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The Genius of Nicholas Copernicus: An Islamic Perspective

Copernicus and Astronomy:

Continuity, Reform, and Dissemination Conference

at the World Copernican Congress

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Jamil Ragep

How Might Contemporaneous Islamic Astronomers Have Viewed Copernican Astronomy?

- **Mathematical techniques and the *hayʾa* enterprise**
- Variable precession and the changing obliquity
- Rotational motion of the Earth
- Separation of mathematics from natural philosophy
- New Models
- Heliocentrism vs. Heliomiddleism

Mathematical techniques and the *hayʾa* enterprise

- Copernicus's mathematics was advanced over Ptolemy
- Trigonometry was functional but not cutting edge
- Underlying physicality of astronomical models apparent, but Copernicus never wrote a work comparable to *hayʾa/theorica* treatises that make this physicality explicit (cf. Ptolemy's *Planetary Hypotheses*, Ṭūsī's *Tadhkira*, Ibn al-Shāṭir's *Nihāya*, and Peurbach's *Theoricae*)

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Variable Precession (as reported by Battānī)

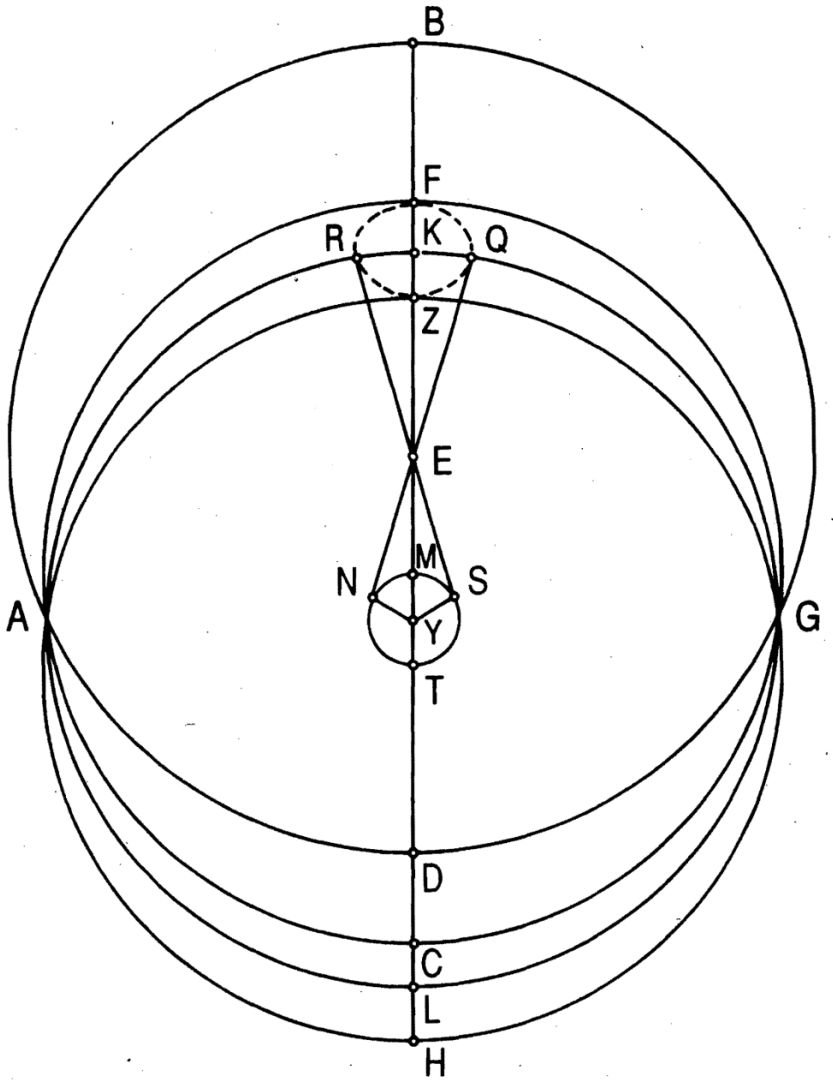
	Precession 1°/ x years
Babylonians	1°/261 years
Hipparchus	1°/125 years
Ptolemy	1°/100 years
Battānī (early Islam)	1°/66 years

Later Islam: 1°/70 years

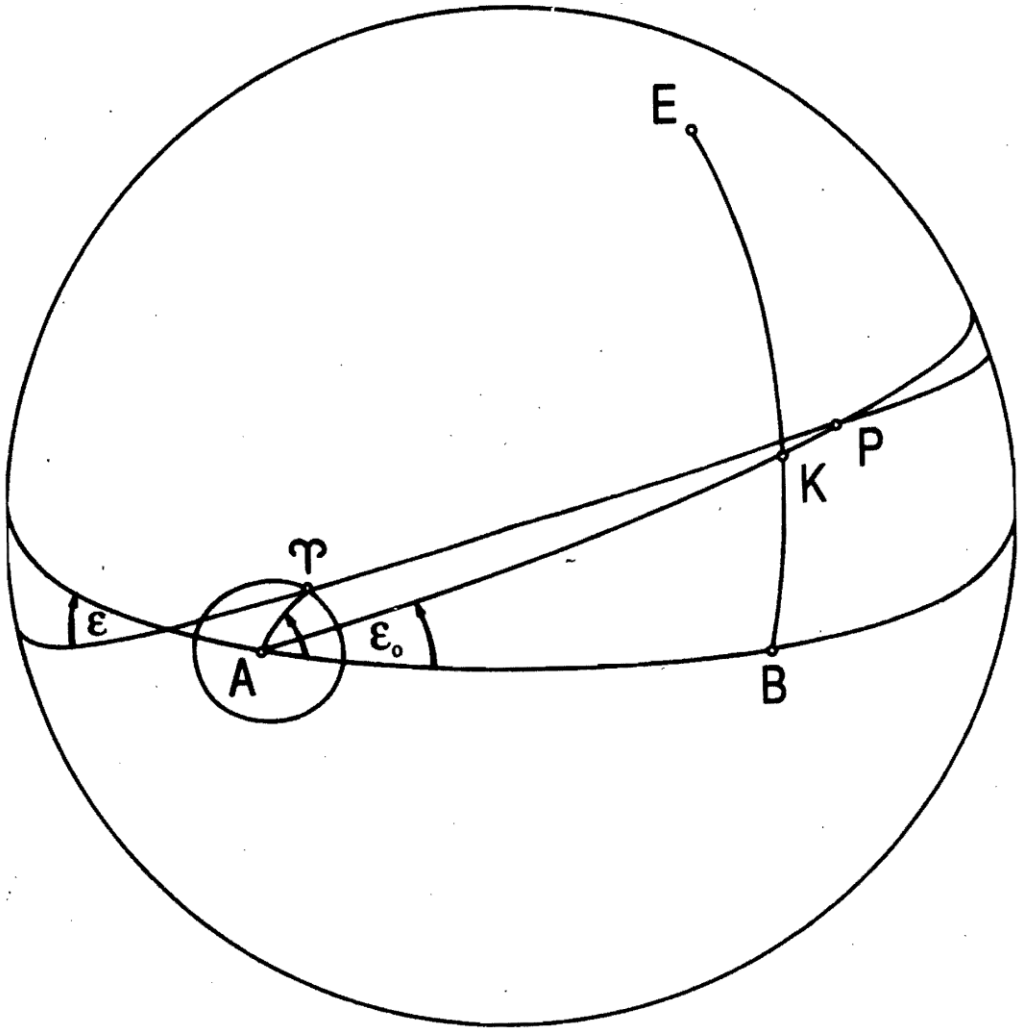
Obliquity reports from Bīrūnī's *al-Qānūn al-Masʿūdī*

Observer	Obliquity Value	Modern estimate
Euclid	24°	23°44′ (for –300)
Eratosthenes/ Hipparchus	23°51′20″	23°43.5′ (–250)/ 23°43′ (–150)
Ptolemy	**23°51′20″**	**23°40.5′ (140)**
Indian Group	24°	23°38′ (500)
Yaḥyā ibn Abī Manṣūr	23°33′	23°35′25″ (830)
Sanad ibn ʿAlī	23°34′ (23°33′52″ or maybe 23°33′57″ or 23°34′27″)	23°35′25″ (830)
Damascus tables	23°34′51″	23°35′25″ (830)
Banū Mūsā (in Sāmarrāʾ)	23°34½′	23°35′25″ (830)
Banū Mūsā (in Baghdād)	23°35′	23°35′25″ (830)
Manṣūr ibn Talḥa/ Muḥammad ibn ʿAlī al-Makkī	23°34′	23°35′16″ (850)
Sulaymān ibn ʿAṣma (with parallax adjustment)	23°33′42″	23°35′5″ (875)
Sulaymān ibnʿAṣma (without parallax)	23°34′40″	23°35′5″ (875)
Battānī/Ṣūfī/Būzjānī/Ṣaghānī	23°35′	23°34′53″ (900)
Abū al-Faḍl ibn al-ʿAmīd	23°40′	23°34′30″ (950)
Khujandī	23°32′21″	23°34′19″ (970)
Bīrūnī	23°35′	23°33′58″ (1020)

Models for Variable Precession and Changing Obliquity



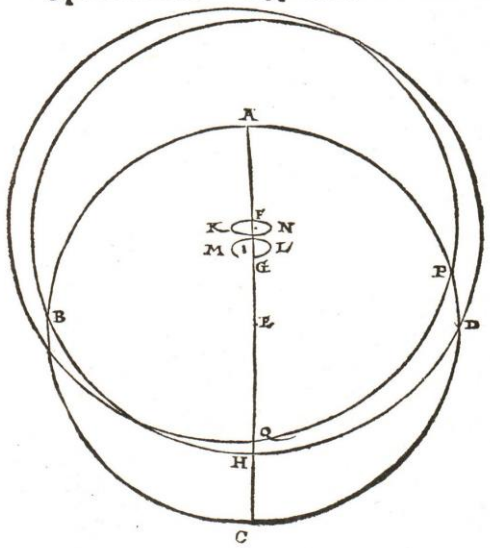
Ibrāhīm ibn Sinān (polar)



Pseudo-Thābit ibn Qurra (equatorial)

Copernicus: Variable Precession/Changing Obliquity

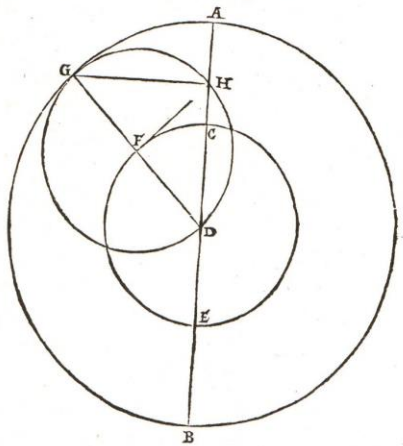
descriptus in eo circulus æquinoctialis per eadē BD segmenta trāsibit, nempe per polos AFEC circuli: sed angulos obliquitatis faciet maiores pro ratione FI circūferētiæ. Ab hoc sumpto principio transiturū terrę polum ad mediā obliquitatē in: alter supervenieńs motus nō sinit recta incedere per FI, sed per ambitum ac extremam in consequentia latitudinem, quæ sit in K deducit ipsum. In q̄ loco descripti æquinoctialis apparentis OPQ, sectio nō erit in B, sed post ipsam in O, & pro tanto minuitur præcessio æquinoctiorū, quantum fuerit BO. Hinc conuersus polus, & in præcedentia tendens, excipitur à concurrētibus simul utrisq; motibus in I medio, & æquinoctialis apparēs p̄ omnia unitur æquali siue medio, ac eo ptransiens polus terræ transmigrat in prȩcedentes partes, & separat æquinoctialem apparentē à medio, augetq; præcessionem æquinoctiorū usq; in alterū L limitē. Inde reuertēs aufert q̄d modo adiecerat æquinoctijs, donec in G puncto cōstitutus minimā efficiat obliquitatē in eadē B sectiōe, ubi rursus æquinoctiorū solsticiorūq; motus tardissimus apparebit eo ferè modo quo in F. Quo tempore constat inæqualitatē eorū reuolutionē suā peregisse, quando à medio utrunq; pertransierit extremorū: motus uero obliquitatis à maxima declinatione ad minimam, dimidium duntaxat circuitum. Exinde pergens polus consequentia repetit ad extremum usq; limitem in M, ac denuo reuersus unitur in medio, rursumq; uergens in præcedentia N limitem emensus concludit



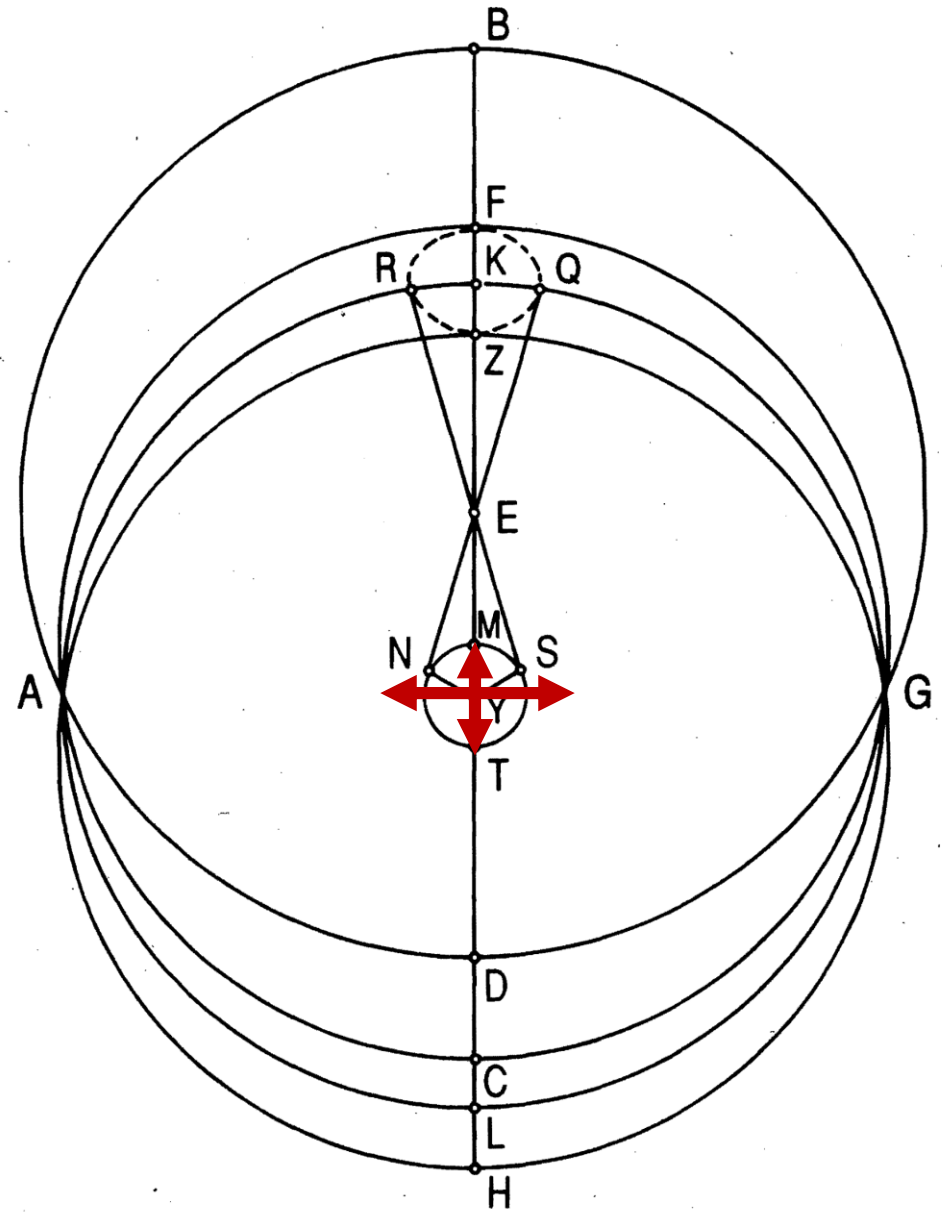
cludit tandem quā diximus intortā lineam FKILGMINF, ltaq; manifestum est, quòd in una reuersione obliquitatis bis præcedentium bisq; sequentium limitem terræ polus attingit.

Quomodo motus reciprocus siue librationis ex circularibus constet. Cap. IIII.

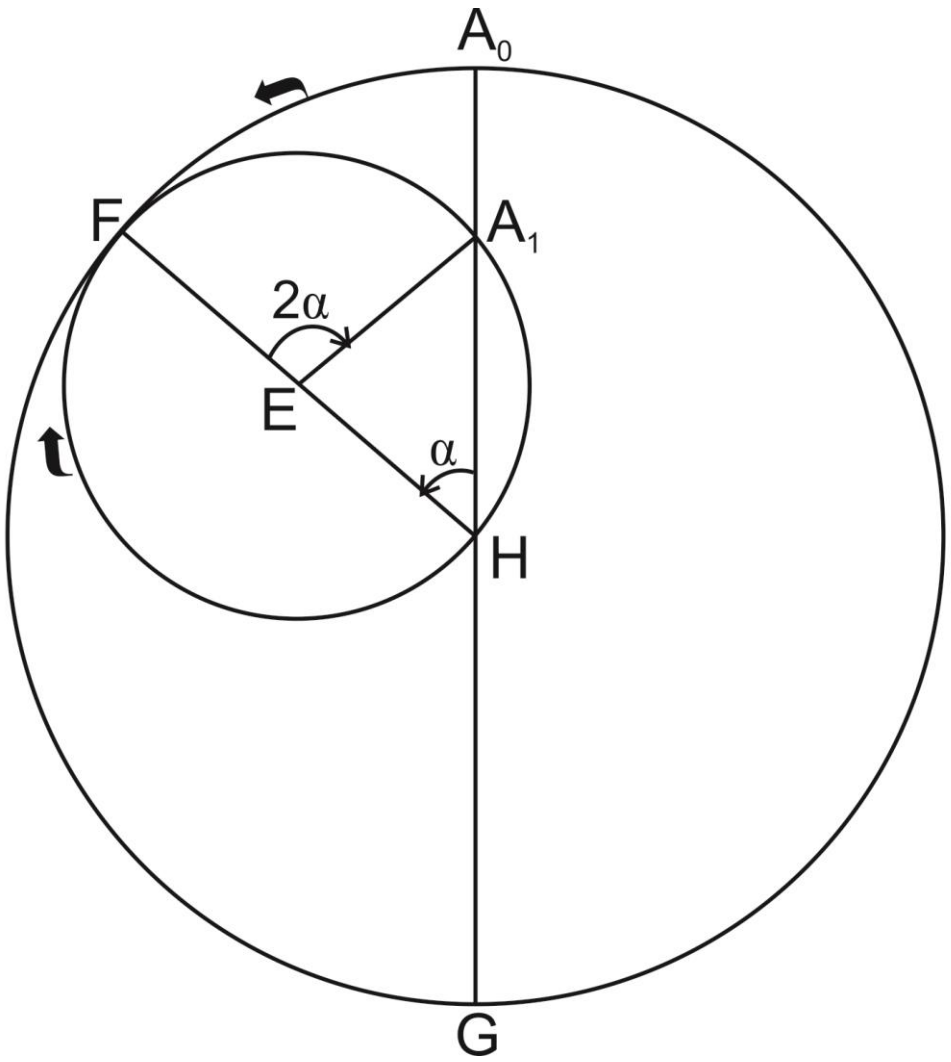
QVod igitur iste motus apparentijs consentiat amodo declarabimus. Interim uero quæret aliquis, quo nam modo posit illarum librationum æqualitas intelligi, cum à principio dictum sit, motum cȩlestem æqualē esse, uel ex æqualibus ac circularibus cōpositum. Hic aūt utrobiq; duo motus in uno apparēt sub utrisq; terminis, q̄bus necesse est cessationē interuenire. Fatebimur quidem geminatos esse, at ex ȩqualibus hoc modo demonstrant. Sit recta linea AB, quę quadrifariā secetur in CDE signis, & in D describātur circuli homocentri, ac in eodē plano ADB, & CDE, & in circūferentia interioris circuli assumat utcūq; F signū, & in ipso F cētro, interuallo uero FD circulus describatur GHD, qui secet AB rectā lineā in H signo, & agat dimetiēs DFG. Ostēdendū est, q̄ geminis motibus circulorū GHD & CFE cōcurrētibus inuicē H mobile p eandē rectam lineā AB hinc inde reciprocādo repat. Quod erit, si intelligat H moueri in diuersam partē, & duplo magis ipso F. Quoniā idē angulus, q̄ sub CDF in cētro circuli CFE & circūferētia ipsius GHD cōsistēs cōprehēdit utrāq; circūferentiā circulorū ȩq̄liū GH duplā ipsi FC, posito q̄ aliquādo in cōiunctiōe rectarū linearū ACD & DFG mobile H fuerit in G cōgruente cū A, & F in C. Nūc aūt in dextras ptes pFC motū est centrū F & ipsum H p GH circumferentiā in sinistras duplo maiores ipsi CF.

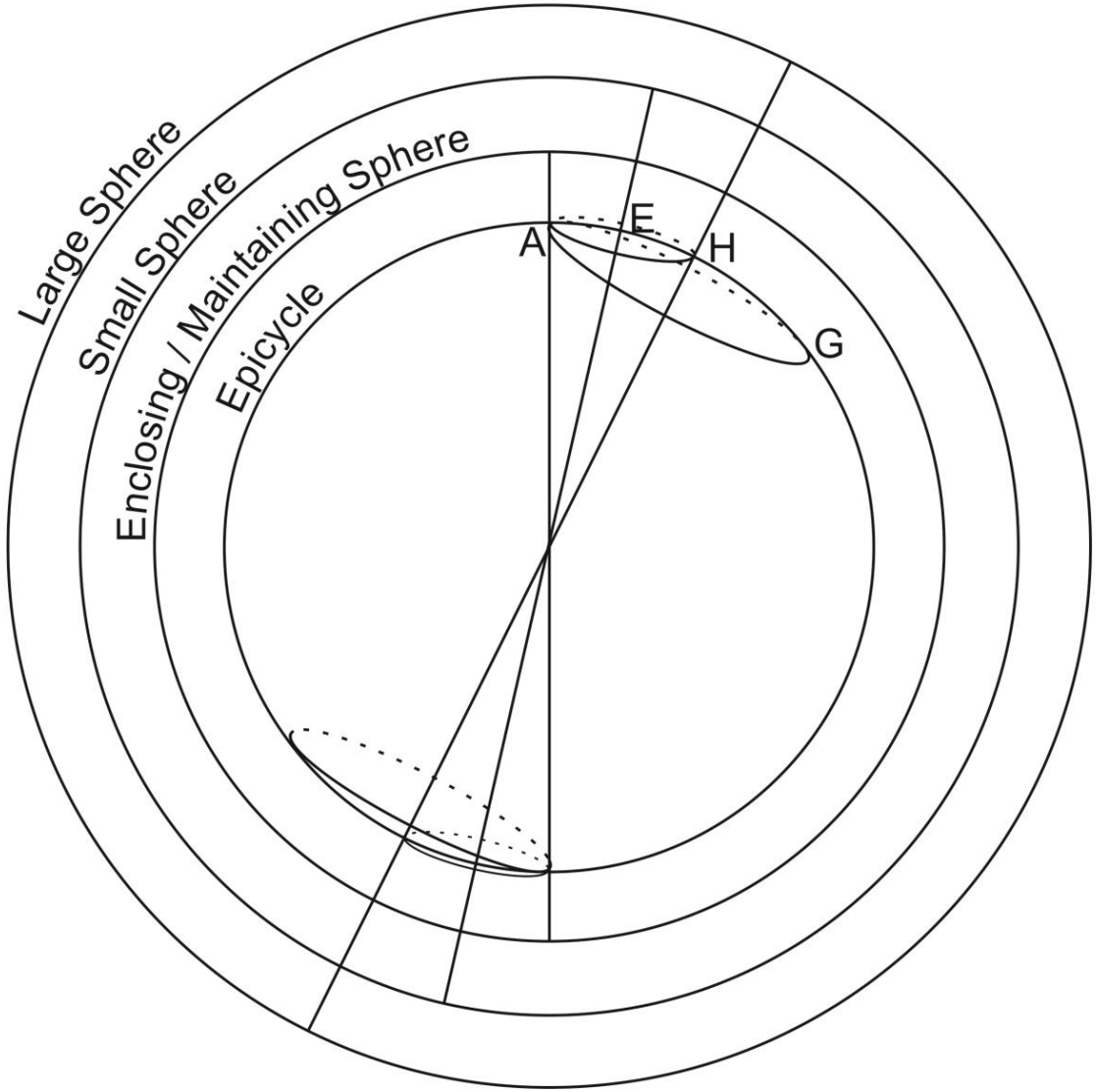


Copernicus: Variable Precession/Changing Obliquity

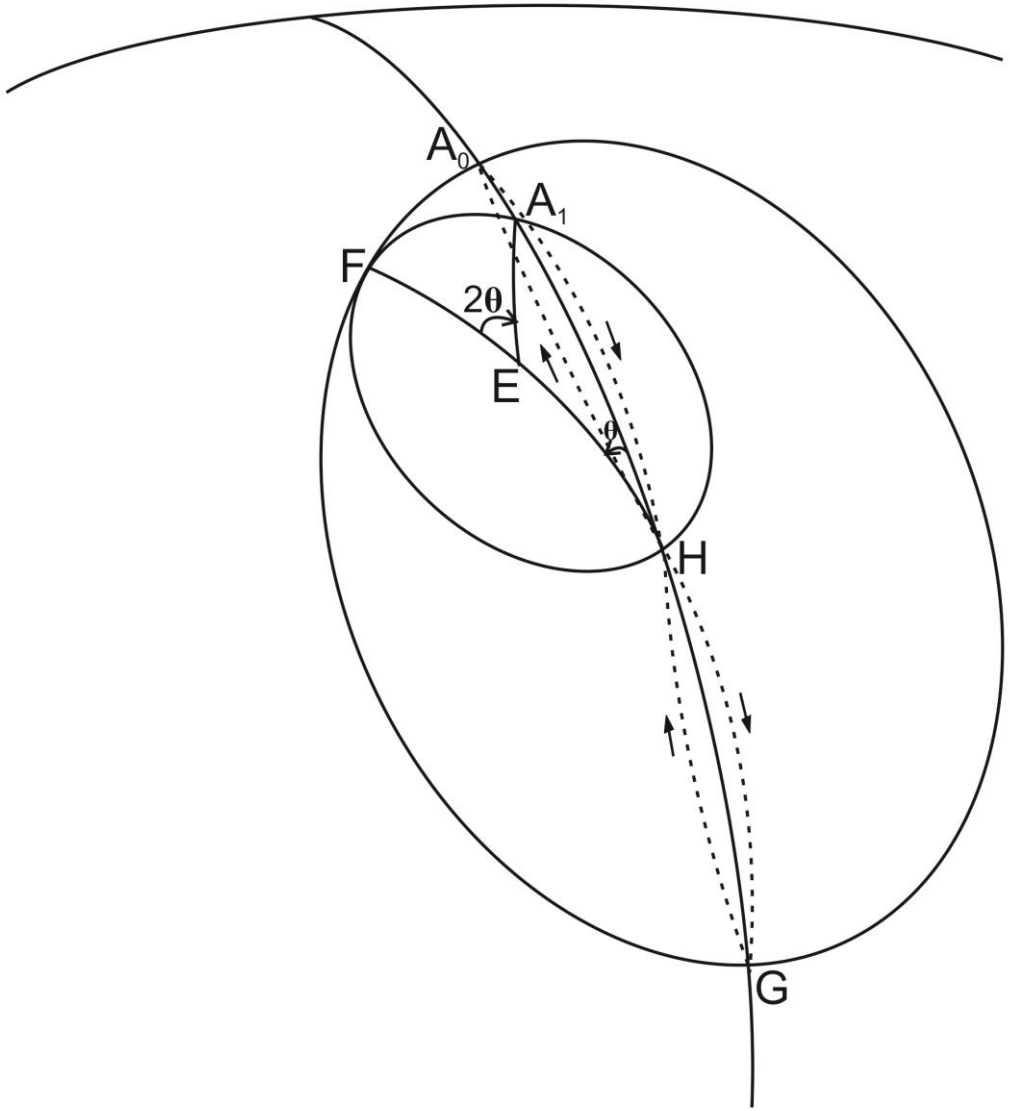


Rectilinear vs. Curvilinear Ṭūsī-Couple

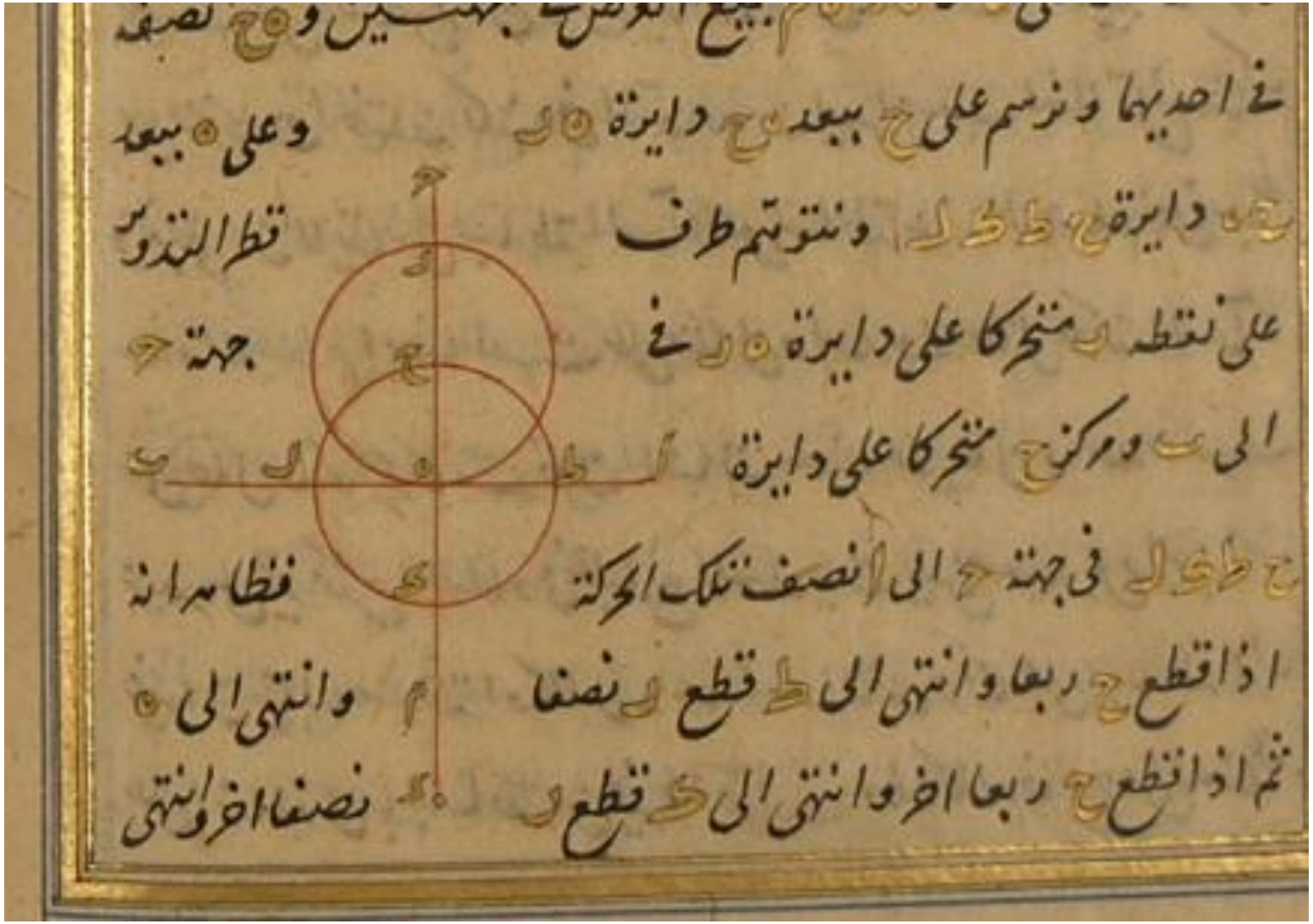




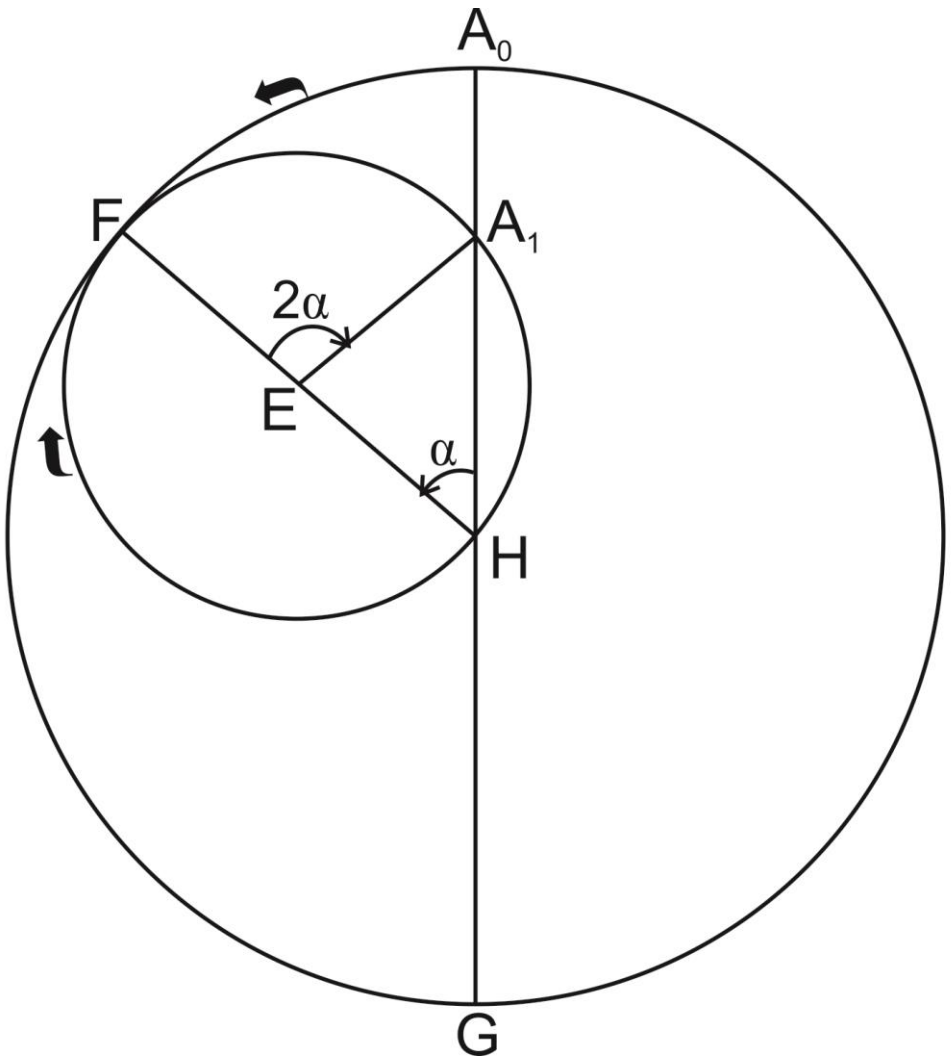
Path of the Curvilinear Ṭūsī-Couple

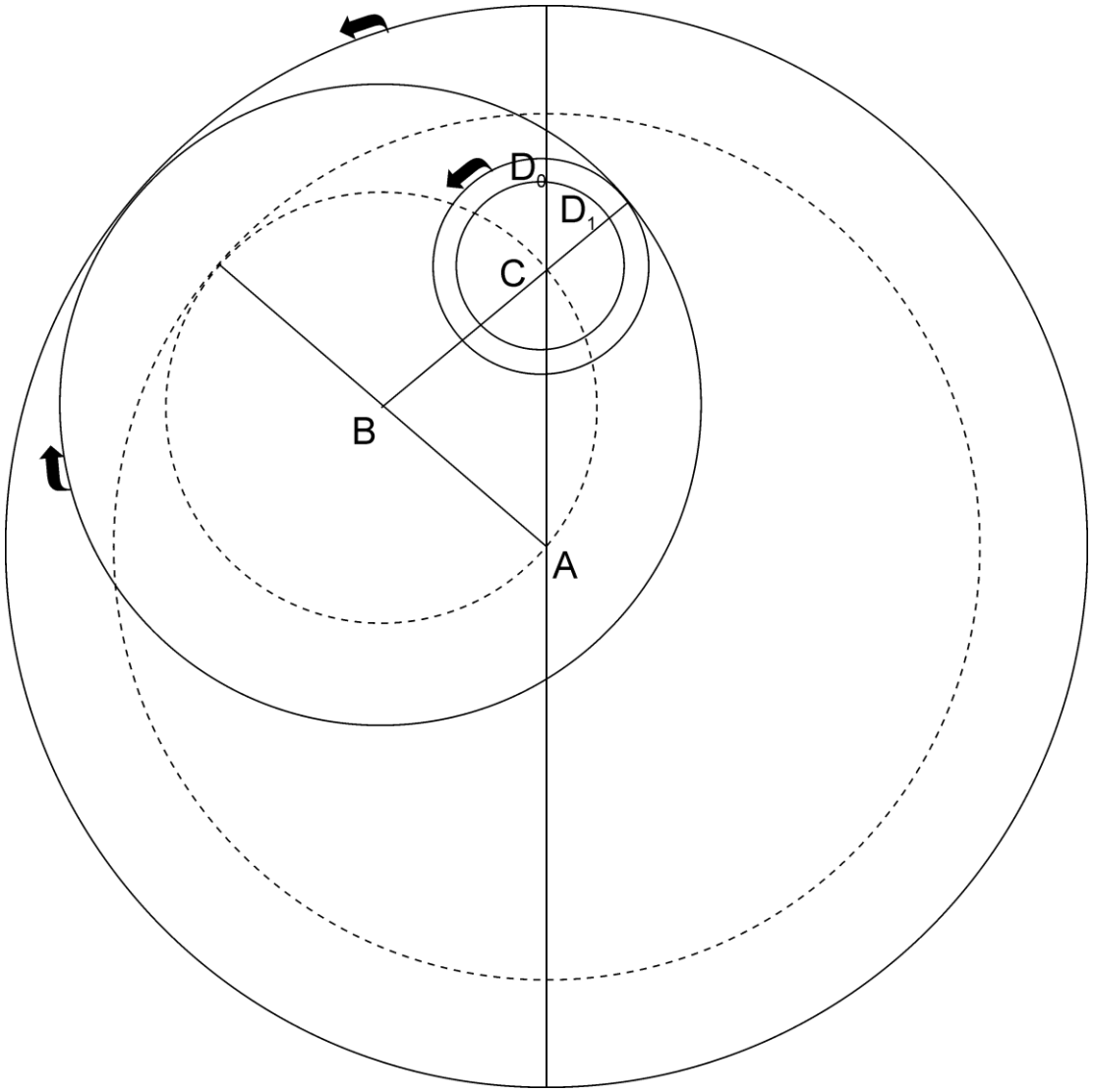


Ṭūsī-Couple in the Recension of the *Almagest*

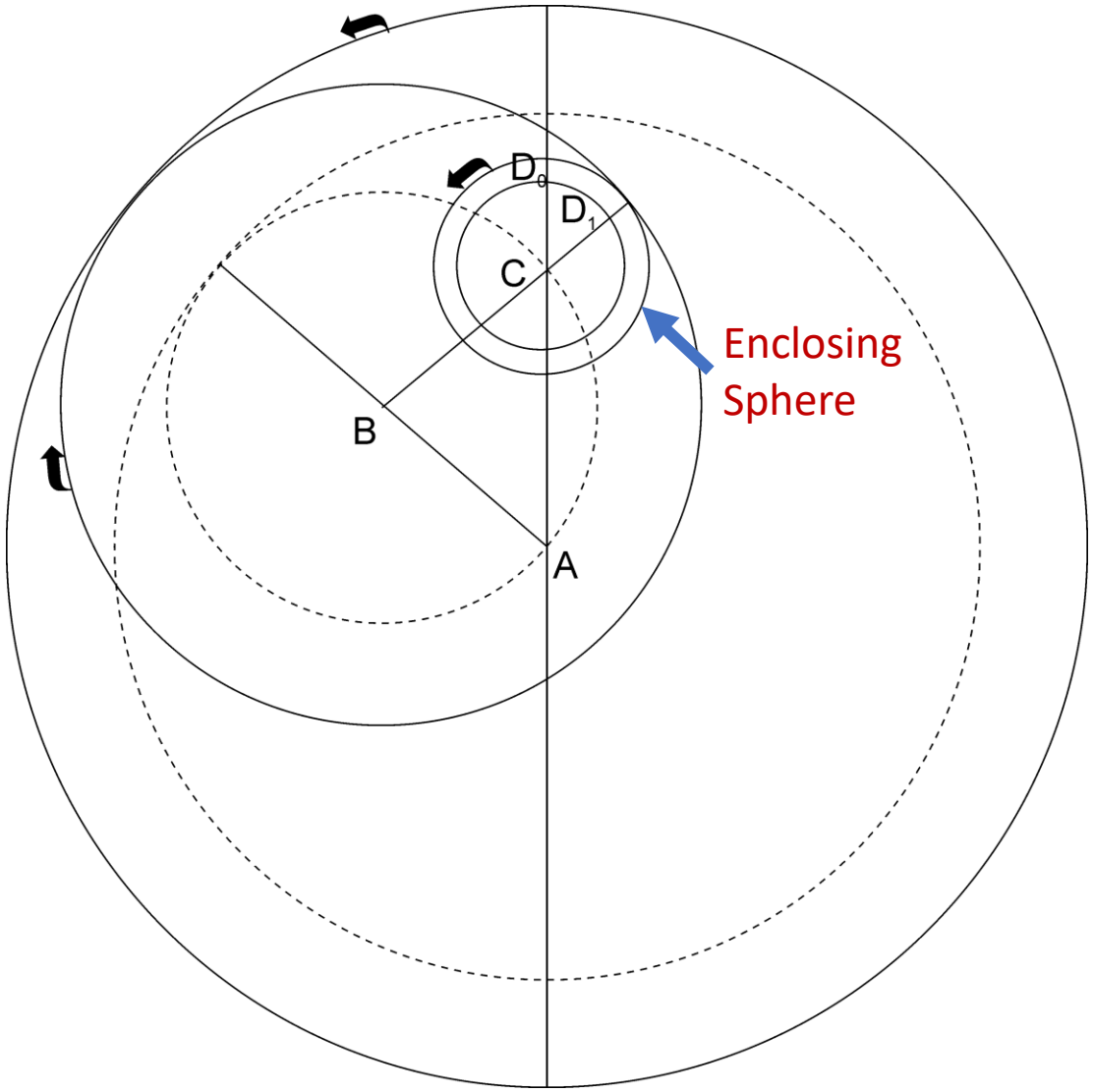


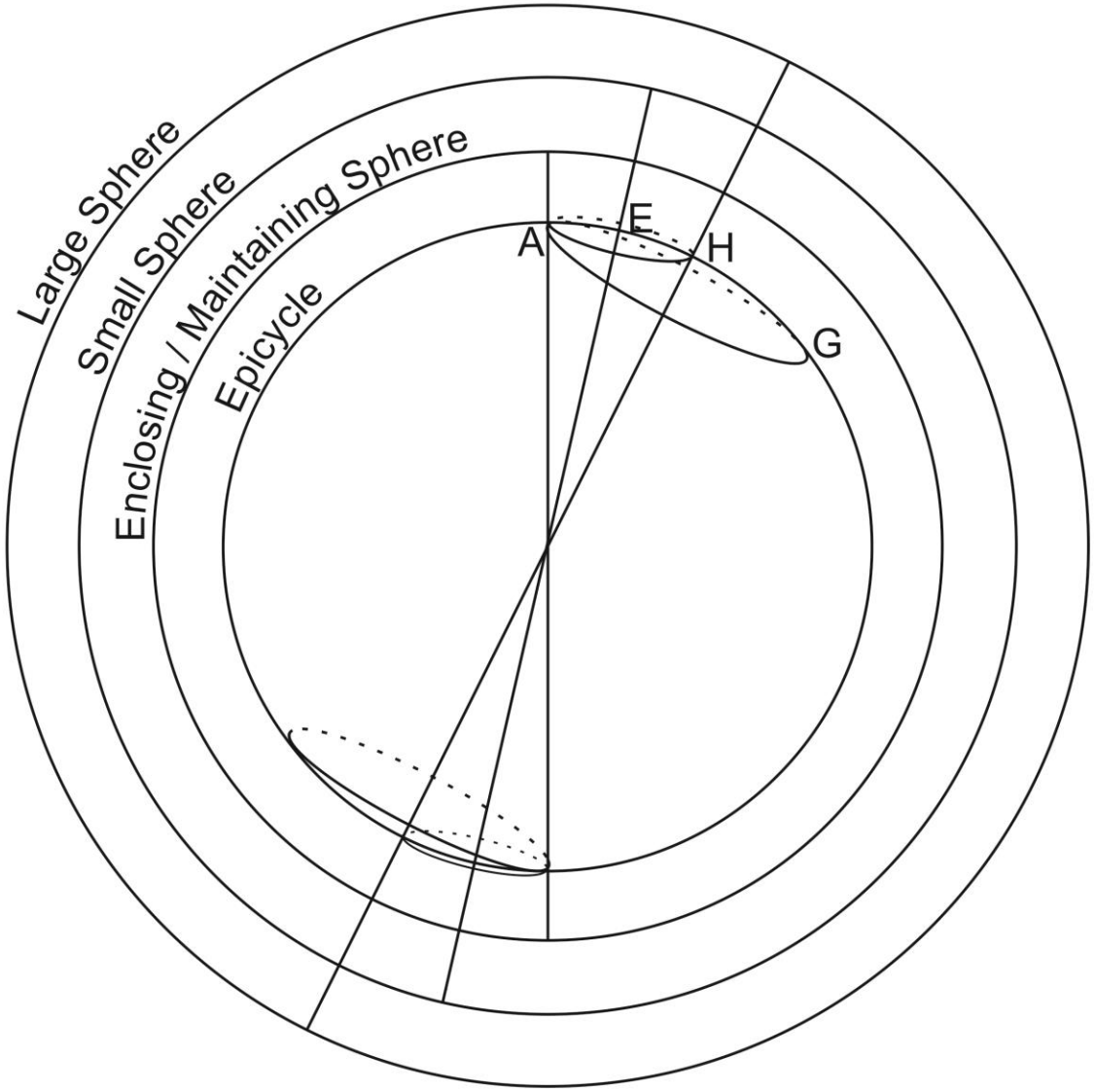
Mathematical vs. Physicalized Ṭūsī-Couple





Physicalized Ṭūsī-Couples





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CAN OBSERVATIONAL TESTS SETTLE THE MATTER?		DO ASTRONOMERS NEED THE (PERIPATETIC) NATURAL PHILOSOPHERS TO SETTLE THE MATTER?	
YES	NO	YES	NO
Ptolemy **Bīrūnī** (*Qānūn Masʿūdī*) **Shīrāzī**	**Ṭūsī** **Ibn Sīnā** (probably no) **Nīsābūrī** **Jurjānī** **Bīrjandī** **Qushjī** **Copernicus**	**Ṭūsī** **Ibn Sīnā** (probably yes) **Nīsābūrī** **Jurjānī** **Bīrjandī**	**Ptolemy** **Bīrūnī** (*Qānūn Masʿūdī*) **Shīrāzī** **Qushjī** **Copernicus**

COPERNICUS, *DE REV, I.8*

Then what should we say about the clouds and other things suspended in the air in whatever way or things that fall down or conversely things that rise up to the upper regions? [We would say] that not only the earth with the watery element conjoined with it moves in this way, but also not a small part of the air and whatever in the same way has a natural connection (*cognatio*) to the earth. Either the nearby air, mixed with the matter of earth or water, should conform to (*sequatur*) the same nature as the earth, or the motion of the air, which has been acquired by the contiguity of the earth, participates in a perpetual rotation without resistance. On the other hand, it is no less remarkable that the upper region of the air conforms to (*sequi*) the motion of the heavens, which is indicated by those suddenly-appearing stars that the Greeks call comets and bearded stars.

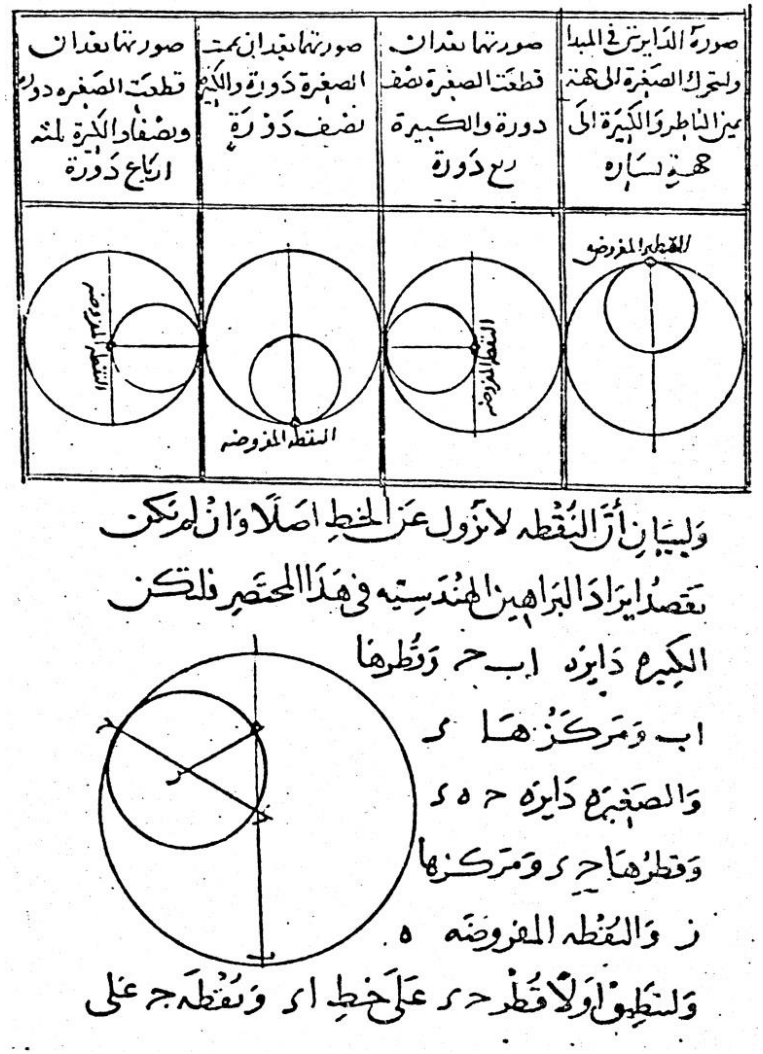
ṬŪSĪ, *TADHKIRA,* II.1

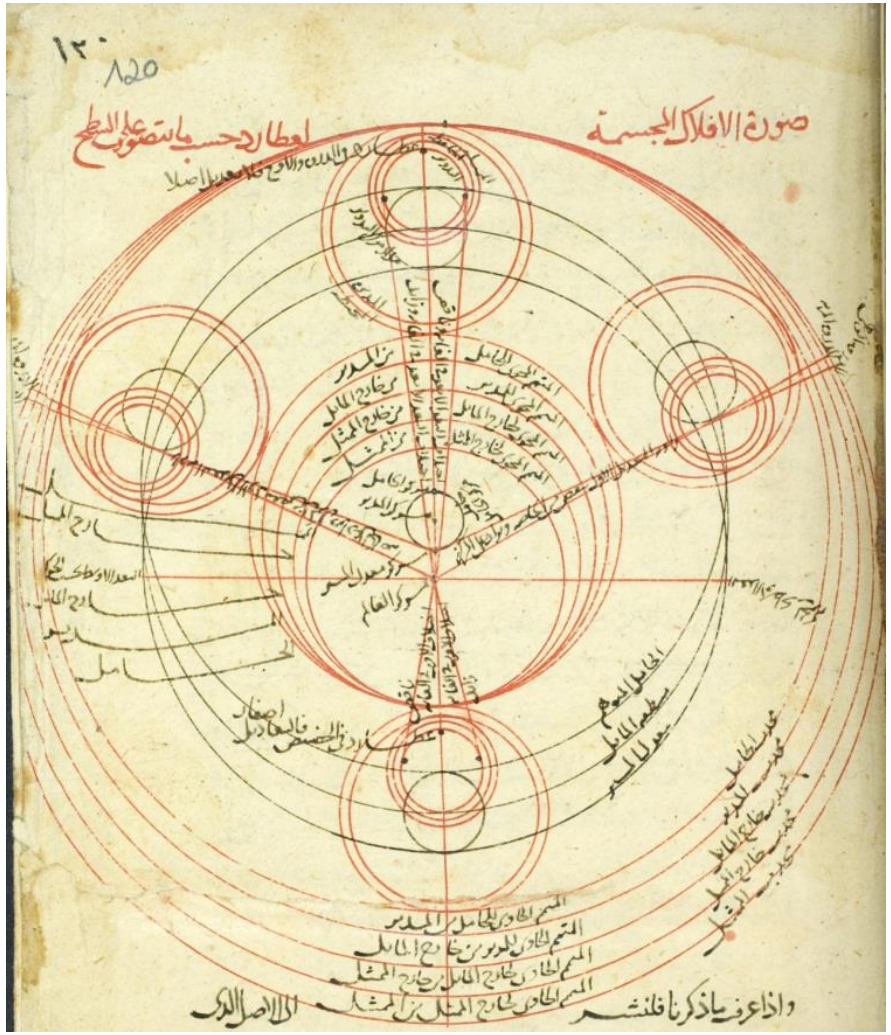
It is not possible to attribute the primary motion to the Earth. This is not, however, because of what has been maintained, namely that this would cause an object thrown up in the air not to fall to its original position but instead it would necessarily fall to the west of it, or that this would cause the motion of whatever leaves the [Earth], such as an arrow or a bird, in the direction of the [Earth's] motion to be slower, while in the direction opposite to it to be faster. For the part of the air adjacent to the [Earth] could conceivably conform (*yushāyi`u*) to the Earth's motion along with whatever is joined to it, just as the aether [(here) = upper level of air] conforms (*yushāyi`u*) to the orb as evidenced by the comets, which move with its motion.

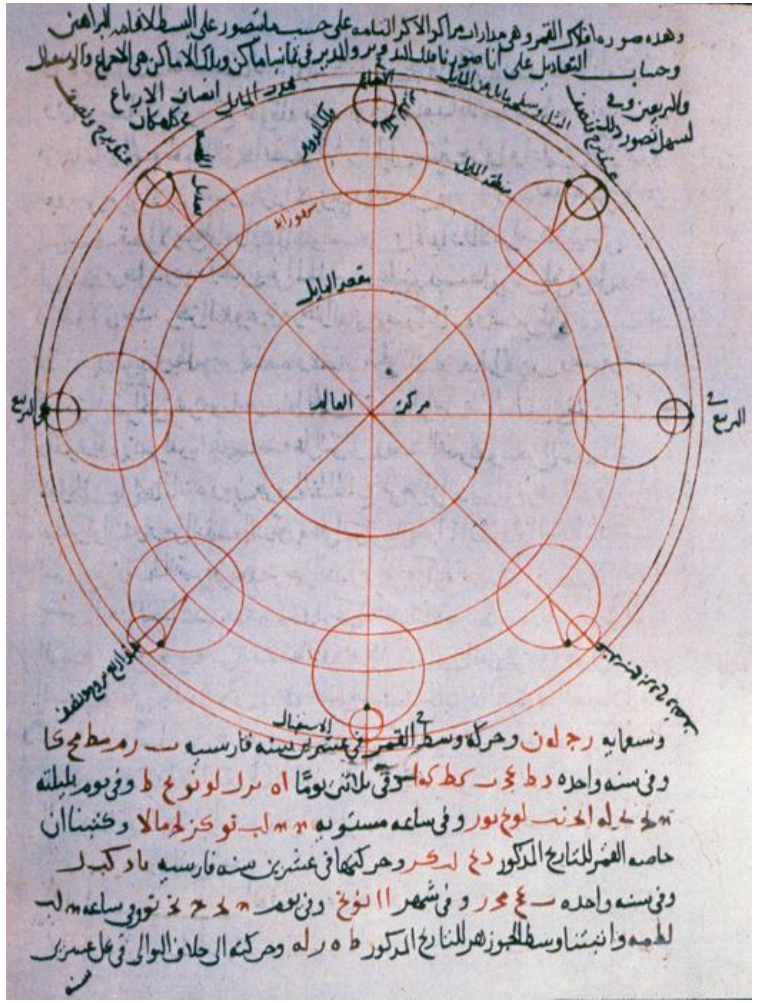
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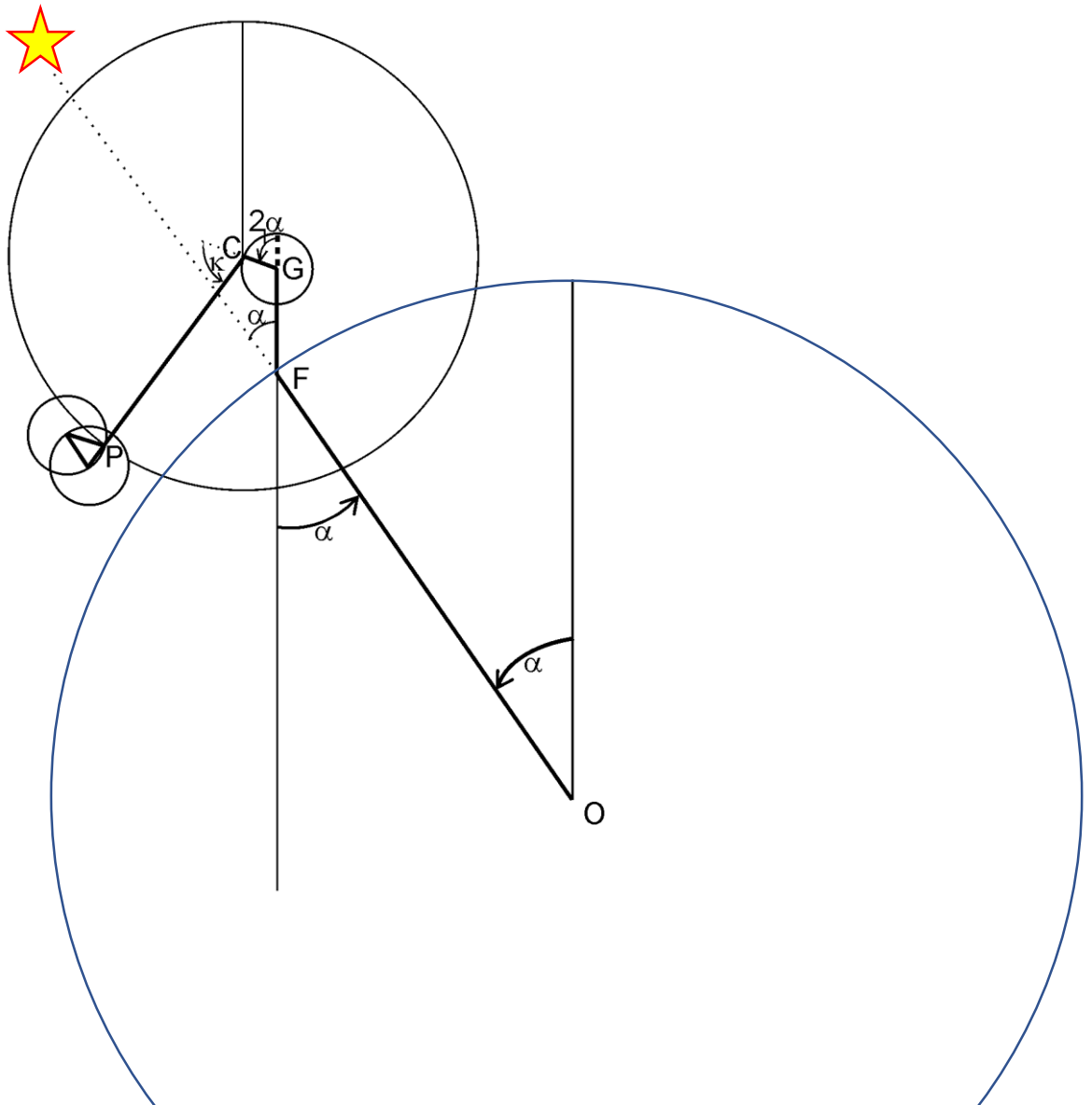
Some New Models



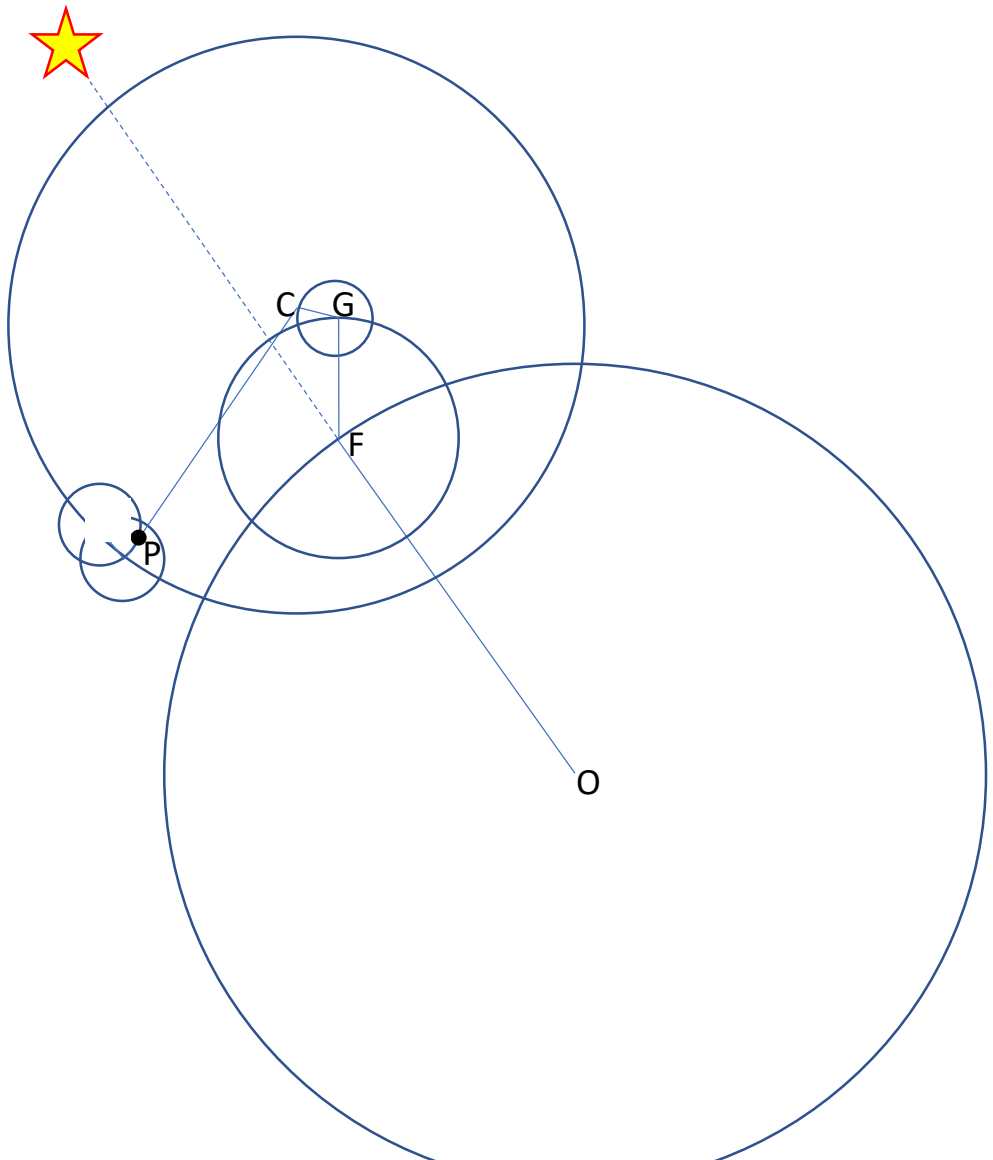


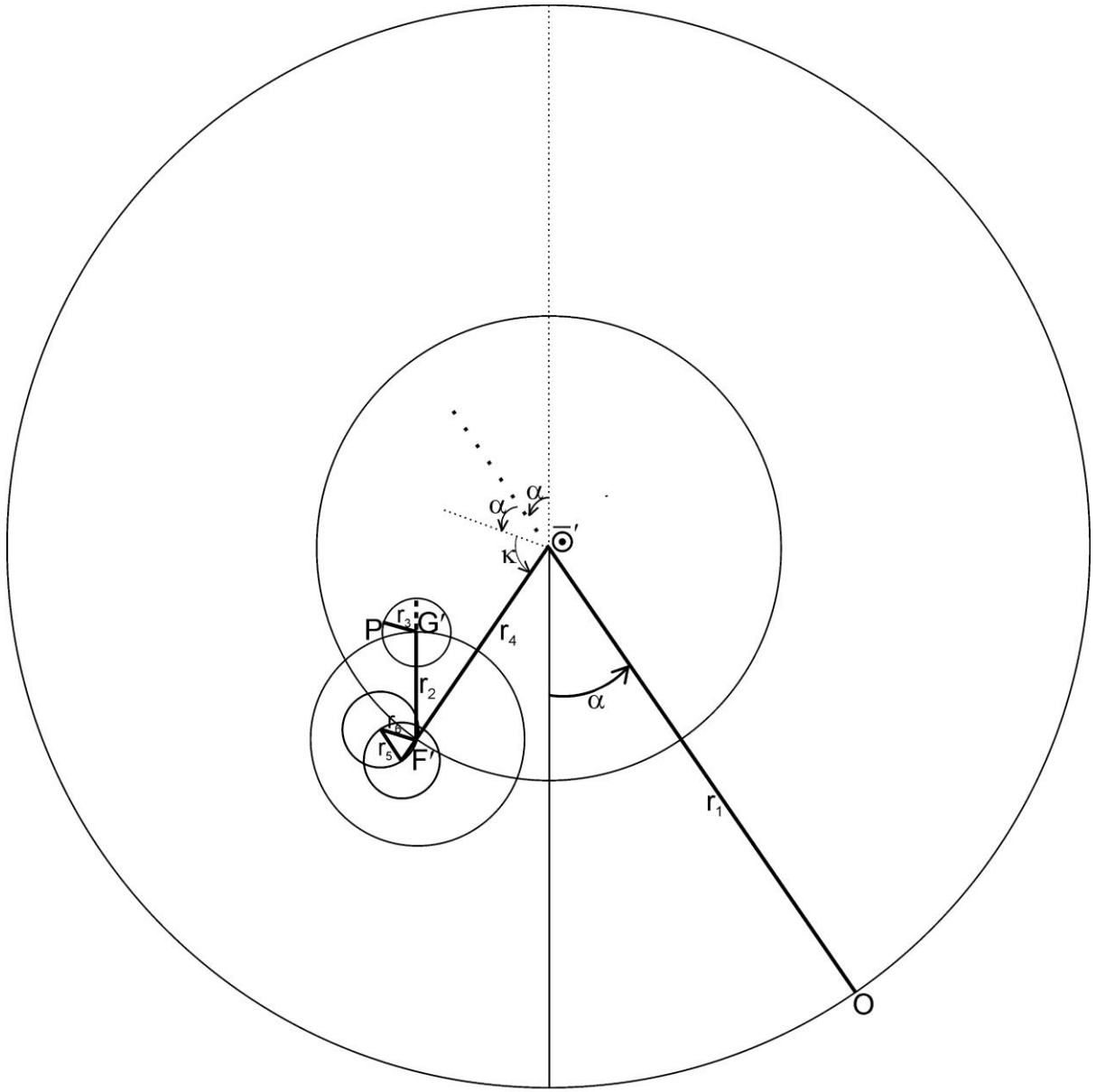


Mercury: Ibn al-Shāṭir to *De rev*

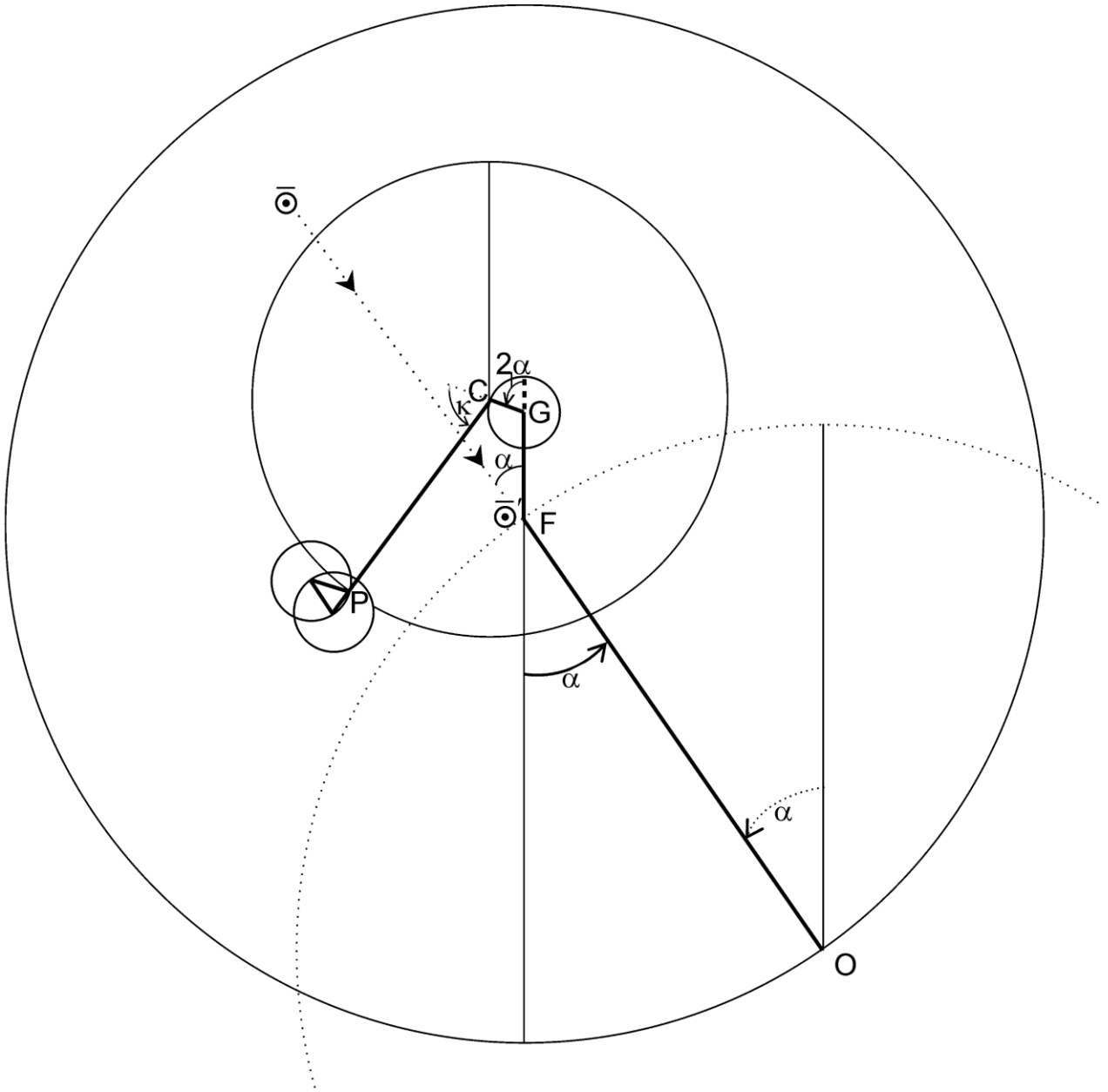


Mercury: Ibn al-Shāṭir to the *Commentariolus*

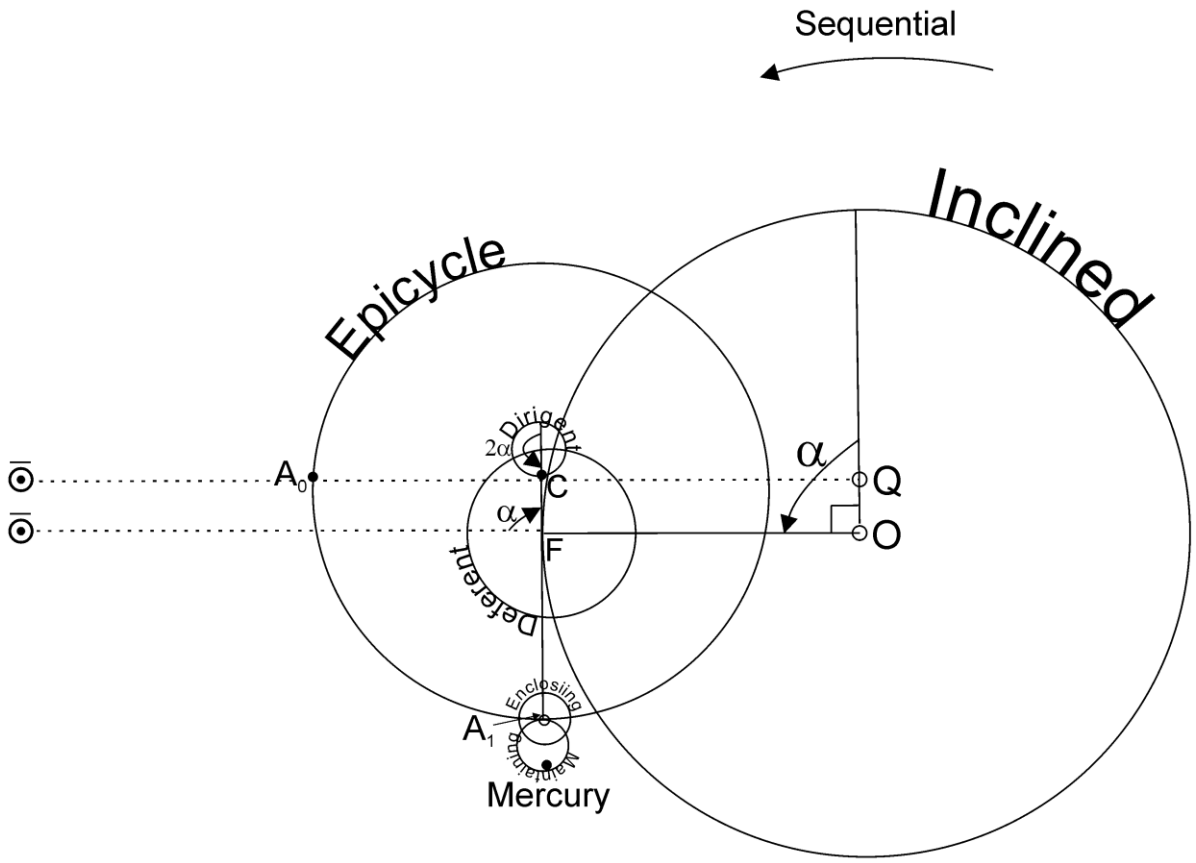




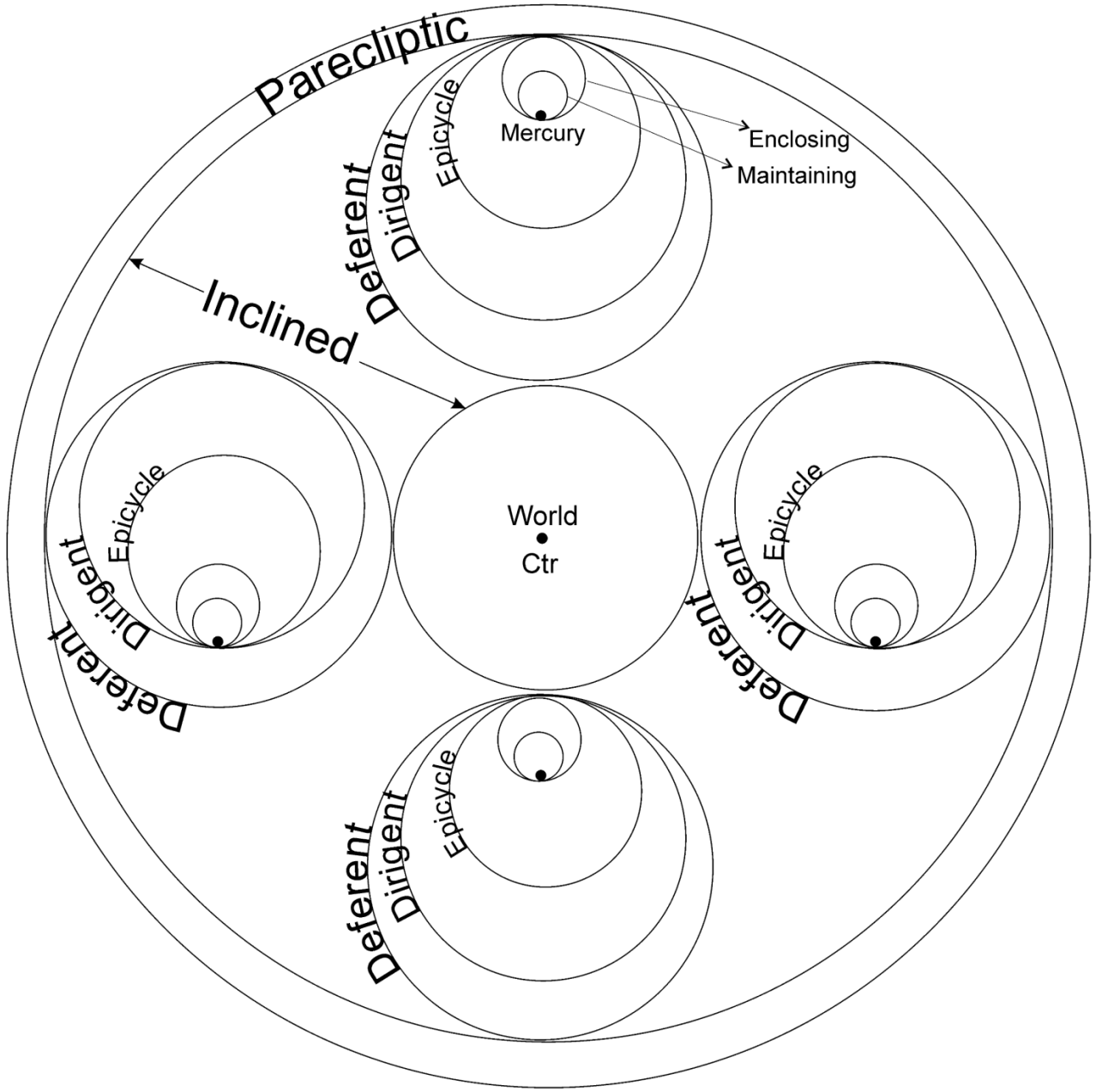
Mercury: *Commentariolus*



Mercury: *De rev*

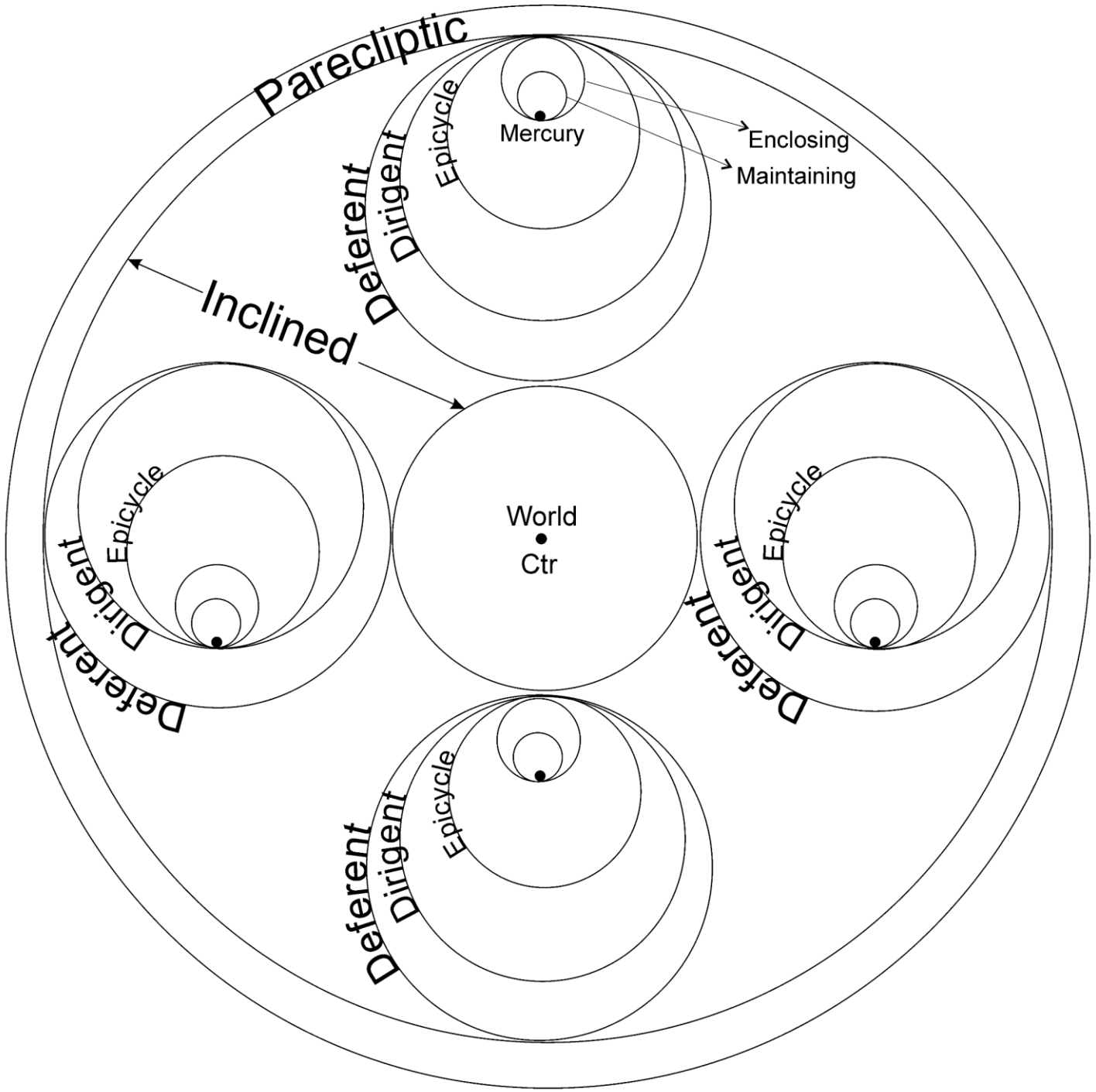


Ibn al-Shāṭir's Mercury Model
(schematic view)



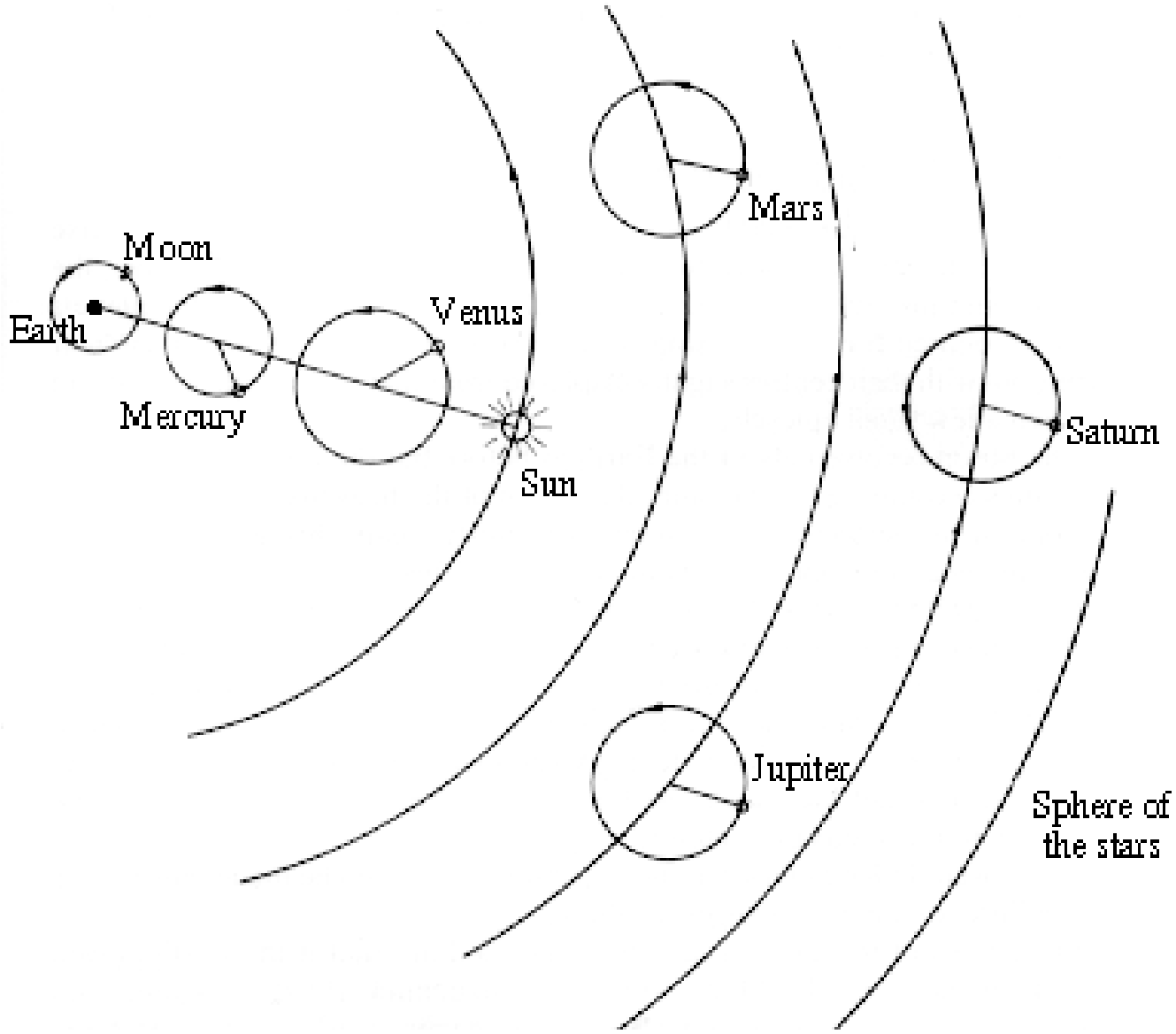
Ibn al-Shāṭir's Mercury Model
(solid-orb version at 4 different positions)

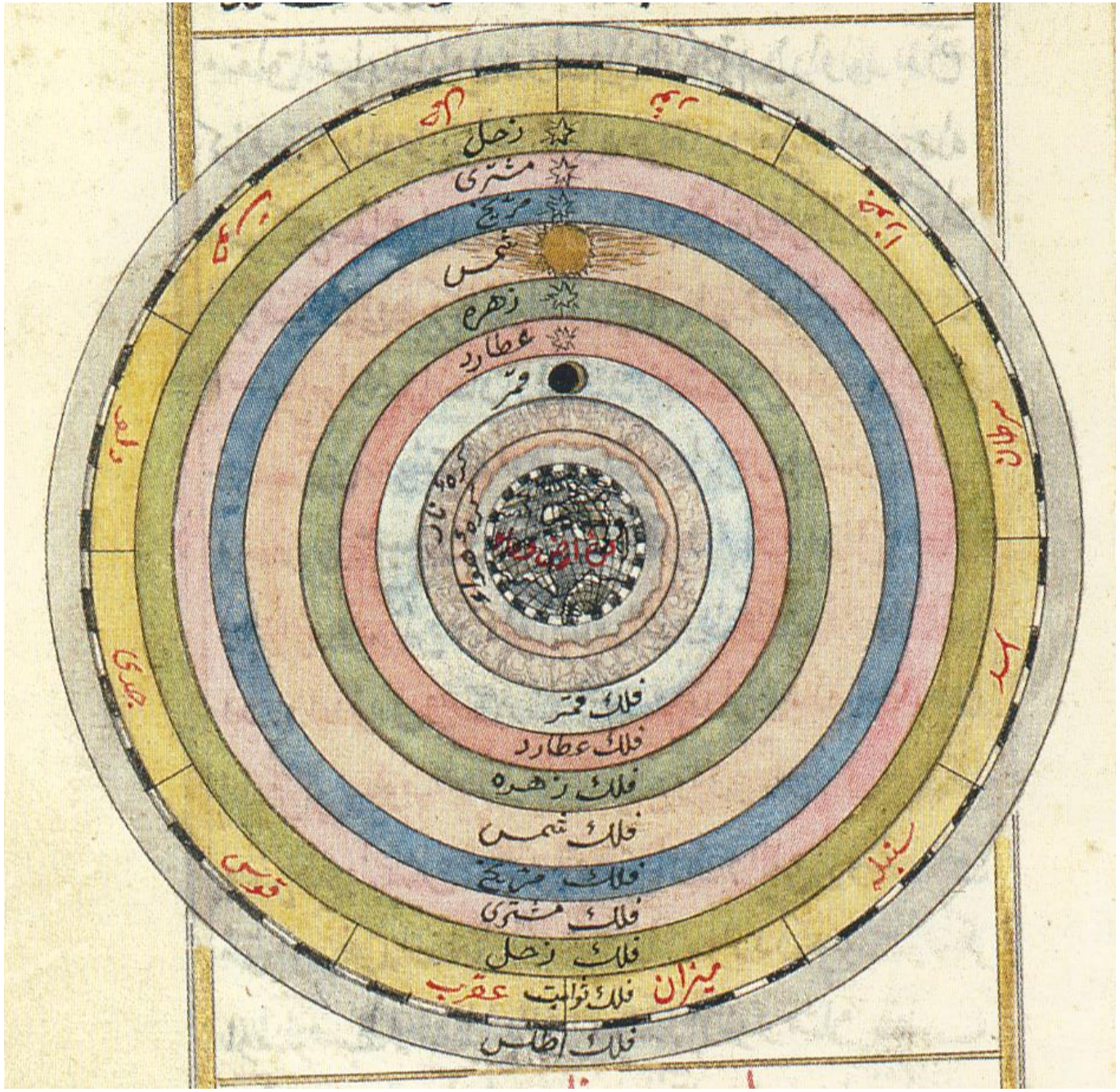
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Moon
Earth
Mercury
Venus
Sun
Mars
Jupiter
Saturn
Sphere of
the stars


زحل
مشتری
مریخ
شمس
زهره
عطارد
قمر
فلک قمر
فلک عطارد
فلک زهره
فلک شمس
فلک مریخ
فلک مشتری
فلک زحل
فلک ثوابت
فلک اطلس
میزان
عقرب
قوس
جدی
دلو
حمل
ثور
جوزا
سرطان
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Dziękuję!

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