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The Ninth Sphere and Axial Precession in Rambam's Hilchot Yesodei HaTorah Chapter Three

Abstract and executive summary

Abstract

This study argues that Rambam's discussion of the "ninth sphere" in *Mishneh Torah*, *Hilchot Yesodei HaTorah* ch. 3 presupposes—and is most coherently read as deploying—a "starless ninth orb of the signs" that functions as the conceptual carrier of the tropical zodiac and thereby *accounts for* the phenomenon known today as axial precession (the precession of the equinoxes). Close textual analysis shows that Rambam distinguishes (i) a ninth sphere that "encompasses all," is associated with the zodiacal "signs," and is explicitly said to be starless, from (ii) the eighth sphere containing the fixed stars whose slow longitudinal drift causes misalignment between zodiacal sign-divisions and constellational figures. Rambam's quantitative remark—"approximately seventy years" for a stellar shift equal to the Sun's daily motion—encodes a precessional rate near 1°/70 years, strikingly close to the modern precession rate (~50.29″/yr). Historically, this model aligns with a well-attested Arabic/Latin cosmological tradition (often associated with Māshāʾallāh's "Orb of the Signs") and its reception in Hebrew scientific writing (notably Ibn Ezra). The article situates Rambam's formulation within Greek antecedents (Hipparchus → Ptolemy), Abbasid transmission, Andalusi/Toledan mediation, and medieval controversies over linear precession versus trepidation. [1]

Executive summary

Rambam explicitly describes **nine spheres** and characterizes the **ninth** as the all-encompassing sphere whose diurnal rotation is from east to west; in the same chapter he also reports that "the ancient sages" divided this ninth sphere into **twelve sections** corresponding to the **mazalot** (zodiacal signs). [2]

In the climactic passage, Rambam states that the ninth sphere "itself" has **no division and no star**, and that the recognizable "forms" (constellational figures) are actually configurations of prominent stars in the **eighth sphere**, which have shifted since "the time of the Flood" because the stars of the eighth sphere move slowly ("in heaviness"). [3]

Rambam then supplies a numerical rule: a distance the Sun traverses in one day corresponds to the motion of each fixed star in about **seventy years**, i.e., ~1°/70 years if the Sun's daily motion is approximated as ~1° along the ecliptic. [4]

This coupling of (a) a **starless ninth orb of "signs"** and (b) the **slow drift of the eighth-sphere constellations** is precisely the medieval cosmological strategy for explaining precession as a relative motion between a coordinate-bearing zodiac and the sphere of fixed stars. **Shlomo Sela** has argued in detail that Rambam's account reflects this "Orb of the Signs" tradition, plausibly derived from a cosmological text attributed (in Latin) to Māshāʾallāh and known in Jewish milieus of Islamic Spain. [5]

Within Hebrew scientific literature, a closely parallel logic appears in Josefina Rodríguez-Arribas [6]'s analysis of Abraham ibn Ezra [7]: the drift of the fixed stars at 1°/70 years motivates positing "something like" a superior sphere that drives daily motion, while the ecliptic and equinoxes anchor calendrical meaning. [8]

The astronomical constant "1° in 70 years" circulated as one member of a medieval family of precession values alongside Ptolemy's 1°/100 years and al-Battani's 1°/66 years; Sela documents a Latin report (transmitted through Ibn Ezra's astronomical tradition) explicitly juxtaposing these three rates ("Ptholomeus … 100 annis"; "Albateni … 66 annis"; "Azofi … 70 annis"). [9]

Finally, Rambam's value is not merely programmatic: in modern units, the IAU-adopted mean precession rate is about **50.29 arcseconds/year**; interpreting Rambam's "sun's one-day arc" as ~0.9856°/day yields ~50.69″/yr, within ~0.8% of the modern figure—well within the conceptual and observational tolerances of medieval positional astronomy. [10]

Introduction and thesis

The claim under investigation is specific: that Rambam, in *Mishneh Torah*, *Hilchot Yesodei HaTorah* ch. 3, refers to a **ninth celestial sphere** that is *responsible for axial precession*. As stated, this requires careful unpacking, because "axial precession" is a modern dynamical explanation (Earth's spin axis precesses under external torques), whereas Rambam's cosmology is geocentric and sphere-based. [11]

This article advances a thesis with two parts:

1. **Textual thesis (what Rambam says):** Rambam distinguishes the **ninth sphere** as a starless, all-encompassing sphere associated with the **twelve signs** (mazalot), while the **eighth sphere** contains the fixed stars whose slow longitudinal drift (≈1° per ~70 years) has displaced the constellational figures relative to the sign-divisions. [12]

2. **Interpretive thesis (what that implies):** The only astronomically coherent way to reconcile a **starless zodiacal ninth sphere** with a **moving stellar eighth sphere** is to read Rambam as adopting the medieval "Orb of the Signs" model—well attested in Arabic/Latin cosmological traditions—whose explanatory target is exactly what modern astronomy calls **precession of the equinoxes** (a coordinate drift manifested observationally as the slow shift between the equinox-defined zodiac and the backdrop of fixed stars). In this sense, the ninth sphere is "responsible" not as a physical torque-agent, but as the structural *cosmological posit* that allows precession to be represented as a relative motion between the eighth-sphere stars and an equinox-anchored zodiacal frame. [13]

Under journal-article conventions, the argument proceeds by (i) establishing the precise wording and translation of Rambam's passage, (ii) situating it among Greek and Islamic antecedents and the 12th-century transmission environment, (iii) comparing it with medieval Jewish scientific writing, and (iv) analyzing the numerical claim and model mechanics against modern precession constants and medieval uncertainties. [14]

Sources and methodology

The study uses a source-prioritization approach typical of historical astronomy:

Primary textual control is through Rambam's Hebrew and a widely used modern English translation. The chapter is cited from the Chabad-hosted bilingual presentation (translated by Rabbi Eliyahu Touger, published under Moznaim), which supplies aligned Hebrew and English and preserves the internal halakhic numbering; Hebrew readings are cross-checked against a vocalized Hebrew presentation at Mechon Mamre. [15]

Interpretive and historical framing relies heavily on peer-reviewed and scholarly research, especially Shlomo Sela [16]'s detailed study of Rambam and the "ninth orb of the signs" tradition, which directly addresses *Hilchot Yesodei HaTorah* ch. 3 and connects it to Arabic/Latin cosmological lineages. [17]

For Greek antecedents and the late antique precession constant, the analysis uses modern historians' close engagement with Ptolemy's *Almagest* and its precession parameter (notably Dennis Duke [18] and Alexander Jones [19]), rather than relying on paraphrase-only summaries. [20]

For Islamic astronomy and parameter history, the study draws on (i) a peer-reviewed analysis of Ibn Yunus's precession reporting, and (ii) a detailed academic study of al-Sufi's stellar catalogue and its precession correction procedure. [21]

Transmission history (Greek → Arabic → Latin, with 12th-century Iberian nodes) is supported using institutional reference resources and scholarly prosopography: a Qatar Digital Library exposition of Arabic Almagest translations and a Bavarian Academy resource on Gerard of Cremona's Arabo-Latin *Almagest*. [22]

Numerical comparisons are derived from (a) Rambam's stated ratio, (b) medieval constants as documented in the above sources, and (c) modern IAU values as reported in NASA technical literature and university-level positional astronomy notes. [10]

Textual analysis of Hilchot Yesodei HaTorah chapter three

Rambam's key moves occur in the contiguous sequence where he (1) enumerates the spheres, (2) defines the ninth orb's diurnal role, (3) reports an ancient division of the ninth into twelve sections named for zodiacal "forms," (4) denies that the ninth itself contains such forms or stars, and (5) explains the present misalignment by a slow stellar drift with an explicit numerical scale.

The nine spheres and the diurnal ninth sphere

Rambam states in English (Touger translation):

> "The spheres are called the heavens... There are nine spheres... The eighth sphere contains all the stars... The ninth sphere is the sphere which revolves each day from the east to the west. It surrounds and encompasses everything." [23]

The corresponding Hebrew line is explicit:

"וְגַלְגַּל תְּשִׁיעִי — הוּא גַּלְגַּל הַחוֹזֵר בְּכָל יוֹם מִן הַמִּזְרָח לְמַעֲרָב וְהוּא הַמַּקִּיף וּמְסַבֵּב אֶת הַכֹּל".[24]

This is the standard medieval "primum mobile" function (daily east-to-west rotation), but Rambam's later identification of this same ninth orb with a zodiacal *division into twelve* is what generates the interpretive pressure: the diurnal outer sphere becomes simultaneously the *carrier of the signs* (mazalot), which is not the default Ptolemaic arrangement. [25]

The ninth sphere divided into twelve "sections" and the starless clarification

Rambam continues:

> "The ninth sphere, which encompasses all the others, was divided by the Sages of the early generations into twelve sections... These are the mazalot... [named] the lamb, the ox... the fish." [24]

He immediately adds the critical restriction:

> "The ninth sphere itself has no division, nor does it possess any of these shapes or any stars. Rather, the larger stars of the constellations of the eighth sphere are seen in the shape of these forms..." [25]

Hebrew is unambiguous about the ninth orb being starless and "undivided" in itself:

"...גַּלְגַּל הַתְּשִׁיעִי עַצְמוֹ, אֵין בּוֹ לֹא חֲלֻקָּה ה... וְלֹא כּוֹכָב"[24]

This two-step structure (affirm a 12-fold division, then deny intrinsic division) is a hallmark of the *astronomical* conception of "signs" as idealized equal arcs of the ecliptic, contrasted with the *constellational figures* formed by stars. Rambam's formulation anticipates precisely this distinction. [9]

The "Flood epoch" alignment and the slow drift of the eighth-sphere stars

Rambam then states:

> "These twelve forms corresponded to these divisions only at the time of the flood... However, at present, they have already moved slightly, because all the stars in the eighth sphere move, as the sun and the moon do. It is just that these stars move more slowly." [3]

The Hebrew likewise attributes the misalignment to a slow motion of the stars in the eighth sphere:

"אֲבָל בַּזְּמַן הַזֶּה כְּבָר סָבְבוּ מְעַט... שֶׁכָּל הַכּוֹכָבִים שֶׁבְּגַלְגַּל שְׁמִינִי כֻּלָּם סוֹבְבִים... אֶלָּא שֶׁהֵן סוֹבְבִין בִּכְבֵדוּת."[26]

The "Flood" chronological anchor is not required by astronomy; rather, it is a marker of a *received cosmological narrative* about when the zodiacal naming/partitioning was fixed. Sela's study argues that this narrative element is characteristic of the "Orb of the Signs" tradition associated with cosmological works attributed to Māshāʾallāh. [27]

The numerical claim: “one day” equals “about seventy years”

Finally, Rambam quantifies the drift:

> “It would take any of these stars approximately seventy years to move the same distance which the sun and the moon move in one day.” [4]

Hebrew:

> “וְחֶלְקָן... בְּיוֹם אֶחָד — יֵלֵךְ... כָּל כּוֹכָב... בְּקֵרוּב מֵשׁ בְּעִים שָׁנָה.” [28]

A textual note embedded in the translation tradition is crucial: Chabad’s footnote explains that “authoritative manuscripts” omit “and the moon,” since lunar daily motion differs sharply from solar daily motion, implying that the intended comparator is the Sun’s ≈1°/day motion along the ecliptic. [29]

Translational control comparison

Because the central claim hinges on whether the passage truly encodes precession, it helps to compare Touger with an older public-domain translation tradition (digitized in the Sefaria ecosystem from Simon Glazer’s 1927 translation). The Sefaria snippet for *Foundations of the Torah* 3:1 indicates the same conceptual content: “It would take any of these stars approximately seventy years…” and identifies the translation as “Mishnah Torah, Yod ha-hazakah, trans. by Simon Glazer, 1927.” [30]

On philological grounds, the key semantic load resides not in subtle diction but in the coupled assertions: (a) ninth sphere “divided” into 12 mazalot vs (b) ninth sphere itself “has no star,” and (c) misalignment caused by slow motion of eighth-sphere stars with an explicit 70-year ratio. These features are stable across the cited Hebrew witnesses and the Touger rendering. [12]

Table of Rambam’s key phrases and interpretive implications

Rambam phrase (Hebrew / English)	Immediate sense in ch. 3	Astronomical implication
“גַּלְגַּל תְּשִׁיעִי... הַחוֹזֵר... מִן הַמִּזְרָח לְמַעֲרָב... הַמַּקִּיף וּמְסַבֵּב אֶת הַכֹּל” / “The ninth sphere... revolves each day... encompasses everything”	Outermost diurnal mover	Standard “primum mobile” role in nested-sphere cosmology [31]
“גַּלְגַּל הַתְּשִׁיעִי... חֻלְּקוּהוּ... לִשְׁנֵים עָשָׂר חֲלָקִים... הַמַּזָּלוֹת” / “divided... into twelve sections... the mazalot”	Zodiacal sign-division reported as ancient tradition	Suggests a *sign-bearing* orb distinct from the starry orb (unusual in strict Ptolemaic layout) [25]
“גַּלְגַּל הַתְּשִׁיעִי עַצְמוֹ... וְלֹא כוֹכָב” / “The ninth sphere itself... has... no stars”	Explicit starless ninth	Matches the medieval “Orb of the Signs” concept (zodiac as ideal divisions, not star bodies) [32]

Rambam phrase (Hebrew / English)	Immediate sense in ch. 3	Astronomical implication
“כְּבָר סָבְבוּ מְעַט… כָּל הַכּוֹכָבִים שֶׁבַּגַּלְגַּל שְׁמִינִי… סוֹבְבִין בִּכְבֵדוּת” / “they have moved slightly… all the stars in the eighth sphere move… slowly”	Misalignment attributed to slow motion of fixed stars	Describes precession as a slow longitudinal drift of the star sphere relative to sign-divisions [24]
“בְּקֵרוּב מֵשׁ בָּעִים שָׁנָה” / “approximately seventy years” for one-day solar arc	Quantitative constant	Encodes ≈1°/70 yr, a recognized medieval precession constant [4]

Historical context and transmission

The interpretive question is not whether Rambam knew “precession” in some vague sense, but whether his *specific ninth-sphere formulation* belongs to a recognizable intellectual lineage that uses a starless orb-of-signs to stabilize an equinox-defined zodiac while allowing the fixed stars to drift.

Greek antecedents: Hipparchus and Ptolemy as the parameter baseline

In the Greek tradition, precession is classically associated with Hipparchus and is parameterized in Ptolemy’s *Almagest*. Modern scholarship emphasizes that Ptolemy adopts a precession rate of **1° in 100 years** and attributes related reasoning to Hipparchus. [33]

The point for Rambam’s context is twofold: (i) precession is already a standard parameter in the Almagest tradition, and (ii) this parameter becomes a locus for later Islamic revision and for medieval disagreement (precession vs trepidation). [34]

Abbasid and post-Abbasid astronomy: revised constants and the “menu of rates”

Arabic-Islamic astronomy inherited the Almagest and revised its parameters through long-baseline comparisons and improved observational practice. A documented avenue is the translation tradition of the Almagest itself: multiple Arabic translations, including those associated with al-Ḥajjāj and with Isḥāq ibn Ḥunayn as emended by Thābit ibn Qurra; these versions later nourished the Arabic-to-Latin transmission in 12th-century Iberia. [35]

The same translation ecosystem explicitly facilitated the survival and study of the Almagest in Andalusia and beyond, and it is part of the background against which Arabic astronomical parameters circulated into Hebrew scientific writing. [36]

For the precession constant itself, later Arabic observers often preferred values closer to the modern rate than Ptolemy’s 1°/100 years. The peer-reviewed study of Ibn Yunus’s report describes the precession parameter as central for updating star and planetary tables and situates it in a long history of Greek and Islamic observational work. [34]

A detailed academic study of al-Sufi’s star catalogue shows how a concrete precession constant was applied to translate Ptolemy’s star longitudes to a later epoch; al-Sufi “adding 12 degrees 42 minutes” to Ptolemy’s

longitudes “to allow for precession,” and using a 1° per 66 years constant as the chosen parameter in that computation. [37]

This is exactly the kind of parameterized practice a medieval author like Rambam presupposes when he speaks of the fixed stars having “already moved slightly” relative to sign divisions. [38]

The “Orb of the Signs” and the ninth sphere in Arabic/Latin cosmology

The most direct historical bridge to Rambam’s ninth-sphere formulation is the “Orb of the Signs” tradition analyzed by Sela. In his account, Rambam presents the ninth orb as starless, divided into twelve signs, and distinct from the mobile constellations of the eighth sphere; this corresponds to a cosmological strategy of distinguishing **static signs** (equinox-anchored) from **mobile constellations** (star patterns). [17]

Sela’s analysis frames this as the reception of a starless ninth orb of signs, which Rambam addresses in *Hilchot Yesodei HaTorah* and later in the *Guide of the Perplexed*. [39]

Sela further notes that in philosophical circles, the status of a starless ninth sphere could be debated: he quotes Averroes as finding such a ninth starless sphere “far-fetched” because a sphere exists for the sake of the star that is its noblest part. [40]

This provides a historically grounded explanation for why Rambam’s ninth sphere receives a distinctive treatment: it stands at a crossroads between physical astronomy, cosmological metaphysics, and astrological sign theory, and it is precisely the starless “sign sphere” that allows the drift (precession) to be conceptualized without moving the signs themselves. [27]

12th-century Iberia, Toledo, and the “transmission corridor” toward Rambam

The institutional record confirms a strong channel for transmission into the Latin West (and meaningfully, into the bilingual Arabic–Hebrew intellectual environment) through Arabic translations and a later Latin translation program. The Qatar Digital Library describes the Almagest as transmitted to Europeans “through Arabic translations in the ninth century” and translated into Latin in the twelfth century. [41]

The Bavarian Academy resource documents that Gerard of Cremona translated the Almagest from Arabic into Latin in Toledo between roughly the mid-12th century and 1175 and used multiple Arabic versions. [42]

Within that same Toledo-centered environment, the Toledan Tables were compiled and widely used; *Britannica* notes that they were compiled in Spain by Muslim and Jewish astronomers and put into final form by Ibn al-Zarqallu around 1080, then translated into Latin. [43]

The relevance to Rambam is not that he depended on a Latin corridor, but that 11th–12th-century Iberia and its connected networks sustained a technical astronomical culture in which precession parameters and “eighth sphere” theories circulated among Jewish scholars, including Ibn Ezra. Sela’s broader narrative explicitly frames the orb-of-signs tradition as widely known among Jewish intellectuals in Muslim Spain before Rambam. [27]

Medieval Jewish scientific discourse: Ibn Ezra as a close analogue

A striking parallel to Rambam's conceptual architecture appears in Rodriguez-Arribas's analysis of Ibn Ezra. She quotes Ibn Ezra as stating that "the stars move from west to east one degree every 70 years," and that because the star sphere and planetary spheres exhibit a daily motion opposite the stars' own slow motion, "something like the form of a sphere... exists above all of them, moving everything with its own motion." [8]

That passage is historically significant because it demonstrates (i) the 1°/70 years constant in Hebrew scientific discourse, and (ii) the motivation to posit a superior or upper sphere to account for the composite motions—exactly the kind of reasoning Rambam echoes when he explains daily motion, starless sign division, and the slow drift of the eighth sphere. [44]

Mermaid timeline of transmission

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timeline
    title Transmission of precession knowledge into Rambam's milieu
    2nd c BCE : Hipparchus identifies systematic shift of equinoxes vs fixed
stars (precession)
    2nd c CE  : Ptolemy parameterizes precession in the Almagest (canonical
Greek synthesis)
    9th c     : Almagest translated into Arabic in Abbasid context; multiple
translation traditions form
    9th–10th c: Islamic astronomers refine parameters (precession constants
debated and updated)
    11th c    : Andalusi astronomy and tables develop; Toledan milieu becomes an
astronomical hub
    12th c    : Hebrew scientific writing in Iberia (e.g., Ibn Ezra) discusses
1°/70 years and upper spheres
    12th c    : Rambam composes Mishneh Torah in Egypt; integrates a starless
ninth orb of signs and a 70-year drift
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The translation-chain claims in the timeline (Arabic Almagest transmission; Latin translation in the 12th century) are documented in institutional scholarship. [45]

Astronomical analysis

The decisive question is whether Rambam's description is better understood as *axial precession* (modern dynamical explanation) or merely as some ad hoc "movement of stars." The strongest reading is that Rambam describes *the same observable phenomenon* that modern astronomy explains via axial precession, using the geocentric sphere-motion idiom inherited from the Almagest tradition.

Reconciling models: axial precession vs "motion of the eighth sphere"

Modern astronomy describes precession as the slow precessional motion of Earth's rotation axis, which shifts the equinox points relative to the fixed stars and produces a ≈26,000-year cycle. A NASA technical

document reports an adopted IAU value of about **−50.29″/year** for precession, reflecting modern measurement standards. [46]

In ancient and medieval *phenomenological* astronomy, the same effect is often represented as a slow motion of the "sphere of fixed stars" (the eighth sphere) relative to equinox-defined coordinate points and sign divisions. The Ibn Yunus study explicitly notes that in modern astronomy precession is justified by Earth's axial motion, while ancient astronomy justified it by different methods, including interpreting it as the westward motion of equinoxes. [47]

Rambam's formulation belongs to this older representational logic: the constellation figures (eighth sphere stars) have "moved slightly" relative to the twelve sign divisions associated with the ninth sphere. That is observationally equivalent to precession of the equinoxes. [25]

Geometry: what "moves" in each frame

A minimal modern–medieval reconciliation can be stated precisely:

- Modern: the *equator/equinox reference frame* shifts because Earth's axis precesses.
- Medieval (Rambam's idiom): the *eighth sphere stars* shift relative to the sign divisions (which are treated as fixed conceptual arcs). [48]

A standard university-level description of lunisolar precession notes that precession adds about **50.35″ per year** to the ecliptic longitude of every star, leaving ecliptic latitude essentially unchanged—exactly the sort of "longitude drift" Rambam describes. [49]

Rate comparison: Rambam's 70-year rule and medieval constants

Rambam's statement gives a ratio: the distance a star covers in ~70 years equals the Sun's distance in 1 day. In the simplest approximation used in many medieval texts, the Sun advances about 1° per day along the ecliptic, so Rambam's statement encodes about **1° per 70 years**. Sela explicitly identifies this as the "value of 1° in 70 years… implicit at the end of LFT III:7," and situates it among medieval precession constants. [50]

To be explicit, the principal medieval constants relevant to Rambam's milieu are:

- Ptolemaic constant: **1°/100 years** (≈36″/yr). [51]
- al-Battani constant: **1°/66 years** (≈54.5″/yr) as a refined post-Ptolemaic measure. [52]
- Ibn Yunus reporting tradition: a value close to **1°/70.25 years** is relevant because it is a rival near-70ish constant in Islamic parameter culture. [47]
- Rambam: **≈1°/70 years**. [4]
- Ibn Ezra (explicit in Rodriguez-Arribas): **1°/70 years**. [8]

Modern reference values cluster near **50.29″/yr**, corresponding to ~1°/71.6 years. [10]

Table of rates: sources, dates, and values

Source tradition	Approx. date	Reported/used rate (as stated in scholarship)	Equivalent arcsec/year	Notes
Greek parameterization (Ptolemaic)	2nd c CE	1° / 100 years [51]	36″/yr	Baseline constant widely transmitted and later criticized
Islamic revision (al-Battani tradition)	9th–10th c	1° / 66 years [52]	~54.5″/yr	Appears in medieval comparative lists of constants
Islamic reporting (Ibn Yunus parameter discussions)	10th–11th c	near 1° / 70.25 years (as discussed in modern study of the reports) [47]	~51.25″/yr	Illustrates the existence of near-70 constants in Egypt-linked astronomy
Hebrew scientific discourse (Ibn Ezra, per Rodriguez-Arribas)	12th c	1° / 70 years [8]	~51.43″/yr	Used to motivate an "upper" sphere framework in Ibn Ezra's cosmology
Rambam (Yesodei HaTorah ch. 3)	12th c	~1° / 70 years inferred from "one day" vs "~70 years" [4]	~51.43″/yr	Encoded as a comparative ratio rather than a direct precession statement
Modern IAU-adopted mean rate (NASA technical reporting)	modern	~50.29″/year [46]	50.29″/yr	Varies slightly over time; modern theory-based reference

Rambam's number vs modern value: why the match is plausibility-enhancing

If Rambam's "one day" is taken as "one degree," then 1°/70 years equals ~51.43″/yr, a modest (~2–3%) deviation from modern 50.29″/yr. If instead one uses the Sun's mean daily motion (~360°/365.24 ≈ 0.9856°/day), then Rambam's ratio implies ~0.9856°/70 years ≈ 50.69″/yr, within ~0.8% of the modern mean rate. [53]

In a medieval observational–computational setting, where different astronomical schools offered competing constants (36″/yr vs ~54.5″/yr vs ~51″/yr), Rambam's selection of a near-modern figure is historically plausible as a choice among circulating parameters, not as a uniquely "modern" discovery. The textual evidence that Iberian Hebrew astronomy explicitly contrasted Ptolemy's 100-year degree, al-Battani's 66-year degree, and "Azofi's" 70-year degree reinforces precisely this setting of options. [9]

The ninth sphere as the "responsibility locus"

The core of the thesis is not that Rambam supplies a torque-based cause; rather, he adopts a cosmological architecture in which the **ninth sphere** defines a sign-division schema that remains stable (conceptually) while the eighth-sphere stars drift. Sela explicitly articulates that Rambam draws "a sharp distinction between the twelve signs of the ninth orb… essentially static… [and] the twelve constellations… mobile (moving with the eastward motion of the eighth orb)." [17]

In other words, the ninth sphere is "responsible" in the same way a reference frame is responsible: it is the structural postulate that makes the *phenomenon* legible as precession—i.e., a mismatch between two coordinate systems (equinox-anchored signs vs star-anchored constellations). [54]

Counterarguments and evaluation

A rigorous thesis must address plausible alternative readings.

The eighth sphere, not the ninth sphere, "moves"—so how can the ninth be responsible?

Textually, Rambam attributes the *motion* to the stars of the eighth sphere ("all the stars in the eighth sphere move… slowly") and not to the ninth. [55]

Response: the thesis does not require the ninth to be the *moving body* that causes precession; rather, it requires that Rambam's ninth sphere is the **orb of signs** whose conceptual stability allows precession to be described as a relative shift. This is exactly Sela's framing: Rambam uses the ninth orb to host "static" signs while the eighth provides "mobile" constellations. [27]

Thus, "responsible for precession" is best read as "the ninth sphere is the cosmological device that makes precession intelligible as a star-vs-sign drift," not as "the ninth sphere physically drags Earth's axis." [56]

Could Rambam be describing trepidation rather than uniform precession?

Medieval Latin and some Islamic traditions sometimes used "trepidation" models—oscillatory motions of the eighth sphere—rather than uniform linear precession; these models were incorporated into major table traditions (e.g., in the later Latin Alfonsine framework) and were subject to criticism. [57]

Rambam's language, however, is linear and monotonic: "they have already moved slightly… [because] all the stars… move… slowly," followed by a fixed time-per-distance ratio. Nothing in the passage suggests periodic reversal or oscillation. [55]

Moreover, Rodriguez-Arribas explicitly notes (in the Ibn Ezra context) that while some astronomers supported trepidation as an explanation, Ibn Ezra is not among them—consistent with a uniform drift model that matches Rambam's. [8]

The “Flood” reference looks non-astronomical—does it undermine the scientific reading?

The “time of the flood” is indeed not an astronomically motivated epoch marker. [58]

However, Sela’s analysis uses this feature as part of the fingerprint linking Rambam’s passage to a specific cosmo-astrological narrative tradition (the orb-of-signs account attributed to Māshāʾallāh and related Arabic materials), where such historical anchoring serves broader claims about the “natural reality” of signs and the structuring of sacred chronology. [27]

Thus, rather than undermining the astronomical reading, the Flood motif strengthens the *source-critical* argument: it looks like inherited cosmological lore embedded in a largely technical description. [50]

Rambam’s anti-astrological stance: why would he incorporate an “Orb of the Signs” doctrine?

Rambam is famous for criticizing astrology, yet the orb-of-signs tradition has strong astrological motivations. Sela directly addresses this tension by framing Rambam’s passage as a reception and transformation of the theory, not necessarily an endorsement of astrology’s normative claims. [59]

Textually, Rambam attributes the division to “the ancient sages” and immediately qualifies that the ninth sphere itself contains no such divisions or star-forms. This fits a pattern of reporting and rationalizing an astronomical distinction (sign arcs vs star constellations) while bracketing astrological metaphysics. [25]

Could the 70-year figure be merely rhetorical or derivative without real astronomical import?

The 70-year value is embedded in a quantitatively meaningful ratio. Sela shows that it corresponds to a recognized precession constant within medieval discourse and that medieval Hebrew/Latin scientific texts explicitly compared the competing constants (100, 66, 70). [9]

Further, the modern proximity of the implied rate to the IAU value is not a proof of “modernity,” but it does increase plausibility that Rambam is using a serious astronomical constant rather than a purely rhetorical number. [53]

Conclusion and bibliography

Rambam’s passage in *Hilchot Yesodei HaTorah* ch. 3 does more than list spheres: it constructs a **two-layer zodiacal framework** in which a starless ninth sphere is associated with twelve sign divisions (“mazalot”), while the starry eighth sphere’s slow motion displaces the constellational figures relative to those divisions. The encoded constant—roughly **one degree per seventy years**—is a known medieval precession value and stands close to the modern precession rate. [60]

Historically, the best explanatory hypothesis is that Rambam is participating in a specific Arabic/Latin cosmological tradition of a **“ninth orb of the signs”** that stabilizes an equinox-defined zodiac. This

interpretation is strongly supported by Sela's peer-reviewed source-critical analysis and reinforced by parallel Hebrew scientific cosmology in Ibn Ezra as analyzed by Rodriguez-Arribas. [61]

In anachronistic modern terms, Rambam does not teach "axial precession" as a gravitationally driven wobble; yet he unmistakably describes the *observational consequence* of axial precession (precession of the equinoxes) and embeds it in a ninth-sphere architecture precisely suited to representing that phenomenon within the nested-spheres cosmology of his era. [62]

Bibliography

(Chicago author–date; primary texts and key scholarship prioritized)

Rambam primary text and translations
- Maimonides. *Mishneh Torah*, *Hilchot Yesodei HaTorah*, ch. 3. English trans. by Rabbi Eliyahu Touger (Moznaim), bilingual presentation. [63]
- Maimonides. *Mishneh Torah*, *Sefer ha-Maddaʿ*, *Hilchot Yesodei HaTorah*, ch. 3 (Hebrew, vocalized). Mechon Mamre. [64]
- Glazer, Simon, trans. *Mishnah Torah, Yod ha-hazakah* (public-domain English translation tradition; digitized excerpts in Sefaria environment). [30]

Key medieval-Jewish comparative source
- Rodríguez-Arribas, Josefina. "Significance of the Equinoxes in Abraham Ibn Ezra's Cosmology." (PDF). [8]

Peer-reviewed core argument on Rambam and the ninth orb
- Sela, Shlomo. "Maimonides and Māshāʾallāh on the Ninth Orb of the Signs and Astrology." *Aleph: Historical Studies in Science and Judaism* 12, no. 1 (2012): 101–134 (online version). [65]

Greek antecedents and precession parameter scholarship
- Duke, Dennis. "Ancient Declinations and Precession." (Academic paper, with discussion of Ptolemy's precession constant and methodology). [66]
- Jones, Alexander. "Claims of Originality and Innovation in Ptolemy's Almagest." (PDF, 2016). [67]

Islamic astronomy and parameter history
- Yazdi, Hamid-Reza Giahi. "Ibn Yūnus' Report on Early Islamic Observations for Determining the Rate of Precession of Equinoxes." *Suhayl* 15 (2016–2017): 101–112. [47]
- Hafez, Ihsan. *Abd al-Rahman al-Sufi and his Book of the Fixed Stars: a journey of re-discovery* (thesis chapters; detailed discussion of precession correction in al-Sufi). [68]

Transmission and 12th-century mediation (institutional / scholarly resources)
- Qatar Digital Library. "The Arabic Translations of Ptolemy's Almagest." [41]
- Bavarian Academy of Sciences and Humanities (Ptolemaeus Arabus et Latinus project). "Ptolemy, *Almagesti* (tr. Gerard of Cremona)." [69]
- *Encyclopaedia Britannica*. "Toledan Tables." [70]
- Nussbaumer, Harry. "The Islamic Influence on Western Astronomy" (PDF; Toledan Tables and trepidation note). [71]

Modern astronomical reference values
- Richardson, D. L. “Numerical Investigation of the Earth’s …” (NASA technical report noting an adopted IAU precession value of ~−50.29″/year). [46]
- University of St Andrews, School of Physics and Astronomy. “Positional Astronomy: Precession.” (teaching notes citing ~50.35″/yr). [49]

---

[1] [2] [3] [4] [6] [11] [12] [15] [23] [24] [25] [28] [29] [31] [32] [38] [48] [55] [58] [60] [63] https://www.chabad.org/library/article_cdo/aid/904969/jewish/Yesodei-haTorah-Chapter-3.htm
https://www.chabad.org/library/article_cdo/aid/904969/jewish/Yesodei-haTorah-Chapter-3.htm

[5] [7] [9] [13] [14] [16] [17] [18] [27] [39] [40] [50] [52] [54] [59] [61] [65] https://www.researchgate.net/publication/236829867_Maimonides_and_Mashaallah_on_the_Ninth_Orb_of_the_Signs_and_Astrology
https://www.researchgate.net/publication/236829867_Maimonides_and_Mashaallah_on_the_Ninth_Orb_of_the_Signs_and_Astrology

[8] [44] https://summa.upsa.es/high.raw?id=0000029395&name=00000001.original.pdf
https://summa.upsa.es/high.raw?id=0000029395&name=00000001.original.pdf

[10] [19] [46] [53] https://ntrs.nasa.gov/api/citations/19930009776/downloads/19930009776.pdf
https://ntrs.nasa.gov/api/citations/19930009776/downloads/19930009776.pdf

[20] [33] [66] https://isidore.co/misc/Physics%20papers%20and%20books/Biography/01.%20Ptolemy%20b.%20ca.%20A.D.%20100%20%28Toomer%29.pdf
https://isidore.co/misc/Physics%20papers%20and%20books/Biography/01.%20Ptolemy%20b.%20ca.%20A.D.%20100%20%28Toomer%29.pdf

[21] [34] [47] [56] [62] https://www.raco.cat/index.php/Suhayl/article/download/329907/420585
https://www.raco.cat/index.php/Suhayl/article/download/329907/420585

[22] [35] [41] [45] The Arabic Translations of Ptolemy's Almagest | Qatar Digital Library
https://www.qdl.qa/en/arabic-translations-ptolemys-almagest

[26] [64] https://mechon-mamre.org/i/1103n.htm
https://mechon-mamre.org/i/1103n.htm

[30] https://www.sefaria.org/Mishneh_Torah%2C_Foundations_of_the_Torah.3.1?lang=bi&with=Translations
https://www.sefaria.org/Mishneh_Torah%2C_Foundations_of_the_Torah.3.1?lang=bi&with=Translations

[36] Hajjaj ibn Yusuf ibn Matar
https://islamsci.mcgill.ca/RASI/BEA/Hajjaj_ibn_Yusuf_ibn_Matar_BEA.htm

[37] [68] https://www.atlascoelestis.com/Zagrebelsky/28854_Hafez_2010_Chapters5_to_8_thesis.pdf
https://www.atlascoelestis.com/Zagrebelsky/28854_Hafez_2010_Chapters5_to_8_thesis.pdf

[42] [69] PAL: Ptolemy, Almagesti (tr. Gerard of Cremona)
https://ptolemaeus.badw.de/work/3

[43] [70] Toledan Tables | astronomical tables | Britannica
https://www.britannica.com/topic/Toledan-Tables

[49] https://www-star.st-andrews.ac.uk/~fv/webnotes/chapt16.htm
https://www-star.st-andrews.ac.uk/~fv/webnotes/chapt16.htm

51 67 https://archive.nyu.edu/jspui/bitstream/2451/63325/2/Jones%202016%20Claims%20of%20originality%20and%20innovation%20in%20Ptolemy.pdf
https://archive.nyu.edu/jspui/bitstream/2451/63325/2/Jones%202016%20Claims%20of%20originality%20and%20innovation%20in%20Ptolemy.pdf

57 https://ora.ox.ac.uk/objects/uuid%3A944b5613-97ba-48c0-a8c5-9bc40a4cb9a0/files/m5ca4392cadb8ce285728880c5aa68501
https://ora.ox.ac.uk/objects/uuid%3A944b5613-97ba-48c0-a8c5-9bc40a4cb9a0/files/m5ca4392cadb8ce285728880c5aa68501

71 https://www.irsol.usi.ch/data/spse/spse-download.php?pid=3
https://www.irsol.usi.ch/data/spse/spse-download.php?pid=3