023).

Overall, the literature indicates a clear trend toward interdisciplinary integration, where astronomy and technology are increasingly used to enhance the understanding of Hadith. However, a notable gap persists in developing a comprehensive framework that systematically combines these domains. This study seeks to address this gap by proposing an integrative approach that aligns technological advancements with traditional Hadith methodologies.

Conceptual Framework (Naqli and Aqli Integration)

The integration of *Naqli* (revealed knowledge) and *Aqli* (rational or scientific knowledge) forms a foundational epistemological framework in contemporary Islamic scholarship. This paradigm emphasizes that knowledge in Islam is inherently unified under the principle of *tawḥīd* (the oneness of God), which rejects the dichotomy between religious and empirical sciences. Rather, both sources of knowledge are viewed as complementary in understanding reality and guiding human life (Muslih et al., 2024).

Naqli knowledge refers to divine revelation derived from the Qur'an and Hadith, which provides ultimate guidance and normative principles. In contrast, *Aqli* knowledge encompasses human reasoning, scientific inquiry, and empirical observation. Contemporary scholars argue that the separation between these two domains, largely influenced by modern secular frameworks, has led to fragmentation in knowledge production within Muslim societies (Bahri et al., 2025). Therefore, reintegrating these epistemologies is essential for developing a holistic and relevant Islamic intellectual tradition.

Recent studies propose structured models for this integration, particularly within Islamic higher education institutions. For example, the INAQ (Integration of Naqli and Aqli Knowledge) framework highlights multiple levels of integration, including textual grounding (*al-nuṣūṣ*), comparative analysis (*al-muqāranah*), and contextual application (*al-taqyīm*), culminating in a comprehensive understanding (*al-tafaqquh*) (Zarkasih et al., 2021). This model demonstrates

that revealed texts and scientific knowledge can be systematically harmonized without compromising their respective epistemological boundaries.

In the context of this study, the integration framework serves as a basis for analysing Hadith related to astronomical phenomena through modern technological tools. Astronomical data and computational methods (*Aqli*) are employed to enhance the interpretation of prophetic traditions (*Naqli*), particularly in areas such as lunar observation and timekeeping. This approach does not replace traditional Hadith methodologies but rather complements them, ensuring both textual authenticity and empirical accuracy. Ultimately, the integration of *Naqli* and *Aqli* knowledge offers a balanced and dynamic framework for advancing interdisciplinary research in Islamic studies.

Methodology

This study adopts a qualitative research design based on document analysis and thematic analysis to explore the integration of astronomical knowledge with Hadith through modern technological tools. A qualitative approach is considered appropriate because the study aims to interpret religious texts alongside scientific and technological data rather than generate statistical findings (Creswell & Poth, 2018).

The primary data sources consist of selected Hadith narrations from authoritative collections, particularly *Ṣaḥīḥ al-Bukhārī* and *Ṣaḥīḥ Muslim*. The selection of Hadith was based on several criteria: (1) narrations directly related to astronomical phenomena such as lunar observation (*ru'yah*), eclipses, prayer times, and celestial movements; (2) Hadith classified as authentic (*ṣaḥīḥ*) by recognized Hadith scholars; and (3) narrations frequently referenced in classical and contemporary discussions concerning Islamic astronomy and calendrical determination. These criteria were applied to ensure the relevance, authenticity, and scholarly significance of the selected texts.

To facilitate systematic retrieval and verification, credible digital Hadith databases such as Sunnah.com and Al-Maktabah al-Shamilah (Shamela) were utilized. These platforms were selected due to their wide scholarly usage, accessibility, cross-referencing capabilities, and reliance on recognized Hadith compilations. The databases also allow thematic keyword searches and comparative examination of narrations, improving the efficiency and consistency of textual analysis.

Secondary data include recent peer-reviewed journal articles on astronomy, crescent moon visibility, artificial intelligence, and astronomical simulations. Only articles indexed in recognized academic databases were prioritized to ensure academic reliability and research quality.

The study also incorporates modern technological tools as analytical instruments, including astronomical software, lunar visibility models, and computational astronomy studies. These tools enable comparison between classical interpretations and contemporary scientific findings, particularly regarding the Islamic lunar calendar. Data were analyzed using thematic analysis by categorizing Hadith according to major astronomical themes, followed by comparative analysis to identify convergences and divergences between traditional interpretations and empirical astronomical evidence.

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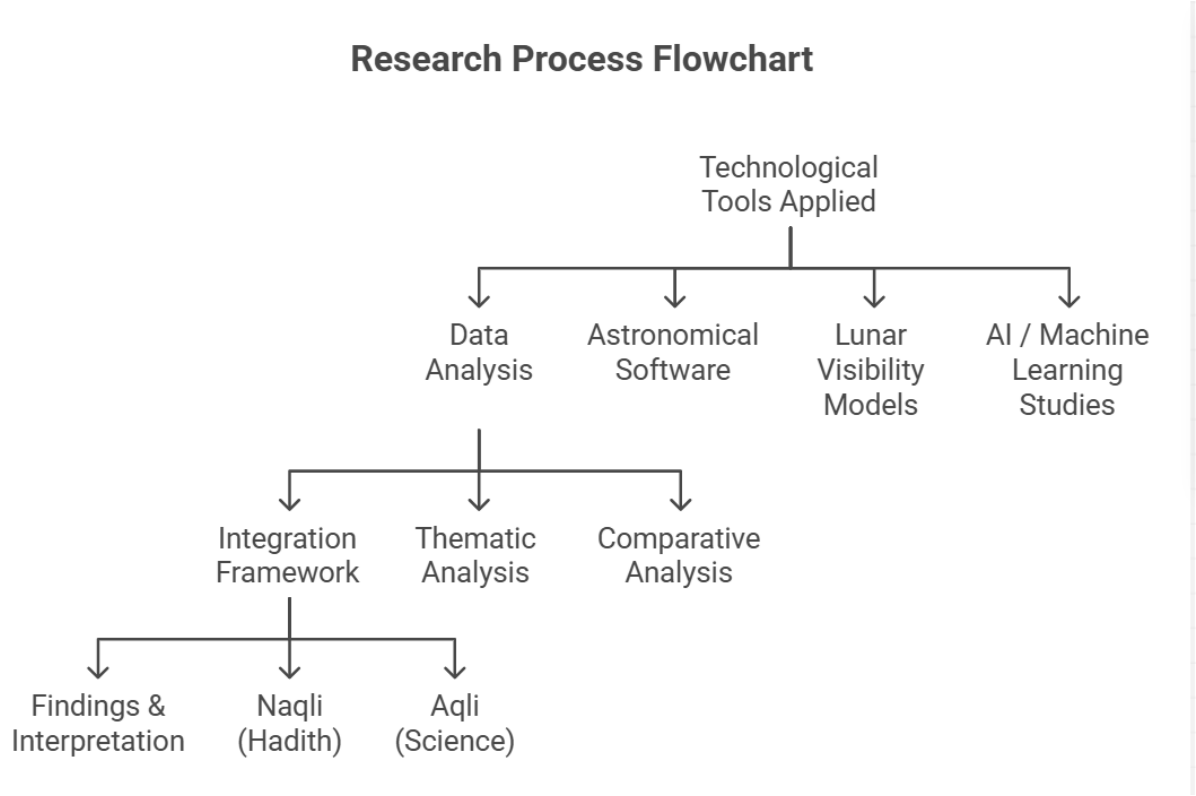
To enhance validity and reliability, triangulation was applied by integrating classical Hadith sources, scientific literature, and technological outputs. This methodological framework supports a balanced integration of *Naqli* and *Aqli* knowledge while maintaining both textual authenticity and scientific rigor.



Findings and Discussion

The findings of this study demonstrate that the integration of astronomical knowledge with Hadith through modern technological tools provides a more precise and contextually enriched understanding of prophetic traditions related to celestial phenomena. One of the key findings is that Hadiths concerning lunar observation (*ru'yah*) in which the Prophet (holding out his ten fingers thrice), said, "The month is thus and thus and thus," namely thirty days. Then (holding out his ten fingers twice and then nine fingers), he said, "It may be thus and thus and thus," namely twenty-nine days. He meant once thirty days and once twenty-nine days. (al-Bukhari, 5302). In this Hadith the Prophet Muhammad explained that the lunar month is sometimes thirty days and sometimes twenty-nine days, this can be meaningfully interpreted in light of contemporary astronomical data and computational models. Modern astronomy defines the synodic lunar month—the interval between successive new moons—as approximately 29.53059 days. This value represents an average rather than a fixed duration, and because it is not a whole number, it cannot be expressed precisely in integer days within calendar systems. Consequently, lunar months must be represented as either 29 or 30 day, which directly corresponds to the Prophetic description of variability in the length of the month. From a computational and mathematical perspective, this fractional value necessitates the alternation between 29- and 30-day months in lunar calendar systems. Contemporary studies employing mathematical modelling and modular arithmetic confirm that the lunar cycle follows a periodic structure of approximately 29.5 days, requiring discrete rounding into whole-day units for practical calendrical use (Rahmadani, 2025). This aligns with classical and modern

computational calendar models, which incorporate alternating patterns to maintain long-term synchronization with the Moon's phases.

Furthermore, recent scientific research highlights the role of advanced computational techniques in determining the Moon's position and phase within the synodic cycle. For example, Nissar et al. (2025) developed machine learning models capable of estimating the Moon's age within the synodic month using image classification, demonstrating the increasing precision of modern astronomical computations. Such developments confirm that the lunar cycle is not only predictable but also quantifiable through high-accuracy algorithms, reinforcing the empirical basis of the 29–30-day variation.

In addition, astronomical studies show that the length of the synodic month is not constant but varies slightly due to the elliptical orbit of the Moon and gravitational interactions within the Earth–Moon–Sun system. Computational analyses over long-time spans indicate that the synodic month can fluctuate within a range (approximately 29.27 to 29.81 days), depending on orbital conditions such as perigee and apogee (Saleh, 2018). This natural variation explains why some lunar months are shorter (29 days) while others extend to 30 days when expressed in whole numbers.

Moreover, observational astronomy supported by simulation software (e.g., Stellarium and ephemeris-based systems) demonstrates that the visibility of the lunar crescent (hilāl) depends on several parameters, including elongation, altitude, and atmospheric clarity. These visibility conditions typically occur within a window of approximately 18–30 hours after conjunction, which determines whether a month concludes at 29 days or extends to 30. Thus, modern lunar visibility models provide a scientific explanation for the observational basis underlying the Prophetic statement.

From an epistemological standpoint, this hadith reflects a profound harmony between *naqli* (revealed knowledge) and *'aqli* (rational scientific inquiry). While articulated in simple observational language accessible to early Muslim communities, the statement accurately captures a complex astronomical reality that is now explained through orbital mechanics, computational modelling, and data-driven simulations. In conclusion, contemporary astronomical research strongly supports the validity of the hadith's description, demonstrating that the lunar month's variation between 29 and 30 days is an inherent consequence of the Moon's non-integer synodic cycle and its dynamic orbital behaviour.

Like this, other natural astronomical event can be more accurately interpreted when supported by contemporary astronomical data and computational models. Modern technologies such as lunar visibility simulations, astronomical software, and artificial intelligence-based prediction systems significantly enhance the analytical capacity of researchers in verifying and contextualizing these narrations.

A major finding is that technological tools do not replace classical Hadith methodologies but rather strengthen them by providing empirical support. For example, Hadiths that instruct Muslims to begin fasting and end it upon sighting the crescent moon can now be examined alongside precise astronomical calculations that determine moon visibility. This helps to reduce uncertainty and regional discrepancies in determining Islamic lunar months. Studies in modern astronomy also show that machine learning models can predict crescent visibility with high

accuracy, which supports the practical application of *hisab* (calculation) alongside traditional *ru'yah* (visual observation) (Al-Rajab et al., 2023; Loucif et al., 2024).

The discussion further reveals that the integration of *Naqli* (revealed knowledge) and *Aqli* (scientific knowledge) creates a balanced epistemological framework. While Hadith provides normative guidance, astronomy and technology contribute empirical validation and contextual precision. This synergy reflects the holistic nature of Islamic epistemology, where revelation and reason are not in conflict but are mutually reinforcing. However, the findings also indicate that tensions still exist between traditional scholars who prioritize direct observation and contemporary scientists who advocate computational certainty. These differences highlight the need for continuous scholarly dialogue and methodological openness.

Another important observation is that digital tools and databases have transformed Hadith studies by enabling faster access, thematic classification, and comparative analysis of narrations. This technological shift improves research efficiency and allows broader interdisciplinary engagement. Nevertheless, the study also identifies limitations, including the risk of over-reliance on technology and the potential marginalization of classical interpretive frameworks if not carefully balanced.

In conclusion, the findings suggest that integrating astronomy and technology into Hadith studies enhances both accuracy and interpretative depth. The discussion emphasizes that a harmonized approach, grounded in both tradition and modern science, is essential for addressing contemporary challenges in Islamic calendrical and astronomical issues.

Conclusion

This study highlights the significance of integrating astronomical knowledge with Hadith through modern technological tools as a meaningful interdisciplinary approach in contemporary Islamic scholarship. The analysis demonstrates that Hadiths related to celestial phenomena, particularly lunar observation and other natural astronomical events, can be better understood when examined alongside modern astronomical data and computational technologies. The use of digital tools such as astronomical simulation software, artificial intelligence models, and online Hadith databases enhances both the accuracy and depth of interpretation.

The findings confirm that technological advancement does not replace traditional Hadith methodology but rather complements it by providing empirical support to textual analysis. This integration strengthens the relationship between *Naqli* (revealed knowledge) and *Aqli* (rational/scientific knowledge), reflecting the holistic epistemological framework of Islamic thought. It also helps address contemporary challenges such as discrepancies in moon sighting and differences in Islamic calendrical calculations across regions.

However, the study also recognizes the importance of maintaining methodological balance to avoid overdependence on technology at the expense of classical interpretive principles. Therefore, scholars must ensure that technological tools are used within the boundaries of established Hadith sciences.

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