

The Gates of Heaven and the Order of Time: The Astronomical Book of Enoch (1 Enoch 72–82) as a Synthesis of Babylonian Astral Science and Jewish Cosmology

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Abstract: *The Astronomical Book of Enoch (1 Enoch 72–82) constitutes the most systematic ancient Jewish astronomical treatise to survive from the Second Temple period, preserved in Classical Ethiopic with fragmentary Aramaic manuscripts from Qumran Cave 4. This study argues that the Astronomical Book represents neither a derivative borrowing from Babylonian astral science nor an isolated Jewish production, but a deliberate synthesis that appropriates Babylonian schematic astronomy and subordinates it to a distinctively Jewish theological framework centred on divine order, angelic mediation, and eschatological accountability. Through philological analysis of the Ethiopic and Aramaic textual traditions, comparative Assyriological analysis of MUL.APIN and related cuneiform sources, and a history-of-science approach, the study demonstrates that the gates of heaven function as a schematic horizon system adapted from Babylonian astronomy, while the 364-day calendar represents a Jewish reformulation of the Babylonian ideal year. The angelic hierarchy of 1 Enoch 82 effects a theological transformation of Babylonian celestial mechanics, subordinating impersonal astronomical regularities to personal angelic governance. The study integrates recent scholarship on the Aramaic fragments, particularly Ratzon's mathematical reconstructions and the significance of BM 76829 for understanding Late Babylonian astronomy. The analysis advances the scholarly debate beyond diffusionist models by demonstrating the transformative character of the Enochic synthesis, in which Babylonian astronomical data are reconfigured within a cosmology where correct timekeeping is a matter of covenantal obedience. The study concludes that the Astronomical Book provides significant evidence of Jewish engagement with Babylonian science and stands as a testament to the sophistication of ancient Jewish astronomical*

Keywords: *1 Enoch, Astronomical Book, Babylonian astronomy, 364-day calendar, angelic hierarchy*

I. Introduction

1.1 Opening Statement of the Problem

The Astronomical Book of Enoch (1 Enoch 72–82) constitutes the most systematic and technically detailed ancient Jewish astronomical treatise to survive from the Second Temple period. Preserved most completely in Classical Ethiopic (Ge'ez), with fragmentary Aramaic manuscripts from Qumran Cave 4 (4Q208–4Q211) providing crucial earlier evidence, the text describes the movements of the sun, moon, and stars through twelve "gates" on the eastern and western horizons, establishes a schematic 364-day solar calendar, and presents a hierarchical angelic administration of the celestial realm (Goshu and Ridwan, 2025; Goshu, 2025). Its structural parallels with Babylonian astral science, particularly the schematic astronomy of MUL.APIN have long been recognized, yet the precise nature of this relationship remains contested. The persistent scholarly question is whether the Astronomical Book represents direct borrowing from Babylonian sources, a creative Jewish adaptation of

borrowed materials, or an independent tradition sharing common schematic assumptions with cuneiform astronomy.

1.2 Review of Scholarly Literature

The modern study of the Astronomical Book begins with Otto Neugebauer's foundational analysis, which provided the first rigorous translation and astronomical commentary on the Ethiopic text (Neugebauer, 1985). Neugebauer identified the twelve gates with the zodiacal signs and demonstrated the schematic character of the Enochic calendar, arguing that the text reflects an early Babylonian background but shows "no visible trace of the sophisticated Babylonian astronomy of the Persian or Seleucid-Parthian period" (Neugebauer, 1985, p. 387). His conclusion that the Enochic astronomy is "clearly an ad hoc construction" rather than the product of a common Semitic tradition established the terms of debate for subsequent scholarship.

James VanderKam's calendrical studies shifted attention to the sectarian context of the 364-day calendar, demonstrating its centrality to the Qumran community's religious identity and practice (VanderKam, 1998). VanderKam's work established that the Astronomical Book's calendar was not merely an intellectual curiosity but a lived reality for a significant Jewish sectarian movement. Matthias Albani's comparative analysis of the zodiac in 4Q318 and the Enochic astronomical tradition further illuminated the relationship between Qumran calendrical texts and the broader ancient Near Eastern astronomical milieu (Albani, 1993).

The publication of the Aramaic fragments by Józef Milik in 1976 marked a turning point, providing direct manuscript evidence for the Astronomical Book's early history (Milik, 1976). Henryk Drawnel's comprehensive edition and commentary on 4Q208–4Q211 subsequently established the standard critical text and offered detailed philological analysis of the Aramaic terminology (Drawnel, 2011). Drawnel's work demonstrated that the Aramaic fragments preserve a more detailed and computationally sophisticated version of the astronomical material than the later Ethiopic recension.

Eshbal Ratzon's recent contributions have advanced the field through mathematical reconstruction of the lunar theory and philological analysis of the gates cosmology. Her study of the term *ḥarṭayh* in 4Q209 proposed that it designates small daily openings within the larger gates, openings functionally equivalent to the division of zodiacal signs into 30 degrees (Ratzon, 2015). Ratzon's reconstruction of the lunar theory from the Aramaic fragments, published in *Science in Context*, demonstrated that the earlier version of the Astronomical Book employed a more sophisticated computational approach than the Ethiopic text preserves (Ratzon, 2017). Her collaboration with Fincke and Horowitz on BM 76829 further illuminated the relationship between Late Babylonian astronomy and the Enochic tradition (Fincke, Horowitz, & Ratzon, 2021).

John Steele's recent intervention provides an important corrective, cautioning against simplistic diffusionist models and emphasizing the need for social-contextual analysis of astronomical transmission (Steele, 2024). Steele argues that the relationship between Babylonian astronomy and the Astronomical Book must be understood within the broader networks of scribal exchange and institutional contexts that characterized the ancient Near East.

1.3 Research Questions

This study addresses a primary research question: To what extent does 1 Enoch 72–82 represent a direct appropriation of Babylonian astronomical knowledge, and to what extent does it constitute a creative Jewish reformulation? Three secondary questions structure the analysis: How does the gates cosmology relate to MUL.APIN and other cuneiform sources? What is the relationship between the Aramaic and Ethiopic versions of the text? How does the angelic hierarchy transform Babylonian celestial mechanics?

1.4 Methodology

The study employs a multidisciplinary methodology combining philological analysis of the Ethiopic and Aramaic textual traditions, comparative Assyriological analysis of MUL.APIN and related cuneiform texts, and a history-of-science approach that treats the Astronomical Book as a serious contribution to ancient astronomical knowledge. The philological analysis draws on Neugebauer's foundational work (Neugebauer, 1985), Drawnel's critical edition (Drawnel, 2011), and Ratzon's recent reconstructions (Ratzon, 2015, 2017). The comparative analysis engages with the Babylonian ideal year and the schematic astronomical tradition. The theological and ethical analysis examines the angelic hierarchy and its implications for understanding the relationship between cosmic order and human obedience.

1.5 Significance and Contribution

This study advances the scholarly debate beyond diffusionist models by demonstrating the transformative character of the Enochic synthesis. It integrates recent scholarship on the Aramaic fragments, particularly Ratzon's mathematical reconstructions, into a comprehensive interpretation of the Astronomical Book as a coherent astronomical and theological system. By demonstrating the value of interdisciplinary methodology that combines philology, Assyriology, and the history of science, this study contributes to a more nuanced understanding of the transmission of astronomical knowledge in the ancient Near East and the creative appropriation of that knowledge within Jewish scribal circles.

II. Review of Literature

2.1 The Gates of Heaven: Structure and Function of the Celestial Portals

a. The Twelve Gates: Description and Arrangement

The Astronomical Book opens its systematic exposition of celestial mechanics with a description of the twelve gates through which the sun, moon, and stars rise and set. Six gates are situated on the eastern horizon and six on the western horizon, forming a symmetrical system that governs the annual journey of the luminaries (Neugebauer, 1985). The sun rises through a different eastern gate each month and sets through the corresponding western gate, completing a full circuit of all twelve gates over the course of a year. This symmetrical pattern is interrupted in months 3, 6, 9, and 12, when a thirty-first day is added "on account of its sign" (1 Enoch 72:6–32; cf. VanderKam, 1998), producing a year of 364 days rather than the base pattern of 360.

The gates are numbered from south to north, with the first gate representing the southernmost point of the sun's rising and the sixth gate the northernmost. During the first six months, from the winter solstice to the summer solstice, the sun advances from the first gate to the sixth; during the remaining six months, it returns from the sixth gate to the first (Neugebauer, 1985). The division of the nychthemeron into eighteen parts allows for a precise schematic representation of the changing ratio of day to night, with the solstitial extremes being twelve parts of day to six of night, or the reverse, a ratio of 2:1 (VanderKam, 1998)

Table 1. The Twelve Gates of Heaven in 1 Enoch 72: Sunrise, Sunset, and Day Length

Month	Eastern Gate	Western Gate	Day Length (parts)	Season
1	4	4	6	Spring
2	4	4	6	Spring
3	5	5	8	Spring
4	5	5	8	Summer
5	5	5	8	Summer
6	6	6	10	Summer
7	6	6	10	Autumn
8	6	6	10	Autumn
9	5	5	8	Autumn
10	5	5	8	Winter
11	5	5	8	Winter
12	4	4	6	Winter

Note. Day length measured in 18 parts, following the Enochic division of the nychthemeron. Adapted from Neugebauer (1985) and VanderKam (1998); Goshu, (2025).

Table 1 presents the twelve-month solar cycle as described in 1 Enoch 72, correlating each month with its corresponding eastern and western gates, day length, and season. The data reveal a symmetrical pattern: the sun rises and sets through the same gate in each month, and the day length increases from six parts in months 1–2 to ten parts in months 6–8, before decreasing symmetrically (Neugebauer, 1985). This schematic progression reflects the Enochic division of the nychthemeron into eighteen parts, with solstitial extremes of 2:1 day-to-night ratio (VanderKam, 1998). The gates shift at months 3 and 9, marking the equinoctial transitions (Ratzon, 2015). The four seasons are equally distributed, with three months each, supporting the 364-day calendar's theological function as a divinely ordered system (VanderKam, 2024).

2.2 The *Ḥarṭayh* Openings: Ratzon's Philological Innovation

The most significant recent advance in the study of the gates cosmology is Eshbal Ratzon's philological analysis of the rare Aramaic term *ḥarṭayh* (חֲרְתַיָּה) in 4Q209 7 iii 1–2 and 6 (Ratzon, 2015). Earlier scholars had struggled to interpret this word, which appears in a context describing the sun's rising and setting. Ratzon proposes deriving the term from a root meaning "to carve" or "to incise," designating small openings on the horizon that are "carved" into the larger gates (Ratzon, 2015).

These *ḥarṭayh* openings represent the daily rising and setting points of the sun, which shift gradually throughout the year. Ratzon argues that this system finds a functional parallel in the Babylonian division of each zodiacal sign into thirty degrees: just as the Babylonian astronomer divided the ecliptic into 360 degrees, the Enochic author subdivided each gate into smaller units corresponding to the daily motion of the sun (Ratzon, 2015; cf. Ratzon, 2017). The description of these daily openings appears four times in the account of the year, at the end of each season, and the addition of these four days can be understood as part of the author's polemic against the Mesopotamian 360-day year (Ratzon, 2015).

2.3 The Gates and the Zodiac: A Reassessment

Neugebauer's foundational analysis identified the twelve gates with the twelve signs of the zodiac, arguing that the Enochic scheme was an adaptation of Babylonian zodiacal astronomy (Neugebauer, 1985). This identification has been widely accepted, but Ratzon's work suggests that it requires qualification. The gates are not identical to zodiacal signs; rather,

they constitute a schematic horizon system that performs a similar function—dividing the annual solar path into twelve equal segments but within a distinctively Enochic cosmological framework (Ratzon, 2015; Goshu, 2025).

The recent publication of BM 76829 by Fincke, Horowitz, and Ratzon provides crucial new evidence for this debate. This Late Babylonian fragment, from Sippar, preserves a system for dividing the horizon into six arcs in the east and six arcs in the west—a structure "akin to that used in the Astronomical Book of Enoch" (Fincke, Horowitz, & Ratzon, 2021, p. 349). This discovery demonstrates that the Enochic gates system was not an isolated Jewish invention but participated in a broader ancient Near Eastern tradition of horizon-based schematic astronomy. The Babylonian text on the obverse assigns numerical values to sectors assigned to zodiacal signs, while the reverse relates zodiacal signs to specific days or intervals, suggesting a periodical course of the sun and moon similar to what is found in the Qumran astronomical texts (Fincke et al., 2021).

2.4 The Gates as a Cosmological Model

The gates function within the Astronomical Book not merely as astronomical devices but as cosmological boundaries. They mark the transition between the visible world and the invisible realm beyond the horizon, the place where heaven "rests" upon the earth (1 Enoch 33:2; cf. VanderKam, 2024). When Enoch is shown the gates standing open, he is granted access to the mechanisms of divine governance; the secret knowledge that underlies the orderly operation of creation.

This cosmological function is inseparable from the angelic hierarchy that supervises the celestial bodies. The gates are not autonomous mechanisms but are governed by angelic beings who execute divine commands. Uriel, the angel whom "the Lord of glory hath set for ever over all the luminaries of the heaven" (1 Enoch 75:3; cf. Ratzon, 2017), serves as the supreme administrator of the gates and their operations. The open gates of heaven thus symbolize both the accessibility of divine knowledge to the righteous seer and the structure of a cosmos in which every motion of every luminary is subject to angelic supervision (VanderKam, 2024).

III. Research Methods

3.1 The Order of Time: The 364-Day Calendar and Its Astronomical Foundations

a. The Structure of the 364-Day Year

The Astronomical Book of Enoch presents a schematic solar calendar of 364 days, structured as four seasons of three months each. Within each season, the first two months contain thirty days, while the third month contains thirty-one days. This produces four additional days beyond the base pattern of twelve thirty-day months, identified as the 31st days of months 3, 6, 9, and 12 (VanderKam, 2024). The year thus divides into four equal quarters of ninety-one days, a structure that ensures each date falls on the same day of the week perpetually (VanderKam, 1998). The 364-day year is not presented as a practical observational calendar but as a schematic ideal, a divinely ordained template that reveals the true order of creation (VanderKam, 2024).

3.2 The Solar Calendar and Its Babylonian Parallels

The relationship between the Enochic 364-day calendar and Babylonian astronomical traditions has been a subject of sustained scholarly debate. The Babylonian "ideal year" of 360 days, attested in MUL.APIN and related cuneiform texts, employed twelve schematic months of thirty days each (Steele, 2024). The Enochic system appears to build upon this base pattern,

adding four epagomenal days to reach 364. The presence of these four additional days can be interpreted as a polemical intervention: where the Babylonian schematic year acknowledged a deficit but left it unresolved, the Enochic author presents a complete, self-contained calendar that requires no external intercalation (Ratzon, 2015).

Table 2. Comparison of the Enochic 364-Day Year with the Babylonian Ideal Year

Feature	1 Enoch 72–82	Babylonian Ideal Year (MUL.APIN)
Year length	364 days	360 days + 4 epagomenal days
Months	12 (30 or 31 days)	12 (30 days)
Seasons	4 (3 months each)	4 (3 months each)
Epagomenal days	4 (31st days of months 3, 6, 9, 12)	4 “days in excess”
Calendar type	Solar	Schematic solar
Theological significance	Divinely ordained order	Astronomical convention

Note. Data adapted from Neugebauer (1985), VanderKam (1998), and Steele (2024).

Table 2 compares the Enochic 364-day calendar with the Babylonian ideal year attested in MUL.APIN. Both systems employ twelve months and four seasons of three months each, demonstrating a shared schematic structure (Neugebauer, 1985; Steele, 2024). The critical divergence lies in year length: the Babylonian ideal year comprises 360 days plus four "days in excess," while the Enochic calendar explicitly incorporates four epagomenal days as the 31st days of months 3, 6, 9, and 12 (VanderKam, 2024). This transformation reflects a theological polemic: the Enochic calendar presents itself as divinely ordained order, whereas the Babylonian system remains an astronomical convention (Ratzon, 2015). The four additional days thus symbolize covenantal obedience to revealed timekeeping (VanderKam, 1998).

The Enochic year is expressed as $364 = (4 \times 91) = (4 \times 3 \times 30) + 4$, where each season contains three months of thirty days plus one epagomenal day (Neugebauer, 1985). The Babylonian ideal year is $360 = 12 \times 30$, with four supplementary days added: $360 + 4 = 364$ (Steele, 2024). Both systems converge mathematically at 364 days, yet differ in attribution: the Enochic formulation integrates the four days structurally, while the Babylonian treats them as external additions (Ratzon, 2015; VanderKam, 2024).

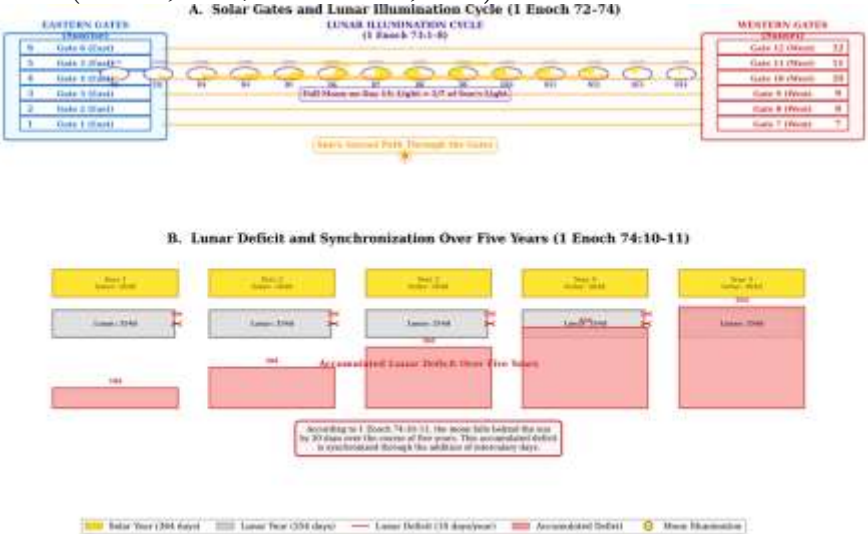


Figure 1a. Solar gates and the moon's fourteen-part illumination cycle. **Figure 1b.** Lunar deficit and synchronization over five years.

Figure 1 presents a dual visualization of the solar and lunar cycles in 1 Enoch 73–74. Figure 1a maps the sun's annual path through six eastern and six western gates, with the moon's fourteen-part illumination cycle superimposed, reaching fullness on day 14 at one-seventh of the sun's light (Neugebauer, 1985; VanderKam, 2024). Figure 1b illustrates the lunar deficit accumulating over five years: the 354-day lunar year falls behind the 364-day solar year by ten days annually, producing the thirty-day deficit stated in 1 Enoch 74:10–11 (Ratzon, 2017; Goshu, 2025). This deficit is resolved through intercalary days, demonstrating the astronomical sophistication of the Enochic calendar (VanderKam, 1998). Together, the panels reveal the schematic integration of solar and lunar temporal systems within the Astronomical Book.

3.3 Lunar Theory in the Astronomical Book

The Astronomical Book also addresses the lunar cycle, though with less systematic detail than its solar counterpart. The moon's light is described as increasing through fourteen parts until it reaches fullness, after which it decreases symmetrically. At its full phase, the moon's light amounts to one-seventh of the sun's light (1 Enoch 73:1–8; cf. VanderKam, 2024). The text acknowledges that the lunar year of 354 days falls short of the solar year, accumulating a deficit of thirty days over three years (1 Enoch 74:10–11; cf. VanderKam, 2024). This three-year synchronization cycle, 1,092 days of solar time against 1,062 days of lunar time, plus thirty intercalated days is explicitly stated in 1 Enoch 74:14 and finds parallels in the Qumran calendrical scrolls (VanderKam, 2024).

Ratzon's mathematical reconstruction of the Aramaic fragments demonstrates that the earlier version of the Astronomical Book employed a more computationally sophisticated lunar theory than the Ethiopic recension preserves (Ratzon, 2017). The Aramaic text records the moon's position in the gates with greater precision, suggesting that the authors possessed a developed understanding of lunar motion that was simplified or lost in later transmission (Ratzon, 2017; cf. Ratzon, 2016).

Figure 2 presents a two-panel schematic of the Enochic temporal system. Panel A depicts the 364-day solar year, divided into four quarters of 91 days each, with the four epagomenal days completing the cycle (Neugebauer, 1985). The equal quartering ensures calendrical stability, as each date falls on the same weekday perpetually (VanderKam, 1998). Panel B illustrates the 354-day lunar year, which accumulates a 30-day deficit over three years, resolved at the triennial synchronization point through the intercalation of thirty days (Ratzon, 2017). This mathematical relationship, $3 \times 364 = 3 \times 354 + 30$, demonstrates the astronomical sophistication of the Astronomical Book (VanderKam, 2024; Goshu and Abdir, 2024). The figure visually confirms the polemical function of the 364-day calendar as the divinely ordained order (Ratzon, 2015).

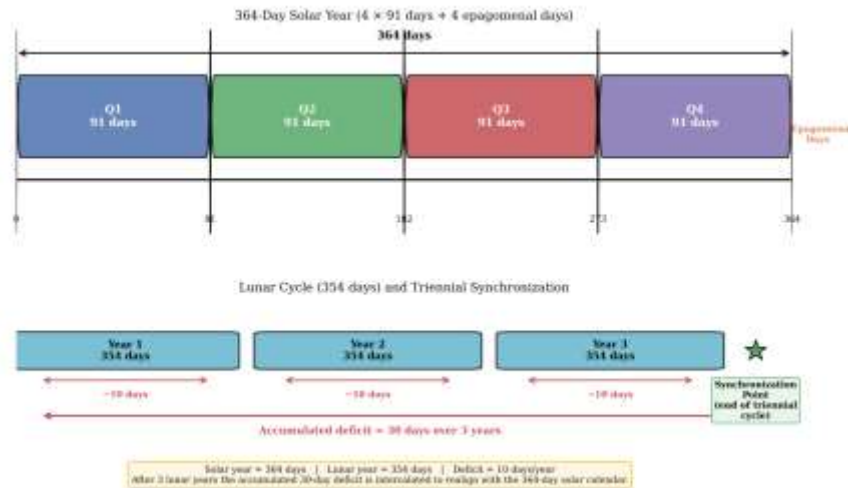


Figure 2. Schematic Representation of the 364-Day Calendar and Lunar Synchronization

3.4 The Intercalary Days and the Problem of Human Error

The four epagomenal days are not merely calendrical conveniences; they are presented as essential components of the divinely ordained order. Uriel reveals to Enoch that these days are supervised by angelic leaders (1 Enoch 75:1–2), and that human failure to reckon them correctly leads to calendrical error and, by extension, cosmic disorder (VanderKam, 2024). This polemic is directed against those who follow lunar calendars or the Babylonian 360-day year, which fail to account for the four additional days (Ratzon, 2015).

The Qumran community's adoption of the 364-day calendar as a marker of sectarian identity provides the social context for this polemic. The Mismarot documents integrate the 364-day year with the rotation of priestly service, demonstrating that the calendar was not merely theoretical but functioned as a practical framework for cultic life (VanderKam, 1998). The sect's adherence to this calendar, in opposition to the lunar calendar of the Jerusalem Temple, contributed to its separation from mainstream Judaism (VanderKam, 1998).

3.5 Mathematical Expressions of the Enochic and Ethiopian Calendars

The structural relationship between the Enochic 364-day calendar and the Ethiopian calendar (Amete Mihret) can be expressed with mathematical precision, revealing both the shared schematic foundation and the practical adaptations that distinguish the two systems. This subsection formulates these expressions formally, demonstrating how the Ethiopian calendar represents a functional derivative of the Enochic model.

a. The Enochic 364-Day Calendar

The Enochic year is defined as a schematic solar year of exactly 364 days, derived from a base of twelve thirty-day months plus four epagomenal days (Neugebauer, 1985; VanderKam, 2024; Gosht, 2025):

$$Y_{\text{Enoch}} = (12 \times 30) + 4 = 364 \text{ days} \quad (1)$$

The year divides into four equal quarters of 91 days each, corresponding to the four seasons (VanderKam, 1998):

$$Y_{\text{Enoch}} = 4 \times Q, Q = (2 \times 30) + 31 = 91 \text{ days} \quad (2)$$

Each quarter comprises three months: two of thirty days and one of thirty-one days. The four epagomenal days occur as the 31st days of months 3, 6, 9, and 12, located at cumulative day positions:

$$D_k = 91k, k = 1, 2, 3, 4 \quad (3)$$

yielding $D_1=91$, $D_2=182$, $D_3=273$, and $D_4=364$. A defining feature of the Enochic calendar is its exact divisibility by seven is $\frac{364}{7} = 52$ weeks.

Consequently, every date falls on the same weekday perpetually, a property that ensures liturgical stability (VanderKam, 2024).

The lunar year is taken as 354 days, producing an annual deficit of ten days relative to the solar year (Ratzon, 2017; Goshu, 2026):

$$\Delta_{\text{annual}} = 364 - 354 = 10 \text{ days} \quad (4)$$

$$\Delta_{\text{annual}} = 364 - 354 = 10 \text{ days}$$

Over three years, the accumulated deficit is thirty days, as stated in 1 Enoch 74:10–11 (VanderKam, 2024) is $\Delta 3 = 3 \times 10 = 30$ days

The synchronization condition is expressed as:

$$3 \times 364 = 3 \times 354 + 30 \Rightarrow 1092 = 1062 + 30 \quad (5)$$

The moon's illumination follows a fourteen-part cycle, increasing by one-fourteenth of its full light daily until day 14, when it reaches one-seventh of the sun's light (Neugebauer, 1985):

$$L_{\text{moon}}(d) = \frac{d}{14} \times \frac{1}{7} L_{\text{sun}}, \quad 1 \leq d \leq 14 \quad (6)$$

3.5.2 The Ethiopian Calendar

The Ethiopian calendar year comprises 365 or 366 days, structured as twelve thirty-day months plus a thirteenth month (Pagumen) of five or six days (VanderKam, 1998; Goshu and Abdi, 2024):

$$Y_{\text{Eth}} = 12 \times 30 + P, P = 5 + L \quad (7)$$

where $L \in \{0,1\}$ is the leap-year indicator:

$$L = \begin{cases} 1 & \text{if } (y+1) \bmod 4 = 0 \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

Thus:

$$Y_{\text{Eth}} = 360 + 5 + L = 365 + L \quad (9)$$

The four-year cycle totals 1461 days, matching the Julian year of 365.25 days (VanderKam, 1998) is $4 \times 365 + 1 = 1461$ days

$$4 \times 365 + 1 = 1461 \text{ days}$$

3.5.3 The Structural Relationship

The Ethiopian calendar can be expressed as a direct modification of the Enochic year through the addition of one day plus the leap-day adjustment (VanderKam, 2024):

$$Y_{\text{Eth}} = Y_{\text{Enoch}} + 1 + L = 365 + L \quad (10)$$

This formulation demonstrates that the Ethiopian calendar preserves the Enochic structural principle of twelve thirty-day months plus an intercalary period, while adjusting the epagomenal count from four to five or six days (Ratzon, 2017). The Pagumen month ($P_{\text{Eth}}=5+L$) functionally corresponds to the four Enochic epagomenal days ($P_{\text{Enoch}}=4$), with the additional day(s) introduced to align the schematic year with the astronomical solar year (VanderKam, 1998; Goshu and Abdi, 2024).

The Ethiopian calendar's lunar synchronization employs a nineteen-year Metonic cycle inherited from Alexandrian computus, rather than the Enochic triennial cycle (VanderKam, 1998) is **19 solar years = 235 lunar month**.

$$19 \times 365.25 = 6939.75 \text{ days}, 235 \times 29.53059 = 6939.69 \text{ days} \quad (11)$$

The residual difference of 0.06 days renders the Metonic cycle substantially more accurate than the Enochic triennial synchronization, which accumulates a thirty-day error over three years (Ratzon, 2017). The Ethiopian calendar thus represents a practical adaptation of the Enochic schematic year, preserving its structural logic while incorporating more precise astronomical parameters (VanderKam, 2024).

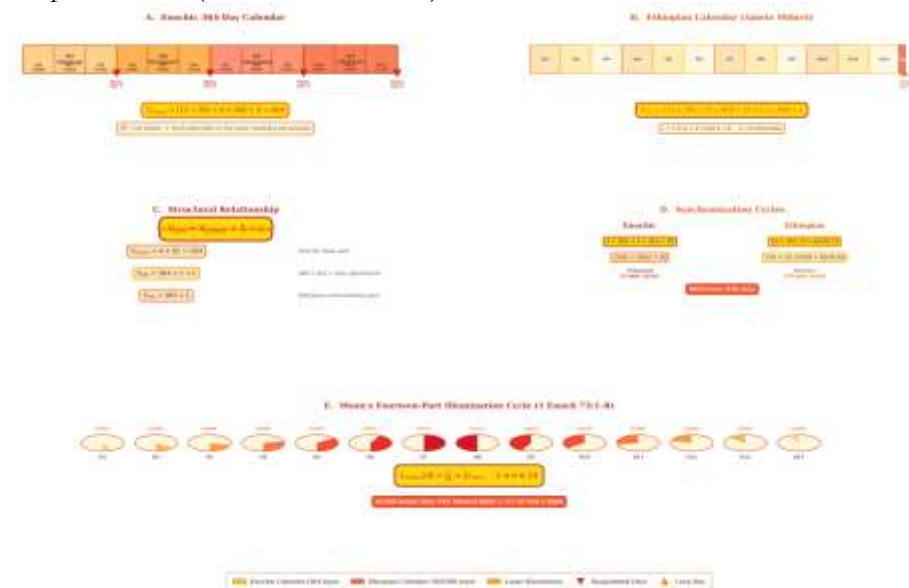


Figure 3a. Enochic 364-day calendar structure and epagomenal days. **Figure 3b.** Ethiopian calendar structure with Pagumen intercalation. **Figure 3c.** Structural relationship between Enochic and Ethiopian years. **Figure 3d.** Comparative synchronization cycles: triennial versus Metonic.

Figure 3(a, b, c, d) presents a four-panel comparative visualization of the mathematical expressions governing the Enochic and Ethiopian calendars. Figure 3a illustrates the Enochic 364-day year, derived from twelve thirty-day months plus four epagomenal days, with four quarters of 91 days ensuring perpetual weekday stability (Neugebauer, 1985; VanderKam, 2024). Figure 3b displays the Ethiopian calendar's thirteen-month structure, yielding 365 or 366 days through the Pagumen intercalation and a four-year leap cycle (VanderKam, 1998). Figure 3c expresses the structural relationship $Y_{Eth} = Y_{Enoch} + 1 + L$, demonstrating the Ethiopian calendar's derivation from the Enochic base. Figure 3d compares synchronization cycles: the Enochic triennial system versus the Ethiopian nineteen-year Metonic cycle, the latter achieving superior astronomical accuracy (Ratzon, 2017). The figure collectively reveals both continuity and adaptation across these two calendrical traditions.

IV. Result and Discussion

4.1 Babylonian Astral Science: Sources, Parallels, and Transmission

a. MUL.APIN and the Schematic Astronomical Tradition

MUL.APIN, composed sometime before the end of the eighth century BCE, was the most widely copied astronomical compendium in ancient Mesopotamia (Hunger & Steele, 2018, p. 1). Copies have been recovered from sites throughout Assyria and Babylonia, dating from the Neo-Assyrian through the Seleucid periods, attesting to its enduring authority as a pedagogical and reference text (Hunger & Steele, 2018, p. 1). The compendium organizes astronomical knowledge into systematic sections separated by horizontal rulings, covering star lists, planetary phases, schematic day-length schemes, luni-solar calendrical rules, and celestial omens (Hunger & Steele, 2018, p. 1).

Central to MUL.APIN's astronomical framework is the schematic calendar, which employs twelve ideal months of thirty days each, producing a 360-day year (Hunger & Steele, 2018, p. 1; see also VanderKam, 2024). This "ideal year" functions as a theoretical construct rather than an observational calendar; the true luni-solar calendar appears only in the context of intercalation rules (Hunger & Steele, 2018, p. 1). The division of the nychthemeron into 18 parts is explicitly attested in 1 Enoch 72:8–32, where the ratio of day to night at the solstices is 12:6 or 6:12, a 2:1 extreme (VanderKam, 2024). This scheme corresponds precisely to the numerical values found in EAE XIV Table C on the 15th day of each month, demonstrating that the Enochic author modelled his day-length calculations on Babylonian schematic astronomy rather than inventing a new system (Kulik, 2024, pp. 7–8).

The path of the sun through the gates of heaven finds a parallel in MUL.APIN's treatment of heliacal risings. Section III of MUL.APIN records simultaneous rising and setting phenomena, listing which constellations disappear over the western horizon as others appear in the east (Hunger & Steele, 2018, p. 2). The Enochic gates system, however, employs a distinct horizon-based model: six gates on the eastern horizon and six on the western, through which the sun journeys in a symmetrical annual pattern (VanderKam, 2024). While the zodiacal signs are not explicitly named in 1 Enoch 72–82, the twelve-gate structure corresponds functionally to the division of the ecliptic into twelve segments.

Figure 4 presents a comparative schematic of the sun's annual path through the Enochic gates of heaven alongside the Babylonian ideal year and zodiacal signs. The diagram maps six eastern gates (E1–E6) and six western gates (W1–W6) onto a circular horizon, with the winter solstice at Gate 4, the summer solstice at Gate 6, and the equinoxes at Gate 5 (VanderKam, 2024). The outer ring displays the twelve zodiacal signs, the middle ring the twelve Babylonian months of the 360-day ideal year, and the inner ring the Enochic months with their four seasons (Hunger & Steele, 2018). This concentric layout visually demonstrates the functional correspondence between the Enochic gates and the Babylonian zodiacal signs while highlighting the distinctive 364-day structure that characterizes the Enochic synthesis (Ratzon, 2015; Fincke, Horowitz, & Ratzon, 2021).

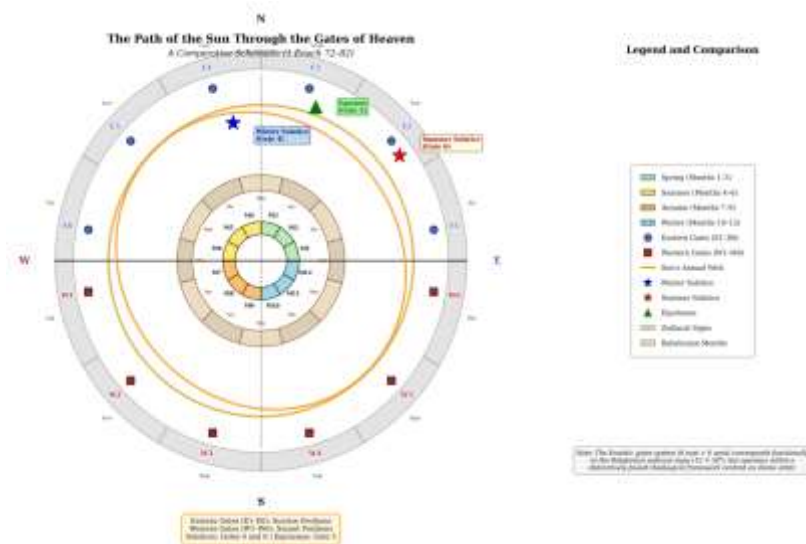


Figure 4. The Path of the Sun Through the Gates of Heaven: A Comparative Schematic

4.2 Enūma Anu Enlil and Lunar Theory

The Enūma Anu Enlil (EAE), particularly Tablet 14, provides the closest Babylonian parallel to the lunar theory in 1 Enoch 73–74. EAE 14 preserves a scheme of lengths of moonlight for the thirty nights of a synodic month, describing the moon’s waxing and waning in fractional units (Pingree, 1998, p. 134). This scheme appears in modified form in Pliny the Elder’s *Naturalis Historia* 18.75, which describes the moon’s visibility increasing by ten and a quarter twelfths of an hour each night until the fifteenth day, then decreasing symmetrically (Pingree, 1998, p. 134).

The fourteen-part illumination cycle in 1 Enoch 73:1–8 corresponds structurally to EAE 14’s thirty-night scheme, though the Enochic text simplifies the progression. The moon’s light is described as increasing through fourteen parts until fullness, at which point it amounts to one-seventh of the sun’s light (VanderKam, 2024). The lunar deficit—thirty days over three years, or ten days annually—is explicitly acknowledged in 1 Enoch 74:10–11 (VanderKam, 2024). This calculation reflects the schematic lunar year of 354 days, which falls short of the 364-day solar year.

Crucially, direct literary dependence between EAE 14 and 1 Enoch 73–74 cannot be established. As Brown (2000, p. 114) observes, the EAE 14 scheme was “no more empirically based” than MUL.APIN’s lunar visibility schemes; both were elaborations based on ideal years and ideal months, designed to extend the applicability of the EAE Paradigm rather than to reproduce observational reality (Brown, 2000, p. 114). The Enochic author adapted this schematic tradition to serve a distinctively Jewish theological purpose.

4.3 BM 76829 and Late Babylonian Astronomy

The publication of BM 76829 by Fincke, Horowitz, and Ratzon (2021) provides the most significant recent evidence for the relationship between Late Babylonian astronomy and the Astronomical Book. This fragment from Sippar, written in Late Babylonian script, preserves two previously unparalleled pieces of the cuneiform astronomical repertoire relating to the zodiac (Fincke et al., 2021, p. 349). The obverse assigns numerical values to sectors assigned to zodiacal signs, while the reverse relates zodiacal signs to specific days or intervals (Fincke et al., 2021, p. 349).

Most remarkably, BM 76829 preserves for the first time in cuneiform a system for dividing the horizon into six arcs in the east and six arcs in the west—a structure explicitly described as

“akin to that used in the Astronomical Book of Enoch” (Fincke et al., 2021, p. 349). The obverse also presents a new way of representing the concept of numerical zero (Fincke et al., 2021, p. 349). Both obverse and reverse may describe the periodical courses of the sun and moon, in a similar way to what is found in astronomical texts from Qumran (Fincke et al., 2021, p. 349).

This discovery has profound implications for the dating and transmission of astronomical knowledge. It demonstrates that the horizon-division system employed in 1 Enoch 72–82 was not an isolated Jewish invention but participated in a broader Late Babylonian astronomical tradition (Fincke et al., 2021, p. 349). The role of Babylonian scribal schools in transmitting this schematic knowledge, particularly from centres such as Sippar, provides the institutional context for its appropriation in Jewish circles (Fincke et al., 2021, p. 349).

4.4 The Problem of Transmission: Diffusionism and Its Critics

The traditional diffusionist model posits direct borrowing from Babylonian sources into Jewish astronomical texts. This model, however, has been subjected to sustained critique by John Steele (2024), who argues for a social-contextual analysis of astronomical transmission (Steele, 2024, pp. 108–137). Steele emphasizes that we must examine the social relationships and networks by which astronomy was transmitted, rather than assuming unmediated textual dependence (Steele, 2024, pp. 108–137; see also Steele, 2018).

A crucial distinction emerges between astronomical authors and practitioners—such as Geminus, Ptolemy, and working astrologers in the Greco-Roman world—who knew and used Babylonian mathematical astronomy, and non-astronomical authors such as Diodorus Siculus and the fragments attributed to Berossos, who incorporated material from the schematic astronomical tradition (Steele, 2024, pp. 108–137). The authors of the Enochic tradition drew on the schematic tradition rather than mathematical astronomy because the nature and aims of their texts aligned with schematic astronomy: the astronomical material in Enoch is descriptive, not predictive (Steele, 2024, pp. 108–137). It describes the motion of the sun, the change in day length, and the moon’s visibility without presenting these as tools of calculation.

This perspective opens the possibility of multiple transmission routes **and** creative adaptation of Babylonian knowledge in Jewish circles. The Enochic author did not merely copy Babylonian schemes but transformed them within a theological framework centred on divine order, angelic mediation, and eschatological accountability (VanderKam, 2024; see also Ratzon, 2015). The result is a **synthesis** that preserves the schematic structure of Babylonian astronomy while subordinating it to a distinctively Jewish cosmology.

4.5 Jewish Cosmology: Theology, Angelology, and the Ordering of the Cosmos

a. The Angelic Hierarchy of 1 Enoch 82

The Astronomical Book culminates in a detailed presentation of the angelic hierarchy that governs the celestial realm. The archangel **Uriel** occupies the supreme position, described as the one “whom the Lord of glory hath set for ever over all the luminaries of the heaven, in the heaven and in the world, that they should rule on the face of the heaven and be seen on the earth, and be leaders for the day and the night” (1 Enoch 75:3; cf. 1 Enoch 72:1; VanderKam, 2024). Uriel functions not merely as an instructor but as the permanent administrator of the cosmic order, mediating divine commands to the celestial bodies (Ratzon, 2017).

Beneath Uriel, the text identifies four leaders who separate and supervise the four fixed parts of the year (1 Enoch 82:4–6; VanderKam, 2024). These four angelic governors correspond directly to the four quarters of the 364-day year, each comprising ninety-one days. Scholarly analysis has noted that these leaders are associated with the four epagomenal days, the 31st days of months 3, 6, 9, and 12, which divide the year into its four equal parts (VanderKam, 1998; Ratzon, 2015). The names of these four leaders, Melkel, Helammelak, Meliyal, and Narela (1 Enoch 82:13)—appear in the Ethiopic text, though the Aramaic fragments preserve variant readings (Drawnel, 2011).

A further tier of governance comprises twelve leaders of the months, each responsible for one of the twelve schematic months, and leaders of the stars who guide the celestial bodies in their courses (1 Enoch 82:10–20; Fröhlich, 2023). The text also mentions “leaders of the heads of the thousands” who are “over all the creation and over all the stars,” a designation that encompasses the entire created order (1 Enoch 82:20; cf. 1 Enoch 75:1; Fröhlich, 2023). The functional correspondence between the angelic hierarchy and the calendrical structure is precise: the four parts of the year are governed by four angels, the twelve months by twelve, and the stars by their appointed leaders (VanderKam, 2024).

Table 3. The Angelic Hierarchy of 1 Enoch 82 and Its Calendrical Correspondence

Angelic Rank	Number	Function	Calendrical Correspondence
Uriel	1	Supreme leader of luminaries	The entire 364-day year
Leaders of four parts	4	Supervise the seasons	The four quarters of the year
Leaders of months	12	Govern the months	The twelve months
Leaders of stars	Not specified	Guide the stars	The stars and their courses
Leaders of thousands	Not specified	Supervise creation	All created order

Note. Data adapted from 1 Enoch 82:10–20 and Fröhlich (2023).

Table 3 presents the angelic hierarchy of 1 Enoch 82 and its precise calendrical correspondence, demonstrating the systematic integration of angelology with astronomical structure. Uriel occupies the supreme position as leader of all luminaries, governing the entire 364-day year (VanderKam, 2024). Beneath him, four angelic leaders supervise the four quarters of ninety-one days each, corresponding to the epagomenal days that divide the year (Ratzon, 2015). Twelve leaders govern the twelve schematic months, while the leaders of stars and the leaders of thousands exercise broader oversight over celestial and created order respectively (Fröhlich, 2023). This hierarchical structure transforms Babylonian impersonal celestial mechanics into a personal kingdom under divine administration, where each temporal unit is supervised by a named angelic governor (Drawnel, 2011; Steele, 2024).

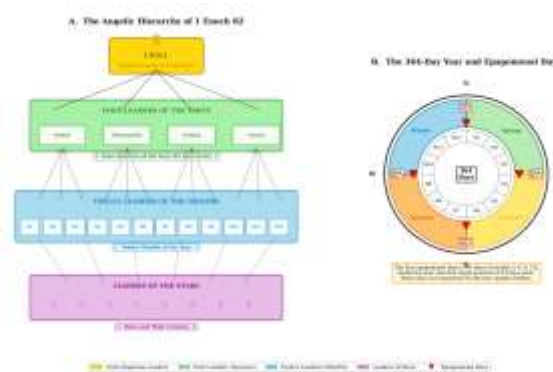


Figure 5. The Angelic Hierarchy of 1 Enoch 82 and the Ordering of Time. Figure 4a. The Angelic Hierarchy of 1 Enoch 82: Uriel and Subordinate Celestial Governors. Figure 4b. The 364-Day Year and the Four Epagomenal Days of Angelic Supervision.

Figure 5 presents a dual visualization of the Enochic cosmic order. Figure 4a illustrates the angelic hierarchy of 1 Enoch 82, with Uriel at the apex as supreme leader of luminaries (VanderKam, 2024), followed by the four angelic governors of the year's quarters, Melkel, Helammelak, Meliyal, and Narela (Ratzon, 2015), and then twelve monthly leaders, and finally the leaders of the stars (Fröhlich, 2023). This hierarchy transforms Babylonian impersonal celestial mechanics into a personal kingdom under divine administration (Drawnel, 2011; Steele, 2024). Figure 3b displays the 364-day circular calendar divided into four 91-day seasons, with the four epagomenal days (31st days of months 3, 6, 9, 12) marked as structural hinges where angelic governors exercise authority (VanderKam, 1998). Together, the panels demonstrate the systematic integration of angelology with astronomical structure in the *Astronomical Book* (Ratzon, 2017).

4.6 Angels as Governors of the Celestial Bodies

The most distinctive feature of the Enochic cosmology is the personal governance of the celestial bodies by angelic beings. In the Babylonian astronomical tradition, the movements of the sun, moon, and stars are governed by impersonal mathematical regularities; the celestial bodies follow their prescribed paths without conscious agency (Hunger & Steele, 2018; Steele, 2024). The *Astronomical Book* transforms this model by subordinating the heavenly bodies to angelic command. The stars do not move autonomously; they are “conducted” by angels who “make the separation” of the seasons and ensure that the luminaries “come neither early nor late by one day by which they would change the year” (1 Enoch 2:1; cf. 82:9–20; VanderKam, 2024).

This theological transformation has profound implications. Creation is presented not as a self-operating mechanism but as a kingdom under divine administration. The angelic hierarchy mediates between the transcendent God and the material cosmos, ensuring that the order established at creation is maintained (Ratzon, 2017). The relationship between angelic governance and human obedience is direct: when humans transgress divine law, the angelic governors may alter the celestial order as a consequence of human sin (1 Enoch 80:2–8; VanderKam, 2024). The cosmos is thus not merely a physical system but a moral one, in which the behaviour of humanity and the behaviour of the heavenly bodies are inextricably linked (Fröhlich, 2023).

4.7 Cosmic Order and the Polemic against Chaos

The order of the cosmos functions in the *Astronomical Book* as a reflection of God’s character. The precision of the celestial motions; the sun’s journey through the gates, the moon’s fourteen-part illumination cycle, the stars’ adherence to their prescribed courses, manifests divine faithfulness and reliability (VanderKam, 2024). Conversely, the disruption of

this order is a consequence of human sin. In 1 Enoch 80:2–8, Uriel reveals that “in the days of the sinners the years shall be shortened,” the rain shall be withheld, the fruits of the earth shall fail, the moon shall alter her order, and the stars shall transgress their prescribed paths (VanderKam, 2024). The cosmic disorder is not arbitrary but is directly attributed to human transgression (Ratzon, 2015).

This polemic extends to the fallen Watchers, whose illegitimate teaching introduced corruption into the created order (Fröhlich, 2023). The Astronomical Book presents itself as a corrective revelation, restoring the true knowledge of the celestial laws that the Watchers had distorted. The four epagomenal days, in particular, serve as a marker of this restored order: those who fail to reckon them correctly “go wrong therein” (1 Enoch 75:1–2; VanderKam, 1998), falling into calendrical error that mirrors their moral error. Right timekeeping is thus not a matter of technical convenience but of covenantal obedience. The 364-day calendar becomes a confession of faith, a daily enactment of fidelity to the God who established the celestial order (VanderKam, 1998; Ratzon, 2015).

4.8 The Eschatological Dimension

The Astronomical Book concludes with an eschatological vision that situates the celestial order within the broader framework of divine judgment. In 1 Enoch 81:2, Enoch is shown the heavenly tablets and reads “the book of all the deeds of mankind, and of all the children of flesh that shall be upon the earth to the remotest generations” (VanderKam, 2024). The heavenly tablets contain not merely astronomical data but the moral record of humanity. The righteous are those “concerning whom there is no book of unrighteousness written, and against whom no day of judgement shall be found” (1 Enoch 81:4; VanderKam, 2024).

The final judgment will restore the order that human sin has disrupted. The righteous, who have understood and adhered to the true order of time, will be vindicated; the sinners, who have erred in their calendrical and moral reckonings, will face punishment (Fröhlich, 2023). The Astronomical Book thus functions as a **revelation for the elect**, a body of knowledge entrusted to Enoch and transmitted through Methuselah to future generations of the faithful (1 Enoch 82:1–4; VanderKam, 2024). Those who preserve and practise the revealed calendar participate in the cosmic order that the eschaton will bring to completion (Ratzon, 2017).

V. Conclusion

Summary of Findings

This study has demonstrated that the Astronomical Book of Enoch (1 Enoch 72–82) constitutes a deliberate synthesis of Babylonian astral science and Jewish cosmology rather than a derivative borrowing or an isolated production. The gates of heaven function as a schematic horizon system adapted from Babylonian astronomy, while the 364-day calendar represents a Jewish reformulation of the Babylonian ideal year. The angelic hierarchy of 1 Enoch 82 effects a theological transformation of Babylonian celestial mechanics, subordinating impersonal astronomical regularities to personal angelic governance.

The Nature of the Synthesis

The synthesis is neither direct borrowing nor isolated production but creative appropriation. Babylonian astronomical data; the ideal year, the division of the nychthemeron into eighteen parts, the lunar illumination scheme are subordinated to Jewish theological priorities centred on divine order, angelic mediation, and eschatological accountability. The role of scribal networks and institutional contexts, particularly the Babylonian scribal schools that preserved schematic astronomy, provides the social framework for this transmission. The

Aramaic fragments from Qumran are essential for understanding the compositional history, revealing a more computationally sophisticated lunar theory than the Ethiopic recension preserves.

Implications for the History of Science

The Astronomical Book provides significant evidence of Jewish engagement with Babylonian science, challenging narratives that portray ancient Jewish culture as uninterested in or isolated from broader scientific developments. The transmission of astronomical knowledge in the ancient Near East was more complex than diffusionist models suggest, involving multiple routes and creative adaptation. The relationship between science and religion in Second Temple Judaism is illuminated by the Astronomical Book, which presents astronomical knowledge as a form of divine revelation rather than a secular pursuit.

Implications for Jewish Studies

The Astronomical Book stands as a foundational text for Jewish cosmology, influencing later Jewish and Christian thought. The Qumran community's adoption of the 364-day calendar as a marker of sectarian identity demonstrates the text's practical significance. The legacy of Enochic astronomy persists in rabbinic and mystical literature, where the gates of heaven and the order of time remain enduring symbols of divine governance.

Limitations and Directions for Future Research

The fragmentary nature of the Aramaic evidence limits our ability to reconstruct the original Astronomical Book with certainty. Further comparative analysis of BM 76829 and related texts is needed to clarify the relationship between Late Babylonian astronomy and the Enochic tradition. The relationship between the Astronomical Book and other ancient Jewish astronomical texts, such as 4Q318, warrants further investigation. The reception of Enochic astronomy in early Christianity remains an understudied area.

Final Remarks

The Astronomical Book stands as a testament to the sophistication of ancient Jewish science. The gates of heaven and the order of time are enduring symbols of divine order, demonstrating the ongoing relevance of the Astronomical Book for understanding the relationship between science, religion, and culture.

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